

climate change counts

STRENGTHENING UNIVERSITY CONTRIBUTIONS TO CLIMATE COMPATIBLE DEVELOPMENT IN SOUTHERN AFRICA

Knowledge Co-production Framework



Volume 1: Knowledge Co-Production Framework

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SARUA CLIMATE CHANGE COUNTS MAPPING STUDY

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STRENGTHENING UNIVERSITY CONTRIBUTIONS TO CLIMATE COMPATIBLE DEVELOPMENT IN SOUTHERN AFRICA

Knowledge Co-Production Framework

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Note

This document is the result of an extensive mapping study to establish needs and existing institutional contributions to climate compatible development knowledge production (research, teaching and learning, community and policy outreach) in SADC countries, involving primarily the 62 universities that are part of the Southern African Regional Universities Association (SARUA). It is based on questionnaire data, document analysis and consultations with universities and stakeholders involved in climate compatible development knowledge production in 12 southern African countries. The study provides the first 'baseline' analysis of the role of universities in knowledge co-production for climate compatible development. It is accompanied by a substantial database.

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Southern African Regional Universities Association (SARUA)

PO Box 662

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SOUTH AFRICA

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SARUA is a not-for-profit leadership association of the heads of the public universities in the 15 countries of the SADC region. Its mission is to promote, strengthen and increase higher education, research and innovation through expanded inter-institutional collaboration and capacity-building initiatives throughout the region. It promotes universities as major contributors towards building knowledge economies, national and regional socio-economic and cultural development, and for the eradication of poverty.

The authors are responsible for the choice and the presentation of the facts contained in this document and for the opinions expressed therein, which are not necessarily those of SARUA and do not make any commitment for the Association.

The *Climate Change Counts* mapping study is the inception phase of the SARUA Programme for Climate Change Capacity Development. The mapping study was made possible through the professional, financial and in-kind support of multiple partners. The principal study sponsor was the Climate and Development Knowledge Network (CDKN).

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Foreword

Africa as a continent has been found by the Intergovernmental Panel on Climate Change (IPCC) to be one of the most vulnerable to climate change. The vulnerability of southern Africa to climate change is exacerbated by a range of multiple stressors that are related to poverty and other development concerns in the region. Climate change threatens to reverse development progress, unless concerted efforts are made to make development climate resilient.

This mapping study, which examines the role of higher education in contributing to climate resilient development pathways, is the first of its kind in southern Africa, and in Africa more widely. Since more holistic approaches to climate change and climate compatible development are relatively new knowledge production areas in southern African universities, this study, which brings together information from twelve southern African countries across a wide range of disciplines, is particularly valuable. The study has engaged with university professionals from a wide range of faculties – science, agriculture, law, education, humanities, architecture, engineering, and health, amongst others, to establish where and how climate compatible development research, teaching and outreach is already taking place, and where the gaps may be. Additionally, the perspectives of multiple stakeholders on knowledge needs and gaps in this area have been captured – from national stakeholders concerned with climate change and climate compatible development, to university professionals, to members of civil society and the private sector.

In essence, the SARUA climate change and development programme is designed to build the capacity of the region's universities to respond comprehensively and innovatively to the region's climate change challenges via research, teaching, community engagement and policy outreach contributions that will strengthen the region's capacity for climate resilient development in the future. To guide this process, the mapping study has identified four regional networks to be established, which include seven potential research-themed clusters (research network); a curriculum innovation network; a capacity building network and a policy engagement network. Such a framework would focus regional efforts to ensure collaboration takes place in a way that positions SADC's universities to take a leading role in confronting the region's climate change knowledge and policy challenges.

The climate change challenges facing the region cannot be resolved in isolation, nor by applying methodologies, perspectives and approaches of the past. This mapping study therefore provides a framework for transdisciplinary collaboration and knowledge co-production across research, teaching and learning and community engagement, and highlights the gaps to be addressed by policy makers across the region to enable universities to have a material impact on the region's future development path.

The mapping study findings inform the next phase of the SARUA climate change and development programme, which is to establish the identified networks. SARUA is proud to have initiated such an important programme, excited about the participation of regional stakeholders to date, and committed to successfully guiding the process of network establishment in order for SADC to be a global leader in setting the direction for climate resilient development at the regional level.

Piyushi Kotecha
CEO: SARUA
May 2014

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Acronyms

AAP	Africa Adaptation Programme
AAU	African Association of Universities
ACCESS	Applied Centre for Climate and Earth System Sciences in South Africa
ACDI	African Climate and Development Initiative (University of Cape Town, RSA)
ACPC	African Climate Policy Centre
ADEA	African Association for the Development of Education in Africa
AEON	Africa Environmental Observation Network
AFAR	African Futures Are Resilient
AFOLU	Agriculture, Forestry, and Other Land Uses
AFRITEIS	African Teacher Education Network on Education for Sustainable Development
AMCEN	African Ministerial Conference on Environment
AMESD	Africa Monitoring of the Environment for Sustainable Development
AU	African Union
AUC	African Union Commission
BCA	Botswana College of Agriculture
BID	Background Information Document
CC	Climate Change
CCAM	Conformal-Cubic Atmospheric Model
CCD	Climate Compatible Development
CC-DARE	Climate Change Adaptation and Development Initiative (UNEP)
CDKN	Climate and Development Knowledge Network
CDM	Clean Development Mechanism
CEO	Chief Executive Officer
CESSAF	Angola's Centre of Excellence for Sciences Applied to Sustainability (CESSAF)
CGCMs	Coupled Global Climate Models
CGIAR	Consultative Group on International Agricultural Research
CIFOR	Centre for International Forestry Research
COE	Centre of Excellence
COMESA	Common Market for Eastern and Southern Africa
CRM	Climate Risk Management
CSA	Climate-Smart Agriculture
CSAG	Climate Systems Analysis Group
CSIR	Council for Scientific and Industrial Research
CSRSE	Centre for Study in Renewable and Sustainable Energy (Botswana)
CTCN	Climate Technology Centre and Network
CTWG	Climate Change Inter-sectoral Technical Working Group
DfID	UK Department for International Development
DVC	Deputy Vice Chancellor
EAC	East African Community
EbA	Ecosystem-based Adaptation
EE	Environmental Education

EERG	Energy and Environment Research Group (Zambia)
EIA	Environmental impact assessment
ENDA	Environmental Development Action in the Third World
ERM	Environment and Resource Management
ESD	Education for Sustainable Development
FEWSNET	Famine Early Warning System
GEF	Global Environmental Facility
GHG	Greenhouse Gases
GIS	Geographical Information Systems
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HE	Higher Education
HEI	Higher Education Institution
HESA	Higher Education South Africa
HSRC	Human Sciences Research Council (South Africa)
ICSU	International Council for Science
IDRC	International Development Research Centre
IIAM	Institute of Agricultural Research of Mozambique
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
IPCC	Intergovernmental Panel on Climate Change
IRF	Independent Research Forum
ISSC	International Social Science Council
IUCN	International Union for the Conservation of Nature
LCBCCAP	Lake Chilwa Basin Climate Change Adaptation Programme
LDC	Least Developed Countries
LEAD SEA	Leadership for Environment and Development Southern and East Africa
LUANAR	Lilongwe University of Agriculture and Natural Resources
MDGs	Millennium Development Goals
MESA	Mainstreaming Environment and Sustainability in African Universities programme
MICOA	Ministry for the Coordination of Environmental Affairs (Mozambique)
MOOC	Massive Online Open Course
MSc	Masters in Science
NAMA	Nationally Appropriate Mitigation Action
NAPA	National Adaptation Programme of Action
NGO	Non-Governmental Organisation
ODI	Overseas Development Institute
ODL	Open and Distance Learning
OSF	Open Society Foundation
PAU	Pan African University
PAUWES	Pan African University Water and Energy Science Institute
PhD	Doctorate in Philosophy
R&D	Research and Development
R4D	Research for Development
RAEIN-Africa	Regional Agricultural and Environmental Initiatives Network – Africa
RCCP	Regional Climate Change Programme

REC	Regional Economic Community
REDD+	Reducing Emissions from Deforestation and forest Degradation
RISDP	Regional Indicative Strategic Development Plan
SA	South Africa
SADC	Southern African Development Community
SADC REEP	Southern African Development Community Regional Environmental Education Programme
SANEDI	South African Energy Development Institute
SARCHI	South African Research Chairs Initiative
SARUA	Southern African Regional Universities Association
SASSCAL	Southern African Science Service Centre for Climate Change and Adaptive Land Use
SD	Sustainable Development
SDGs	Sustainable Development Goals
SIDS	Small Island Developing States
SNC	Second National Communication (to the UNFCCC)
START	SysTem for Analysis, Research and Training
TVET	Technical Vocational Education and Training
UB	University of Botswana
UEM	Eduardo Mondlane University (Mozambique)
UNCSD	United Nations Conference on Sustainable Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Science and Cultural Organisation
UNFCCC	UN Framework Convention on Climate Change
UNISWA	University of Swaziland
UNZA	University of Zambia
WHO	World Health Organisation
WWF	World Wide Fund for Nature

Glossary of Terms

This glossary provides definitions for key terms involving research interaction and knowledge co-production. Section 1.3 of the main report (Volume 1) provides conceptual clarification of climate compatible development and related terms.

Defining a system of knowledge co-production requires clarifying the meaning of different forms of research interaction, as well as the typical institutional structuring of research capacity. In this mapping study we identified a range of different forms of interaction currently taking place amongst researchers, assisting also with the defining of where specific forms of expertise for climate change and CCD research are to be found (as shown in Appendix A), as well as how new research formations can be supported that expand existing research capabilities and research interactions. Table 1 below provides an overview of the definitions of these research interactions and formations, as found in this mapping study.

Table 1: Definitions of typical research interactions and collaborative formations supporting research

Definitions
<p>This Knowledge Co-Production Framework uses the following differentiations¹ when referring to research interactions and collaborative expertise-based research formations:</p> <ul style="list-style-type: none"> ■ Networking² – a process involving communication and information exchange among participants for mutual benefit. ■ Coordinated Networking – a process that in addition to communication and exchanging information, involves aligning / altering activities so that more efficient results are achieved. ■ Cooperation – a process that involves not only information exchange and adjustments of activities, but also sharing resources for achieving compatible goals. Cooperation is achieved by division of some labour (not extensive) among participants. ■ Collaboration – a process in which entities share information, resources and responsibilities to jointly plan, implement, and evaluate a programme of activities to achieve a common goal. ■ Collaborative network (organisation) – a collaborative network possessing some form of organisation in terms of structure of membership, activities, definition of roles of the participants, and following a set of governance principles and rules.

¹ These differentiations have been developed for use in this mapping study. They follow generally agreed upon definitions of similar concepts, and where exact definitions are sourced from other literature, these are referenced. Where definitions have been framed specifically for this study (drawing on wider meanings) these have not been referenced.

² Networking definitions adapted from Camarinha-Matos, L.M. and H. Afsarmanesh. 2012 (working draft). *Taxonomy of Collaborative Networks Forms*. In collaboration with SOCOLNET (Society of Collaborative Networks).

- **Knowledge network** – a knowledge network as used in this document refers to a group of professionals that are communicating and sharing knowledge and experience relevant to a particular core interest. A structure for communicating and sharing such knowledge and experience exists, but those participating do not do so permanently. Examples from the mapping study include the RAIEN network, MESA, EEASA etc.
- **Node of expertise** – a node of expertise as used in this document refers to a small group of researchers / individual researcher with a team of postgraduates specialising in a particular area of CCD research. The small group of researchers / individual researcher / research Chair with his/her team of postgraduates have an active research programme, which is most often linked to others at either national and/or international level. Participants in the node of expertise are contributing via research to policy and/or practice and are contributing to locally useful publications, with some internationally peer-reviewed publications.
- **Centre of expertise** – a centre of expertise as used in this document refers to a group of researchers working together under the title of a ‘centre’ or ‘unit’ with an explicit CCD research focus or with a strong research programmatic focus on climate change and CCD within a wider research framework. The Centre will typically have relatively strong national and international links, and often also offers training and capacity building programmes for stakeholders / in partnership with stakeholders, and also contributes to policy development. Such a centre also has peer-reviewed, recognised research outputs some of which are published in the international arena, and are also producing documents and/or publications that can be described as locally useful publications.
- **Centre of Excellence**³ – a Centre of Excellence as used in this document refers to a structure (either physical or virtual) that concentrates resources and existing capacity to enable researchers to collaborate, bringing together a team of highly skilled experts in a particular research area that are involved in research and innovation to advance the field. A CoE typically will have a specialist research area focus (e.g. invasion biology, epidemiology, WASH etc), and will involve a cluster of senior researchers (often in multi-disciplinary or inter-disciplinary formations) working together with national and international stakeholders and research partners. The CoE is typically not dependent on one or two individuals but is rather characterised by a ‘critical mass’ of researchers who are associated with and who contribute to the CoE’s core objectives. CoEs can typically also engage in long-term projects that are locally relevant and internationally competitive in order to enhance research excellence and capacity development. In a Southern African CCD research context, this mapping study has found that SADC supports CoEs, NEPAD is supporting Water CoEs, and the South African Department of Science and Technology are supporting CoEs. Other support for CoEs was also found to exist. CoEs typically have recognition at an international level as a Centre of Excellence – they tend to have well-defined research programmes, substantive research budgets, and larger numbers of PhD and Masters scholars, and also have expanded supervision capacity (e.g. ACCESS).
- **Research Cluster** – a Research Cluster is often a grouping of like-minded individuals or entities who work on a particular research theme in a way in which synergies are developed and shared. Members of a cluster each have their own networks, but those network members are not necessarily part of the research cluster.

³ The generally accepted meaning for Centre of Excellence, as reflected in a variety of Centres of Excellence that exist in the SADC region has been used here with examples drawn from SADC Centres of Excellence, NEPAD Centres of Excellence, and the South African Department of Science and Technology Centres of Excellence. This has helped to conceptualised the meaning of Centres of Excellence as used in this document.

Key concepts used in this mapping study

Climate compatible development (CCD) is low carbon, climate resilient development. As explained in Mitchell and Maxwell (2010), “Climate compatible development goes one step further by asking policy makers to consider ‘triple win’ strategies that result in low emissions, build resilience and promote development simultaneously”.⁴ In the southern African context, poverty reduction, as an integral component and goal of regional and national development strategies, would be a desired co-benefit. While CCD is the central concept used in the work that is funded by CDKN, as was this mapping study, it is important that this is understood alongside the concept of climate-resilient development pathways as defined by the Intergovernmental Panel on Climate Change (IPCC) and the wider concept of sustainable development. According to the IPCC, “**Climate-resilient pathways** are development trajectories that combine adaptation and mitigation to realise the goal of sustainable development. They can be seen as iterative, continually evolving processes for managing change within complex systems.”⁵ The concept of CCD highlights the necessity of integrating current and future climate risks into development planning and practice, in the ongoing goal of achieving sustainable development, and the need for ‘strong sustainability’⁶, in which society, economy and environment are seen as interacting in an inter-related, nested system. [See section 1.2 for a more detailed discussion on this term].

Multidisciplinarity as used in this document involves using different disciplinary studies to address a common empirical focus or problem, without changes to existing methodologies or disciplinary approaches.

Interdisciplinarity marks a position between multi- and transdisciplinarity. It involves multidisciplinary studies, but takes this further by synthesis work that takes place across the different disciplines. It often involves development of a common research framework.

Transdisciplinarity entails using strategies from interdisciplinary research, but takes this further into development of new theoretical understanding and new forms of praxis that are needed across sectors and at different scales. These are based on an inter-penetration of disciplinary perspectives and understandings, and a ‘creative re-deployment’ of these into contexts of practice. Distinctions can also be made between ‘weak transdisciplinarity’ which only relates knowledge to practice, and ‘strong transdisciplinarity’ which goes more deeply

⁴ Mitchell, T. and S. Maxwell. 2010. *Defining climate compatible development*. CDKN Policy Brief, November 2010. Accessed on 14 April 2014. <http://r4d.dfid.gov.uk/PDF/Outputs/CDKN/CDKN-CCD-DIGI-MASTER-19NOV.pdf>

⁵ IPCC Fifth Assessment Report: Impacts, Vulnerability and Adaptation. Technical Summary, draft October 2013.

⁶ Neumeyer, E. 2003. *Weak Versus Strong Sustainability. Exploring the limits of two opposing paradigms*. Massachusetts: Edward Elgar Publishing Ltd.

into developing new and more complex ways of understanding and engagement where new forms of theory and practice come together across sectors and at different scales.

Knowledge co-production often involves multi-, inter- and transdisciplinary research approaches, and wider forms of societal involvement in research than would be the norm in disciplinary research practices. Knowledge co-production is also referred to as knowledge co-creation. This requires bringing different contributions together in relation to each other in the knowledge production process. [See section 1.3.]

Nodes of expertise as used in this document refers to ‘clusters of expertise’ related to a specific climate change or CCD-related research area, involving at least one high-performing academic with postgraduate scholars.

Centres of Expertise refers to already established research centres or institutes, most often operating at university level, or between a number of universities with networked partnership links (these may be national or international).

A **Centre of Excellence** as used in this study refers to a multi-institutional partnership framework that addresses a key CCD research area involving multiple universities, and formalised national and international partnerships.

A **research network** refers to interest-based research groupings that convene regularly to discuss or debate research concerns. [See section 4 (Table 5).]

Executive Summary

Mapping study overview and climate change context

This Southern African Regional University Association (SARUA) document provides a **Knowledge Co-Production Framework** for climate compatible development in southern Africa. The Knowledge Co-Production Framework seeks to inform regional collaboration, and to provide a starting point for the SARUA five programme on climate change and development. It is based on a **mapping study**⁷ that involved a **needs analysis** and an **institutional assessment**, focused on the higher education sector and undertaken on a country-by-country basis, which is synthesised in Appendix A, and more fully represented in **12 Country Reports**, published as a companion monograph (Volume 2) to this Knowledge Co-Production Framework (Volume 1).

- **Section 1** of the document outlines the SARUA Climate Change Capacity Development Programme and introduces the key concepts used in this document.
- **Section 2** of the document provides a regional synthesis of the country-by-country Needs Analysis.
- **Section 3** of the document provides a regional synthesis of the country-by-country Institutional Analysis.
- **Section 4** provides strategic direction for knowledge co-production for climate compatible development in southern Africa, in the areas of research, curriculum development and teaching, policy and community outreach.
- **Section 5** provides a short 'road map' pointing to the most important 'next steps' for the SARUA programme on climate change and development.

Climate change and climate compatible development are relatively new knowledge production areas in southern African universities. This mapping study is the first of its kind in southern Africa, with a focus on universities and higher education institutions. It brings together information from twelve southern African countries across a multiplicity of disciplines. It further combines the perspectives of national stakeholders concerned with climate change and climate compatible development, and university professionals, many of whom were gathered in the same forum for the first time during the mapping study workshops in participating countries. It provides insight into the contextual and institutional challenges facing southern African universities and countries as they confront the emerging and projected impacts of climate change, on a continent that has been found by the Intergovernmental Panel on Climate Change (IPCC) to be one of the most vulnerable to climate change.⁸ The

⁷ The mapping study was conducted between December 2012 and January 2014 and involved the following twelve SADC countries: Angola, Botswana, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe.

⁸ Boko, M., I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo and P. Yanda. 2007. "Africa" in *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, edited by M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, 433-467. Cambridge UK: Cambridge University Press.

vulnerability of southern Africa to climate change is exacerbated by a range of multiple stressors that are related to poverty and other development concerns in the region.

The mapping study has occurred within a year in which the urgency for action on climate change has been further emphasised. A number of recent analyses have highlighted that the current window of opportunity for action to keep the global temperature increase to 2°C, or preferably lower (1.5°C), below pre-industrial levels, and to build resilience to current climate variability and projected changes, is rapidly closing. The Africa Adaptation Gap Report, launched on 17 October 2013, confirms that Africa faces huge financial challenges in adapting to climate change. It outlines the costs faced by the continent if governments fail to close the “emissions gap” between current 2020 emissions reduction pledges and what is needed to keep warming below 2°C. The study assigns a 40 percent chance that we will inhabit a ‘4°C World’ by 2100, if mitigation efforts are not stepped up from current levels. This is confirmed by the recently completed IPCC Fifth Assessment Working Group I Report. Due to present and committed climate change caused by past emissions, Africa will already experience adaptation costs in the range of USD 7-15bn per year by 2020. These costs will rise rapidly after 2020, since higher levels of warming result in higher costs and damages.⁹

Within this context of urgency of action, this Knowledge Co-Production Framework forms the basis for the realisation of the longer term objectives of the **five-year SARUA programme on climate change and development** outlined below, and various country-based partnership agreements. It provides a ‘knowledge base’ for regional and country-based fundraising for research and knowledge co-production. As such the framework seeks to benefit universities themselves, while also strengthening regional interaction and co-operation.

The SARUA Climate Change Capacity Development Programme

Overall, the vision of the SARUA Climate Change Capacity Development Programme is to create a system of knowledge co-production that provides southern African researchers with opportunities for capacity building and relevant, high quality knowledge production on climate compatible development. The programme aims to significantly enhance the climate adaptive capacity and resilience of the SADC region through the development of a collaborative network of higher education institutions capable of pooling resources, maximising the value of its intellectual capital and attracting significant investment into the region. This will involve step changes in:

- Research, teaching and knowledge generation on climate change, adaptation measures, low carbon development options and the associated costs and benefits;
- The dissemination of information and knowledge amongst all stakeholders;
- Sensitising communities, governments and the private sector about the risks of climate variability for development prospects in the region;

⁹ “Gaborone Declaration.” 2003. Accessed November 27, http://www.unep.org/roa/Portals/137/Gaborone_declaration.pdf.

- Regional evidence-based policy development and implementation; and
- Regional capacity for active participation in international policy networks.


The initial five-year plan as outlined in the *SARUA Programme for Climate Change Capacity Development across the SADC Higher Education Sector* final programme document identified two phases:

- **Phase 1:** an initial 18-month phase with a strong emphasis on relationship and network building as well as scoping of key issues and themes. The mapping of stakeholder needs and institutional capacity is the cornerstone of this phase, as a basis for the development of future investment frameworks for research, teaching and knowledge development. The objectives of the phase were defined as six collaborative networks established, each with some coordinating capacity and a vision of growth. The analysis that flows from this initial network development will then highlight key areas for network development in the second phase of the programme
- **Phase 2:** a 42-month phase of developing and strengthening the networks according to one or a combination of three scenarios developed. As pointed out in the programme document, a number of factors will influence the exact shape, scope and duration of Phase 2 and a primary one is the results of the mapping study as set out in this document.

The table below provides an adjusted and provisional picture of the overall programme and its two phases, and the next step is for stakeholders and institutions to assess this against the findings, finalise the network design and set out annual targets for the programme.

Table 2: High-level view of the SARUA climate change programme

Planned activities per year				
Phase 1	Phase 2	Phase 3		
Year 1	Year 2	Year 3	Year 4	Year 5 and onwards
<ul style="list-style-type: none"> ■ Conduct an extensive mapping study of current priorities and capabilities of countries in the region. 	<ul style="list-style-type: none"> ■ Engage stakeholders and commence with a network development approach aimed at implementing the revised network model. 	<ul style="list-style-type: none"> ■ Fund and set up the first networks. ■ Demonstrate early outcomes in research, teaching and learning and knowledge. ■ Fund and set up additional networks. 	<ul style="list-style-type: none"> ■ Continue with network capacity building and support. ■ Develop and strengthen knowledge base and regional database of expertise. 	<ul style="list-style-type: none"> ■ Continue with network capacity building and support. ■ Develop and strengthen knowledge base and regional database of expertise. ■ Evaluate and report on outcomes.


KCPF Publication

Methodology used to construct the mapping study

The scope of climate compatible development (CCD) is necessarily wide and cross-sectorial. Consequently, the **Knowledge Co-Production Framework**, which is derived from the needs analysis and institutional analysis across the 12 SADC countries, does not focus on sectoral policy and institutions. It concentrates on overarching policy and knowledge co-production areas or themes that deal with mainstreaming climate change into knowledge production systems, planning and development (see section 4).

The mapping study was **multidisciplinary**, involving active climate change researchers from a range of disciplines including but not limited to the Natural and Environmental Sciences, Agriculture, Engineering, Law, Education, Psychology, Sociology, Gender Studies, Development Studies, Economics and others. It was also **multi-voiced** – involving policy makers; national and regional stakeholders such as government department officials, UNFCCC¹⁰ country co-ordinators, organised business, national research organisations, major national non-governmental organisations and community representatives; and university managers, staff and students.

The mapping study involved 12 of 15 countries in the SADC region, and in these countries, 57 of the 62 universities that are affiliated to the Southern African Regional Universities Association (SARUA) as at the end of 2013. In some countries, universities not yet fully affiliated with SARUA also participated in the study. In each of the 12 countries participating in the mapping study, the following **methodology** was followed (more details can be found in Appendix B):

1. An analysis of national stakeholders and university researchers involved in CCD policy, practice and research in each of the 12 participating countries was undertaken.
2. Two questionnaires, one for university professionals (Appendix C) and one for stakeholders (Appendix D) were distributed to all national stakeholders and universities identified.
3. Background document research was undertaken to establish existing knowledge of CCD policy, knowledge and research needs, and institutional arrangements. This was consolidated into a 'Background Information Document' (BID) on a country-by-country basis and distributed to all national stakeholders and university researchers prior to a country workshop, along with information about the SARUA Climate Change Counts mapping study.
4. All national stakeholders and university researchers identified were invited to a national workshop which was co-hosted by SARUA universities in most countries.
5. Detailed workshop reports were produced and circulated to all workshop participants for verification following the workshop.

¹⁰ United Nations Framework Convention on Climate Change

6. All national stakeholders and university researchers identified were sent reminders to complete questionnaires.
7. The Background Information Document (document analysis), together with questionnaire data received and workshop reports, complemented by additional desktop research where necessary, was used to compile the mapping study.
8. Mapping study reports were produced for each country, which provide background material and further detail to extend the summaries contained in Appendix A. These are potentially useful for supporting country-level climate change and CCD research and for developing knowledge co-production pathways. (As mentioned above, these are contained in an accompanying Monograph, Volume 2.)

All the above have informed the development of this Knowledge Co-Production Framework.

There were also limitations to the mapping study. Most significantly, the mapping study was constrained by a) a lack of baseline data on knowledge and research gaps for climate compatible development and university-based responses in all of the twelve countries involved in the mapping study, and b) by time and resource constraints that did not allow for **in-depth field visitation, individual interviewing or observation** before, during and after the consultation process. Moreover, the information generated at the country workshops relates to the number of participants, their expertise and the number of different sectors and institutions that were present. Further, while every effort was made to obtain questionnaire responses from as wide a range of stakeholders as possible – in total 1 660 individuals were contacted during the course of this study to provide inputs in some way – and follow-ups were made post-workshop to enhance this, the range of questionnaire responses obtained does provide certain limitations to the data set. However, the **best available information was carefully consolidated, reviewed and verified** in the construction of this Knowledge Co-Production Framework. Overall, the mapping study was further constrained by a budget cut imposed mid-way through the study, which impacted on the workshop approach, reduced the depth of analysis possible for some countries, and required in-kind sponsorship as a precondition to hold in-country workshops. While this was achieved, workshop participation was constrained by the fact that no sponsorship for local travel or accommodation was available.

This regional Knowledge Co-Production Framework, based on the mapping study, can therefore be viewed as a useful 'initial document'. It is hoped that universities and Ministries of Higher Education in southern African countries can take this analysis forward in ongoing mapping and planning and evaluative review activities related to CCD research and knowledge co-production.

Needs Analysis: Key findings and implications for the Knowledge Co-Production Framework

The needs analysis identified knowledge and research needs, and institutional and individual capacity gaps relevant to climate change and climate compatible development in 12 SADC countries (summarised in section 2 of the Volume 1 report, with further detail in Appendix A, and in the individual Country Reports presented in Volume 2).

The **key findings of the needs analysis** are as follows:

- ***Despite different contexts, there is a commonality between countries on broad findings.*** Despite progress on policy development and implementation of climate change initiatives in all countries in the region, as well as some attention to identifying related research and capacity needs, the status of CCD knowledge and research and both individual and institutional capacities will need to be enhanced significantly in all countries, in both specific and cross-cutting ways, to address the considerable observed and projected climate impacts. [2.3.1]¹¹
- ***Diverse regional understandings of CCD are strongly linked with adaptation and mitigation and sustainable development.*** While understandings of CCD differ amongst and between stakeholders and university staff involved in the field, there is generally a close conceptual association between climate compatible development and adaptation and mitigation, and climate compatible development and sustainable development. [2.3.1] While across all countries the concept of CCD was felt to be broadly appropriate for the region, the mapping study found that *all three data sources support skewing the emphasis more towards adaptation*. This clearly relates to the developmental status of the region and the low GHG emissions of most countries. Most national policy documents do prioritise both adaptation and mitigation actions, with some framing this as resilient and low carbon development. However, a general framing is that adaptation should be the main priority in the country's development goals, while at the same time embracing any developmental opportunities of cleaner energy and other low carbon technologies. [2.3.1]
- ***There are a range of broad priority areas for addressing climate change.*** The broad priority areas for addressing climate change reflect to a large degree the region's high dependency on natural resources, but also include cross-cutting priorities and those concerned with energy, infrastructure and industry. Common cross-cutting broad priority areas were education, capacity development, policy and institutional strengthening, integrating adaptation and disaster risk reduction, governance, participation and empowerment. There appears to be inadequate consideration of the need to adapt economies and industry to the projected climate change impacts. [2.3.1]
- ***Institutional capacity and support for CCD research and development are significant needs.*** A broad commonality identified in all countries is that out of the numerous and complex knowledge, research and capacity needs expressed by stakeholders and university staff, as well as to some degree in policy documents, the lack of national institutional capacity for climate change, including a lack of support for CCD research and development, are arguably the most significant needs. This highlights the appropriateness of the SARUA mapping study and proposed regional research support programme. [2.3.1]
- ***Knowledge needs are diverse and yet also systemic.*** The scope of the specific knowledge needs identified across the 12 countries reflects a range of disciplines,

¹¹ Numbers in square brackets refer to the sections in the main Volume 1 report in which greater detail on these key findings can be found.

spanning the physical, natural, social, agricultural, educational, engineering, health and economic sciences. This highlights the need for a more systemic response to developing capacity for climate change-oriented research across the range of sectors and institutions. Within the higher education institutions (HEIs), it emphasises the urgent need for mainstreaming climate change into under- and postgraduate curricula across faculties and departments, firstly to create the awareness of the knowledge (and research) gaps, and then to develop research interest and capacity in filling these knowledge gaps. [2.3.2]

- ***In general, knowledge needs identified tended to follow the broader CCD priorities expressed.*** There was, however, greater specificity and divergence between countries, showing the importance of a contextualised approach for identifying specific areas that would require additional research to fill the knowledge gaps. All countries tended to identify a range of knowledge gaps within the agriculture, food security, natural resources management, health and energy priority areas; many of the knowledge gaps related to the lack of systematic and reliable long-term data in different sectors to serve as baselines for research, modelling and monitoring. Stakeholders from different sectors in many countries identified the need for *systemic, integrated perspectives* on global change and climate compatible development concerns at multiple scales and levels. [2.3.2]
- ***Gaps necessitate transcending disciplinary boundaries.*** Despite the articulation of a wide range of disciplinary needs, data from the workshops and questionnaires in many of the countries showed a strong understanding of the need for CCD and of the gaps in the national response that went beyond the disciplines of participants or the mandates of their institutions. [2.3.2]
- ***Research capacity gaps are largely correlated with knowledge needs.*** The research gaps identified in the mapping study largely followed the knowledge needs, and thus were related to the broad priority areas for action identified, but also contained greater specificity and nuance, related to the contextualised knowledge needs, and to the level of capacity for climate change research in the country. A regional commonality was the *significant need for fundamental research on vulnerability and impact assessment across a range of sectors and at different levels*, highlighting inadequacies in these understandings that would need to be addressed in order to develop adaptation strategies and enabling environments for these to be implemented. While priorities for action on climate change were not necessarily aligned along disciplinary or institutional mandates in most countries, the workshops in particular highlighted the *value of engaging specialists across the spectrum in needs analysis*, as they provided a more complete and nuanced description for knowledge and research needs relating to key priority areas than did most of the national policy documents. While this may seem to be a self-evident point, the national policy documents and strategies on the whole do not indicate any detailed specialist engagement in the articulation of knowledge and research gaps, with the exception usually of the frequently cited knowledge and research gaps on climate data. In particular, the workshops were able to highlight some of the *important social research needs such as cultural change, gender and climate change, and community participation in climate change and CCD, which were not always as well articulated in national climate change policy and strategy.* [2.3.3]

- ***There is regional similarity in cross-cutting knowledge and research needs.*** Across the 12 SADC countries included in the mapping study, there was wide agreement on the most important cross-cutting knowledge and research needs for responding better to climate change and implementing CCD. This was striking, given the vastly differing contexts of the countries, but does highlight the potential importance of an integrated regional strategy to address these fundamental needs. These largely relate to information, data and education-related knowledge and research gaps. They include inadequate baseline information (on the subject under study, usually on ecological and/or social conditions), lack of long-term data and time series data (on the subject under study, usually on ecological and/or social conditions), inadequate climate projections and weather prediction, the need to digitise data that does exist, and lack of a national climate change database to house climate-related information across the range of sectors and disciplines. The need for research to identify innovative and creative approaches to enhance national and regional responses to climate change was also widely mentioned. [2.3.4]
- ***Contextualisation and localisation of climate change research is important.*** The mapping study shows that CCD has contextual meanings that are diversely framed, based on different practice and spatial contexts. This finding was most clearly identified in the workshop and questionnaire response data, in which the need for contextualisation and localisation of climate change solutions pointed to the need for targeted and localised research. [2.3.5]
- ***It is important to understand and value indigenous knowledge systems for resilience.*** A cross-cutting knowledge and research gap highlighted was the lack of valuing, studying and understanding local and indigenous knowledge, and the need for more research to understand its potential contribution to adaptation and mitigation. This would also be important for developing integrated adaptation-mitigation approaches, although this was not often specified, given that a number of uses of indigenous knowledge, for example in community forest management or conservation agriculture approaches, have the potential to advance practical integrated adaptation-mitigation approaches. The Tanzania data, for example, highlighted the need to understand the potential role of indigenous knowledge in climate proofing agriculture and food security; while in Malawi this key research gap was framed as the need for capacity to document and evaluate the relevance of indigenous knowledge in relation to western scientific knowledge and to work with both knowledge systems. [2.3.6]
- ***Individual capacity gaps require a system-wide response.*** The mapping study has found that individual capacity gaps for responding to climate change across the region are multidisciplinary and multi-sectoral. Given that relevant individual capacity gaps are to be found in many disciplines and across the range of sectors, this will require a wide ranging, or system-wide response. Workshop and questionnaire data from most countries, and some policy documents, highlighted that there is in general limited research capacity and expertise across the sectors on climate change within the countries. In some cases, this research capacity on climate change, speaking broadly, simply does not exist, while in others it is a question of an insufficient level of contemporary, up-to-date knowledge in certain specialised areas. National-level identification of individual capacity gaps extended across a wide range of sectors and disciplines, highlighting *needs in three main groupings: discipline-specific skills, what may be termed more cross-cutting skills, and new skills sets for integrative thinking*

that will need to be developed. In addition to a wide range of discipline-related skills, developing skills for more integrated approaches, negotiation capacities and social exchange capacities were highlighted. Critical thinking skills and skills for responding to change and uncertainty were also mentioned variously across countries. [2.3.7]

- ***There is a mismatch between skills supply and demand, and a need for integrative skills.*** Individual capacity gaps and institutional capacity gaps contribute to the situation in most countries in which there is a mismatch between the skills of graduates and the market demands – this is a general shortcoming, not restricted to responding to climate change, but the complexity and knowledge intensity of CCD requirements will exacerbate this situation. One example, across a range of scientific disciplines, was that graduates are not being provided with the necessary practical skills. This is related to the limited and declining facilities for practical training, such as laboratories, and funding for field work, as well as inadequate student internship opportunities and service learning programmes. This relates to the availability of funding for higher education, and is a broad and complex issue. Concerning the need for more integrative skills, mentioned above, a critical overarching shortfall is the lack of a coherent approach to tackle the climate change challenge in the development context. There is a need for cross-scale, integral systems thinking and enhanced capacity for dealing with complexity. [2.3.8]
- ***Research and capacity development to engender social change is important.*** Some research gaps identified pointed to the need to understand what would engender the necessary transformations to move societies and economies to a resilient and low carbon development pathway. In Mauritius, these included the commonly cited need to change mind-sets, including a sense of stewardship towards the environment, which would engender social and behavioural change. Regionally, climate change research and practical initiatives have in the past tended to focus on more technological approaches, but this is now shifting to a greater emphasis on participatory social learning and more process-oriented approaches to complement and strengthen technological interventions, as is now apparent in the peer-reviewed literature. This points additionally to the need for more social-ecological systems research linked to ecosystem services approaches to research. These more integrative research approaches were not widely practised, as researchers tended to work in disciplinary silos. While workshop and questionnaire data from all countries highlighted the need, to greater or lesser degrees, for social and behavioural change as a necessary condition for CCD, this was not frequently explicitly captured in policy. This links with the need to design CCD research so that it addresses the needs of poor and marginalised communities, commonly mentioned in the country workshops. [2.3.9]
- ***Significant institutional capacity gaps require a concerted response.*** The mapping study shows wide ranging institutional capacity gaps that act as barriers to responding to climate change and CCD in the region, with a great deal of commonality between countries, despite differing contexts and stages of response to climate change. Some of these reflect fundamental institutional and governance shortcomings, not specific to climate change and CCD. A common theme from all countries was that existing mechanisms and capacity are insufficient to deal with the complex and diverse climate issues, which will require a strategic, coordinated and harmonised approach to increase the effectiveness of actions. Many constraints related to a *widespread lack of*

coordination and holistic approach. Knowledge management emerges as a significant institutional capacity gap. As highlighted in the Botswana data (amongst others), the need for information sharing, collaboration and integrated approaches to environmental management and climate change point also to the fragmented nature of the current institutions, and the insufficient communication and knowledge sharing needed to prepare the country for CCD research and development. Most countries cited the limited knowledge and research on what types of CCD responses exist in the country, calling for the need for a database / informational management system that would collate inter alia research on different aspects of climate change and CCD, and climate change implementation projects and programmes. While countries are at different levels with respect to policy coherence on climate change, *even those with relatively advanced policy and legislative frameworks highlighted the need for better coherence and coordination in practice. A more coherent and supportive research framework, with enhanced funding* to enable all forms of research on climate change is also needed. Zimbabwe data pointed to the need for a *holistic approach towards consolidating interdisciplinary research outcomes* across different disciplines. The mapping study data sources across all the countries consistently highlighted the *need for improved financial resources to build capacity, carry out research and implement adaptation and mitigation measures*. The Malawi data highlighted the limited funding for longer term climate change research and programmes, which created further barriers to CCD implementation, as most funding cycles were short term, leading to a project-based approach to dealing with CCD instead of a longer term, more sustainable approach. This problem was identified in most other countries that rely heavily on donor funded interventions to resource CCD research and development. [2.3.10]

- ***There is a cyclical relationship between individual and institutional capacity gaps.*** A knock-on effect can be detected between individual and institutional capacity gaps, with institutions not carrying enough funding to make climate-related jobs attractive to professionals, which in turn keeps the institutions weak and incapacitated. This then results in inadequate research agendas being set, with the consequence of reduced overall quality of climate change and CCD-related knowledge in almost all countries. An integrated approach to knowledge, research, individual and institutional capacity development is needed, where improved resourcing, and more active and attentive government and legislative support is needed. From this, appropriate research agendas and curriculum development can be developed, further feeding and nourishing the wider climate change and CCD-related research community in southern Africa, ultimately benefitting communities who are facing the severe impacts and implications of climate change. [2.3.11]

Some key implications for the Knowledge Co-Production Framework arising from the needs analysis are the following:

The identified regional needs call for a strategic and integrated approach.

As previously noted, CCD not only recognises the importance of both adaptation and mitigation in new development pathways, but necessitates considering multiple benefit and cross-cutting strategies that build resilience, promote development and result in low emissions simultaneously.¹² The mapping study has revealed the relevance of this approach, with certain caveats and recognising the different perspectives on what CCD could and should constitute at country level, but also regionally. While the study has revealed contextualised knowledge, research and capacity needs, the divergences between countries are, in general, fewer than the similarities. For example, all countries, with the possible exception of South Africa, due in all probability to its several related centres of excellence, highlighted the need for greater localisation of climate projections, models, research on impacts, and application of relevant technology. The wide-ranging nature of the knowledge, research and capacity needs, together with the high level of commonality across countries, calls for *a strategic and integrated approach to capacity development*. A regional approach to this can provide an efficient modality for building capacity for CCD knowledge co-production (see sections 4 and 5 for recommendations in this regard).

Likewise, the analysis of capacity needs outlined above also shows that while there is a need to integrate climate change and CCD into a variety of disciplines to produce the specific knowledge necessary, CCD capacity must *also* be developed cross-sectorially; and should involve multiple stakeholders at all levels of society. The needs analysis also shows that much wider enabling competencies are needed besides those competencies related to the priority thematic areas for CCD, such as agricultural adaptation knowledge, or water management knowledge. Such wider enabling competencies include new financial management skills, new policy formation and networking skills, leadership and ethical competencies, as well as knowledge dissemination competences.

This need for strategic and integrated approaches reveals the need for multi-, inter- and transdisciplinary approaches to research and knowledge co-production, as integrated approaches cannot be developed via silo-based approaches to research only. This does not mean that the individual disciplinary contributions to CCD knowledge are not necessary or valued, but that there is an *additional need* for a broader range of approaches to research and knowledge co-production, as introduced in section 1 above, and discussed in more detail in sections 3, 4 and 5 of volume 1. [2.4.1]

Capacity building is required for providers of CCD education, training and capacity development.

Very little mention is made in policy documents of capacity building for those who are to offer all of these intended education, training and capacity building programmes to address the

¹² Mitchell, T and Maxwell, S. 2010. "Defining climate compatible development." Policy Brief. CDKN. Accessed on 14 April 2014. <http://r4d.dfid.gov.uk/PDF/Outputs/CDKN/CDKN-CCD-DIGI-MASTER-19NOV.pdf>

individual and group-based capacity needs, although this point was raised in the workshops. The SADC Regional Environmental Education Programme (SADC REEP) regional capacity assessment¹³ emphasised the need to give attention to the capacity building of research, environmental education and training professionals at all levels (in universities and higher education institutions, in technical and vocational education and training (TVET) colleges, in NGOs and CBOs, and in government extension units) if southern African countries are to address their research and capacity development needs, as articulated in the needs analysis undertaken for this mapping study. Little is said in any of the policy or strategy documents, or even in national research plans where these exist, about research methodology and research training, yet this is core to the development of new approaches to CCD research and knowledge co-production. It remains a key need in southern African universities, where research methodology training (with few exceptions) tends to be somewhat traditional, whilst CCD research requires new forms of methodology and research training.

Institutional Analysis: Key findings and implications for the Knowledge Co-Production Framework

The **institutional analysis** identified existing research, teaching and community and policy outreach activities that are associated with climate compatible development in SADC universities. It identified research networks, nodes of expertise, existing centres of expertise and centres of excellence for climate change and climate compatible development knowledge co-production (summarised in section 3 of the Volume 1 report, with further detail in Appendix A and in the individual Country Reports in Volume 2). The institutional analysis also reviewed the current institutional context of CCD at a SADC level, and the role of universities in development. Additionally it highlighted a number of institutional aspects that influence the possibilities for CCD knowledge co-production related especially to research, curriculum innovation, and university policy and community outreach.

Key findings of the Institutional Analysis are as follows:

Institutional context

- ***Institutional context and/or disciplinary emphasis influences understanding of CCD.*** As indicated in the needs analysis, there was an agreed upon broad understanding of CCD. While this general agreement existed, it was found that in many cases, stakeholders and university professionals tended to interpret CCD *in relation to their sectoral, institutional and/or disciplinary interests*, and in many cases, they also *interpreted CCD at the level of how climate change would affect their enterprises, institutions or sectors, or key constituents* often not carrying through to conceptualisation of new development paths and alternatives. For many who attended the workshops, it was also the ‘first time’ they had considered the full meaning of the concept of CCD, showing that it is an important concept to develop further through

¹³ M. Mukute, T. Marange, C. Masara, H. Sisitka, and T. Pesanayi. 2012. *Future Capacity Building: Capacity Assessment for Environmental Policy Implementation*. Howick: SADC REEP.

ongoing engagement within and between institutions. [3.3.2] As one of the workshop participants in Mozambique put it:

“CCD also requires epistemological change and a new way of thinking about knowledge in universities and in society.”

- **Universities have an important role to play at the CCD science-policy-practice interface.** The mapping study consultations showed equal concern for how science can and should influence policy; and how science can and should and influence practice. The SARUA mapping study showed that the relationships between science and policy, and science and practice *both need attention*. There was also much concern that while good policies are being developed for CCD at country level, these are not translated into practice, and that they lacked synergy and inter-sectoral coherence and integration. [3.2.3]
- **Universities are currently strong contributors to policy knowledge.** The mapping study found that research *is* informing climate change policy making in all countries. In all the southern African countries, leading researchers at universities have contributed *significantly* to documents like climate policies and strategies where these exist, and the First or Second National Communications to the UNFCCC, although this research was not widely published, except in ‘grey literature’ form. Thus it seems that for these national policy processes, governments are drawing on national researchers in universities, and assisting them, via this process, to re-orient their research interests and trajectories towards CCD, in the process also developing the national scientific base for CCD research. This in turn has curriculum innovation and other effects (see below). [3.2.4]

Research institution building and co-ordination

- **Several research institution building and co-ordination [3.2.5] issues were raised.** These include the need to recognise that there are multiple types of research institutions actively producing CCD knowledge including international organisations and donors, NGOs, research consultants, and independent / parastatal research councils and institutes, in addition to universities, making research partnerships between universities and other research partners possible. [3.2.5.1]
- **Research policy and national infrastructure is needed for CCD research.** Most CCD policies are emphasising research and knowledge generation as a key aspect of CCD responsiveness, yet national Research and Development (R&D) policies and practices were mostly not reflecting this in terms of real commitment to sustained climate change and CCD research programmes and funding. [3.2.5.2]
- **Research co-ordination, data sharing and knowledge management were identified as a key concern for CCD research.** In a few countries, specific **new structures** were being set up to facilitate research co-ordination and knowledge management, as in Mozambique where a Climate Change Knowledge Centre is being established by government, and in Namibia, whose policy also included plans for a Climate Change Research Centre. However, while the issue of knowledge management was raised over and over, there were very few suggestions as to what this entailed and/or how this was to be done. There was, however, a broad understanding that this required research planning, research leadership, and research infrastructure, as well as

communication and outreach functions, and appropriate ICT systems, hardware and software, and skilled operators of these systems. [3.2.5.3]

- ***New institutions for CCD research and knowledge co-production, mainly in the form of Centres are emerging and have an important role to play.*** In some cases these were being conceptualised as national facilities (as in Mozambique and South Africa¹⁴) to which universities contribute, and in other cases they were being established in universities as partnerships with international organisations, and/or by universities themselves.¹⁵ These centres allow for the development of *specialised expertise*, and also allow for development of a *critical mass of scientists and other expertise*, and appear to be an important element of building the knowledge base necessary for dealing with critical concerns such as CCD and sustainable development more broadly. In most cases these Centres are relatively new. [3.2.5.4]
- ***Centres of Excellence, Centres of Expertise and Nodes of Expertise for CCD exist in almost all SADC countries.*** These are an invaluable resource for CCD knowledge co-production.¹⁶ Some of these are still in their infancy and require capacity building. These are important centres of innovation for CCD research, and efforts should be made to link these to various centres of expertise and nodes of expertise to facilitate a more dynamic research environment. [3.2.5.5]
- ***Few countries have well-developed research systems and incentives that provide an enabling environment for university-based CCD research.*** Research funding was repeatedly noted as a critical limiting factor. Where research funding was available, as in South Africa, it was cited being insufficient for the type and scale of research that is needed. The timescale of research funding was also highlighted, as research funding tended to be released in three-year cycles, which again was seen to be inadequate for the scope, type and scale of research that is required. National research policy that incentivises researchers to publish in international journals can have a significant impact on research output. Such incentives were said to be absent or negligible in most countries. This shows that CCD research cannot be de-linked from wider institutional research policies and practices. [3.2.5.6]

Research capacity building

- ***CCD research capacity building and strengthened platforms for research innovation are needed.*** [3.2.6] CCD introduces new research approaches, methodologies and challenges. CCD research is both disciplinary, involving the introduction of new approaches to research within virtually all existing disciplines. Added to this is the challenge of introducing inter- and transdisciplinary approaches to research. There were few examples of inter- and transdisciplinary research ‘on the ground’. In general, this type of research is not widely practised, and could be said to be in its infancy in all

¹⁴ In South Africa the National Climate Change Response White Paper (2011, p.45) suggests using the R&D funding instrument of creating ‘Climate Change Centres of Expertise’ to develop higher levels of climate change science and produce more PhDs and post-doctoral fellows in this area.

¹⁵ Examples of these centres are listed in Appendix A (country by country).

¹⁶ See Appendix A of this volume and Volume 2, for more detail on these.

countries. Participants stated that this type of research required ‘substantial patience’, the ‘development of a new research language’ and that ‘researchers needed to understand each other better’, and ‘time should be invested in building methodological understanding across disciplines’. It also requires engagement with new forms of methodology. Few examples of theorising this new approach to research were found, despite the fact that this is a rapidly growing area of research internationally. [3.2.6.1]

- **CCD research requires ICT-enhanced research systems.** One of the fundamental areas of climate change and CCD-related research is observation, monitoring and modelling. Such research requires sophisticated ICT-enhanced research systems, to which only a few countries have access at the university level. However, international programmes have tended to support provision of equipment to national meteorological systems, which requires new partnerships between universities and these institutions. In all countries, capacity for using modelling data and for producing downscaled models was noted as a critical capacity need. [3.2.6.2]

“The Tanzania Meteorological Agency has good capacity and is producing public goods, and if we have collaboration with the universities, that will be good. If the situation is going on like this, you are not going to have competitive students coming out of the university, because of the problems you are having, like with infrastructure.”

Tanzania government stakeholder

- **Knowledge sharing and participation platforms for CCD need strengthening.** One of the aspects that stood out in the mapping study was the increased dialogue and engagement with climate change and CCD issues, especially surrounding the development of new policy processes. However, few platforms for sharing experience of CCD-related research exist, especially for more innovative approaches to research such as situated, multidisciplinary and transdisciplinary studies. [3.2.6.3]

Patterns relating to universities as co-producers of knowledge

- **Current patterns related to universities as producers and co-producers of CCD knowledge show this to be a relatively new and emergent area of research** [3.2.7]. In general CCD research is a ‘new area’ of research for many of the SADC researchers involved in it, with most researchers working in this area being involved in it for approximately five years, despite having much longer academic careers. There are some experienced CCD researchers with ten years’ experience and longer in this field, but they are not in the majority. This reflects a process in which academics are ‘self specialising’ into climate change and CCD research, and has implications for ongoing capacity building. [3.2.7.1]
- **Disciplinary-based research still dominates, and there is lack of interdisciplinary co-operation:** The mapping study showed an enduring strong dominance of single discipline research, with multi-, inter- and transdisciplinary research approaches still in their infancy, and in some places not developed at all. This contrasts with international scientific trends responding to complex issues such as climate change. [3.2.7.2] For example the 2013 World Science indicates that “intense research efforts involving

inter- and transdisciplinary approaches are needed”, and the 2013 World Social Science Reports states that:

“Social scientists need to collaborate more effectively with colleagues from the natural, human and engineering sciences to deliver knowledge that can help address the most pressing of today’s environmental problems and sustainability challenges. And they need to do so in close collaboration with decision-makers, practitioners and the other users of their research.”

- **While there is some progress, there are still challenges associated with multi-, inter- and transdisciplinary approaches to CCD research.** Amongst those who were already engaged in multi-, inter- and transdisciplinary research and who had seen the benefits of such research approaches in relation to the CCD problems being studied, still requested capacity building for these approaches. There was, in particular, a strong call for university leadership to support these new approaches to research, as they also require structural change in universities at the highest level. Some of the most apparently intractable problems associated with transdisciplinary research were not at the level of research practice itself, but rather at the level of institutional management and incentives for undertaking research. [3.2.7.3]
- **Learning from similar knowledge initiatives on critical societal issues is useful.** A number of countries mentioned the need to learn lessons from the approach to addressing poverty and HIV/AIDS that countries had employed. These lessons were to be drawn from experiences of mainstreaming critical societal issues into the higher education system, as was the case in all SADC universities through government – university partnership programmes for the issues of HIV/AIDS. [3.2.7.4]
- **Universities have an important role to play in CCD knowledge production and co-production.** In addition to the usual roles for university as expressed in the ‘normal’ mandates of universities i.e. to conduct research, teaching, and community outreach, the climate change and CCD research trajectory also expects universities to take up stronger innovation and leadership roles for universities, and to engage more actively in **solution-oriented** research, through research approaches that contribute to solutions and actual changes in practice. [3.2.7.5]

General conditions for CCD knowledge co-production

- **General conditions for CCD knowledge co-production were identified** [3.2.8]. These include the need to acknowledge and maximise institutional diversity and similarities. The SADC region has a range of different Higher Education Institutions, all with their particular niche areas and differentiated mandates. Identifying, recognising and acknowledging differences in institutional focus, specialisation areas, contextual challenges, disciplinary knowledge frameworks and contributions needs to be seen as a valuable and important feature of CCD research. How to harness institutional diversity and diversity of perspective, and the associated expertise that informs such perspectives is the ultimate challenge of a Knowledge Co-Production Framework and process. Trends related to CCD offered by these diverse institutional perspectives and niche areas need to be shared. [3.2.8.1]
- **Barriers to collaborative research exist that need addressing.** It was also agreed in all of the countries engaged in the mapping study that there was a need to a) clearly

identify and articulate, and b) address barriers to collaborative research, given that it would not be possible to address climate change and CCD-related issues within a 'business as usual' approach. [3.2.8.2]

- ***Internationalisation of CCD research, international peer reviewed research publishing and engagement with research networks requires expansion.*** Linked to the above point on the need to address barriers to collaborative research is the need to strengthen internationalisation of CCD research and research networks. In each country some examples were found of researchers working in international research networks and partnerships, particularly with other SADC countries.¹⁷ One of the most striking findings of the mapping study was that, although there is research on climate change and CCD taking place in SADC countries, this is often not being published by SADC researchers, but by international researchers. Research publishing is a critical area to strengthen, to ensure wider credibility and uptake of southern African CCD research, and to inform policy. It was also noted in the mapping study that in many cases SADC researchers find it difficult to access international research funding, as this often requires a complex set of partnerships, which increasingly are also multi-disciplinary and multi-institutional in nature.
- ***Partnerships with international research networks and organisations need to be encouraged.*** The mapping study identified a range of international and regional research networks such as the START (global change System for Analysis, Research and Training) programme, the Regional Agricultural and Environmental Initiatives Network – Africa (RAEIN-Africa), the Benguela Current Commission, the Southern African Science Service Centre on Climate Change and Adaptive Land Use (SASSCAL), Africa Monitoring of the Environment for Sustainable Development (AMESD), Africa Environmental Observation Network (AEON), WATERNET and the Famine Early Warning System (FEWSNET) (to name a few). These institutions were playing an important role in both CCD research capacity building and research networking (see Appendix A), and were operating at a level that allowed for SADC researchers to interact, learn from each other and produce new knowledge at a regional scale. However, more researchers need to become engaged in international and regional networks and partnerships. [3.2.8.3]
- ***Research funding systems for CCD are needed.*** Few of the SADC countries had dedicated national research and development funds that were 'set aside' for climate change and CCD research, except South Africa, which has a funded 10 Year Innovation Plan that includes a National Grand Challenge on Global Change (including climate change) and another National Grand Challenge on Energy, both being relatively well-funded by the Department of Science and Technology. Most national governments do have Science and Technology Innovation Strategies, but these are not (as yet) strongly oriented towards CCD research, leaving a 'big funding gap' for the kind and scope of research that is required. [3.2.8.4]

¹⁷ Examples can be found in the Volume 2 country mapping study reports.

As stated by one workshop participant:

“Funding in Botswana cannot improve as long as Botswana does not have a National Research Foundation of some sort.”

Botswana university staff member

- **Staff capacity building, especially at PhD level is needed.** Another key finding of the mapping study relates to the profile of the researchers engaged in CCD research. In all countries some women researchers were identified, although they remained in the minority. Most of those responding to the questionnaire had five or more years experience in their disciplines. However, a minority of the total number of mapping study respondents identified with specific expertise in CCD-related sciences had PhDs. This shows a need for not only encouraging more women to become involved in CCD research in SADC universities, but also to support those involved in CCD research in SADC universities to obtain PhDs. The study showed that those that did have PhDs were having a strong influence on curriculum innovation, were more strongly networked and linked into international partnerships, and were also making substantial contributions to policy processes.

Curriculum development, policy and community outreach and student involvement

- **Curriculum development and innovation for CCD require strong support.** Curriculum innovation was identified as a strong institutional development need across the 12 countries [3.2.9]. Key findings associated with curriculum development and innovation are that:
 - CCD concerns were slowly being *infused into, integrated with* and generally seen to be ‘part of’ other aspects of training; although where this was the case, it was also noted that existing efforts in this direction were currently inadequate and much more needed to be done [3.2.9.1]. As said by a Namibian professor:

“We have no specific CCD courses, but some of our courses include elements of CCD, usually ‘in passing’.”

Namibian Professor
 - There were very few examples identified of *interdisciplinary curriculum development and teaching*, and where this occurred it was more based on ‘voluntary interest’ than on institutional policy or frameworks. Where cases of interdisciplinary curriculum were found, it was noted that it was *engagement with specialist and contextual knowledge of CCD issues amongst lecturers that appeared to be the key stimulant for interdisciplinary curriculum innovations.* [3.2.9.2]
 - A few dedicated courses / modules focussing on CCD-related concerns are only found at *undergraduate* levels. These were found at a wide range of universities across the region, showing that there is a definite ‘*bottom up*’ curriculum change movement occurring in response to CCD concerns, although this was not institutionally mandated or structured in any way. Again, these were also judged to be ad hoc and inadequate by almost all workshop participants, given the severity of CCD concerns. [3.2.9.3]

- A key area for CCD curriculum innovation was at the *Masters degree level*. A number of universities had plans to develop a climate change-related Masters degree. This is particularly important for the SARUA climate change programme, which seeks to support integration of CCD modules into Masters degrees as one of its key outputs. Curriculum innovation at Masters degree level was beginning to take place in various forms: new Masters degrees as well as focussed integration of CC/CCD into existing Masters degrees. A number of examples of existing Masters degrees specialising in CCD or CCD related concerns (with various disciplinary specialisations) were found across some of the SADC universities. Such Masters degrees are, however, almost all relatively new offerings and have been in existence for three to five years only, showing this to be a potentially important new area for curriculum innovation, especially as existing initiatives were also judged as inadequate for the scope and demand of the CCD challenges in SADC. No specific multi-institutional Masters degree specialising in CCD was identified across SADC countries. The Masters degree therefore seems to be a ‘key curriculum innovation point’ for further development. [3.2.9.4]
- *CCD and PhD programmes and supervision* were also raised in relation to curriculum innovation, although PhDs are generally not ‘taught’ programmes in SADC. It was nevertheless noted that capacity building programmes for PhDs and PhD supervisors were needed to strengthen PhD offerings, especially within a cross-institutional partnership framework. [3.2.9.5]
- A variety of especially problem based and inquiry based learning approaches, case studies, dialogues, fieldwork, modelling, scenario planning and more ‘active’ *teaching methods* were noted as most appropriate for CCD related teaching. Service learning, while recognised as being an important possible strategy for especially strengthening teaching approaches that were also community engaged, was not very widely used. There was little evidence of use of *Web2.0 platforms* in CCD related teaching and learning in most SADC countries, despite new possibilities offered via these technology enhanced learning approaches. [3.2.9.6 and 3.2.9.7]
- A number of ‘key competences’ for CCD learning were identified which included more generic competences such as systems thinking competence, anticipatory competence, strategic planning competence (including use of modelling tools etc.), normative competence and socially engaged practical competence *in addition to CCD area specific competences* e.g. town and regional planning competence, or agricultural adaptation competences. [3.2.9.8]
- There were also calls for ‘new paradigm thinking’, and for giving attention to different types and forms of knowledge in CCD (e.g. indigenous knowledge; knowledge of risks; knowledge of solutions; knowledge of causes etc.), as well as values and attitudes. Such knowledge, values, competences and ‘new paradigm thinking’ concerns were seen to be relevant to *all or most* disciplines. [3.2.9.9]
- There was also a strong demand for *curriculum innovation support*, which includes curriculum development support to develop new programmes and/or strengthen existing programmes. A critical issue here is capacity to assess and build new research-based knowledge into curricula, and to design curricula that are more oriented towards knowledge co-production, and less oriented to assimilation or

transfer of knowledge. Some exemplary programmes and curriculum support initiatives were identified. [3.2.9.10]

- **Student engagement with CCD issues is relatively low.** The mapping study found relatively low levels of student engagement with CCD-related issues, although in most countries at least one student organisation was found that deals with environmental issues, and it was noted that there was an increased interest in these issues amongst the student body. There was also evidence of cross-institutional student networking on CCD related concern, but little *regional* networking amongst student organisations. The Africa Green Campus initiative also seems to be stimulating more student engagement, coupled to campus management improvements. There appeared to be few proactive programmes in the region that were focused on enhancing student participation in issues such as CCD, and yet it was recognised as a very important area for future action.
- **Policy outreach appeared to be one of the strongest forms of outreach** currently being practised by SADC academics in relation to CCD. This can be explained by the recent demands for international reporting via the First and Second National Communications to the UNFCCC, by the NAPA process, and by the associated and very recent emergence of national climate change policies in almost all countries (during the study in most countries a National Climate Change Policy was still in draft). Some countries are still developing such policies. There has therefore been ‘intense’ policy engagement on CC / CCD issues over the past five years in the SADC region. However, this appears to be largely re-active to policy process demand, rather than pro-active which hampers ability to provide for robust evidence-informed policy making. There was, as mentioned above, concern across the region with policy *efficacy and implementation*, and this may well be where the next phase of policy outreach would need to be concentrated. [3.2.11]
- **Community engagement in CCD areas was generally seen to be poorly constituted and not really executed.** This was also due to heavy demands placed on academic staff from large student numbers and heavy teaching loads. However, there were some outstanding examples of community outreach identified across the SADC region, although few such examples were institutionally framed e.g. through service learning courses or modules. In general there was a high level of concern for community well-being and a strong sense that knowledge should be made more relevant and communicated more successfully to communities, but it appeared that the strategies and enabling conditions for doing this were not in place.
- **Campus management and demonstrations of CCD are rare.** There were some cases of proactive CCD oriented campus management actions, but these were not the norm. In some countries universities were trying out ‘green buildings’ (e.g. in Namibia) but it was said that this practice was not widespread and most often university management followed the ‘business as usual’ path when undertaking new developments on campus. This was, however, seen to be a valuable opportunity for *demonstrating* new CCD relevant technologies (e.g. renewable energy), but there was also a realisation that this required new forms of technical competence that did not always exist on the university campus. Nevertheless, it was felt that this was an important area of CCD innovation, as it modelled transitions to low carbon economies, and could also model new forms of knowledge co-production, technological innovation and so on.

Some of the key implications for the Knowledge Co-Production Framework arising from the institutional analysis are that:

- Any knowledge co-production process requires giving careful attention to both the knowledge needs for CCD as articulated in regional and national climate change policy and research, and the institutional context, histories and current realities of SADC universities.
- The Knowledge Co-Production Framework should be accompanied by 1) research system development which includes giving attention to research policy and financing, 2) research capacity building, 3) research institution building, and 4) research management which includes knowledge management, co-ordination and research incentives.
- The Knowledge Co-Production Framework needs to recognise that CCD is a relative new area of research in SADC, but that it is also permeating all disciplines. It is also introducing new approaches to research, especially multi-, inter- and transdisciplinary approaches which are still in their infancy, and under-theorised, and in need of methodological development. Capacity building and leadership support are therefore vital for supporting this new area of research, as is a strong emphasis on capacity building for publishing of research.
- To maximise the emergence of CCD research there is need for recognising that a number of general conditions characterise CCD research including institutional and disciplinary diversity; barriers need to be addressed in a systematic manner and at system level; internationalisation is an important feature of CCD research and needs to be expanded; and research funding systems and capacity building, especially for PhDs, and PhDs in academia need to be prioritised.
- Curriculum development and innovation for CCD is a key priority that must be included in the Knowledge Co-Production Framework. Here attention needs to be given to further infusion / integration of CCD into existing programmes and new course development at both under- and postgraduate levels. In particular, the Masters degree is a potentially important innovation point for CCD curriculum innovation. PhD programming and collaborations that include supervision support are also needed. There is also need to 'frame' CCD curriculum innovation by giving attention to knowledge, competences and values that are relevant to CCD (across disciplines) *as well as* the specific related demands within disciplines. Integration of indigenous knowledge is also a key concern in and for curriculum innovation, as is inter-disciplinarity, social-ecological systems thinking, and use of creative teaching methods, including Web 2.0 platforms which are currently under-utilised.
- Student engagement needs to be strengthened through the Knowledge Co-Production Framework, as does community engagement and policy outreach. Campus management and campus based 'demonstrations' of CCD (e.g. energy efficiency programmes) is currently an under-utilised and potentially easily used and powerful resource for CCD education and research in SADC universities, as are service learning approaches.
- Policy outreach needs to be oriented into a new phase, after an intense phase of policy formulation towards proactive approaches to providing for evidence-informed policy, and research that strengthens policy efficacy.

Strategic direction for CCD knowledge co-production in SADC

Knowledge co-production research themes: rationale and summary

The Knowledge Co-Production Framework (KCPF) provides strategic design suggestions for the SARUA climate change programme, and sets out seven proposed research themes for this programme, arising from the mapping study findings and further developed to promote strengthening of single, multi-, inter- and transdisciplinary research in southern Africa. Both the design considerations and the proposed research themes are presented to be considered and refined by the SARUA executive and universities, as one of the key next steps after receiving the final mapping study report. The KCPF further focuses on the remaining key areas investigated in the mapping study, and for which recommendations are made: curriculum development and innovation, community and policy outreach, and higher education policy and strategy. A summary of the key recommendations of this mapping study is provided, to enable knowledge co-production on climate change and CCD in the SADC region.

Within the context of urgency for action on climate change set out above, southern African countries will need to step up existing efforts to make development more resilient according to national (and regional) needs and priorities. In the context of the international climate negotiations process, all countries will need to develop 'national offers' or contributions for emissions reduction proposals, as well as set out actions for adaptation.¹⁸ These will provide a way to link the 2015 international climate agreement more closely to domestic debates and national circumstances. All of this will entail significant regional preparation, underpinned by action-oriented research. As the mapping study has found, developing capacity for the research to assist in unlocking all this will require strengthening individual disciplines, as well as building research capabilities and removing barriers, including through institutional reform, for multi-, inter- and transdisciplinary knowledge production. It will also require concerted effort to enhance the climate change-related competences, knowledge and expertise of those who will develop and deliver many of the capacity development initiatives – the researchers, educators, trainers and their partners.

The mapping study has identified a wide range of knowledge, research and capacity needs for the region, and indicated how many of the broad priorities for developing a better response to climate change are shared across countries. This does not deny the need for contextualised and localised responses, but highlights that there are broad knowledge and research issues that can be clustered, and that are highly relevant across the region, within the context of national and local development specificities. The study has also identified existing areas and centres of expertise for climate change and CCD within each of the countries, active researchers, and potential knowledge production partners. It is clear that while climate-related capacity and research development needs are many, there are existing nodes and centres of

¹⁸ See, for example, Olsen, K.H., J. Fenhann and S. Lutken. 2013. *Elements of a new climate agreement by 2015*. UNEP Risoe Centre Perspectives Series.

expertise that can play a strong role in further developing research and teaching capacities to address the identified priorities and gaps.

What is required is a strategic approach that builds upon existing expertise, addresses the most pressing shared priorities while allowing for local specificities, and assists the countries and the region to do so in a way that also positions themselves better for the potential opportunities inherent in the unfolding international architecture of climate agreements and funding institutions. To this end, a set of proposed priority research themes, to be addressed through regional research clusters, has been developed, which also link to wider research agendas that are being put forward under, for example, the Future Earth Global Sustainability Research Plan, and which address some of the regionally relevant findings of the World Social Science Report.

The KCPF has been designed to allow for the development of sufficient climate change research capacity at a regional level to initiate and develop research clusters with more capacity to produce and publish knowledge for sustainable development and climate resilient pathways for southern Africa and her people. Overall, the vision of the SARUA programme is to create a system of knowledge co-production that provides southern African researchers opportunities for capacity building and relevant, high quality knowledge production.

Suggested thematic research areas, viewed within the overall SARUA programme framework

The following set of seven priority thematic research areas, based on the articulated needs and the findings of the institutional assessment, has been developed to provide a strategic and integrative direction for supporting research and capacity development in the southern African region. The research areas have been distilled from the mapping study data and are based on articulated needs and the current institutional context for CCD research in SADC. The proposed research themes have been developed through a combined analysis of workshop data, questionnaire data and policy and document analysis from each of the countries engaged in the mapping study. The themes have further been framed to allow for proposed changes and emerging issues in the international and regional climate change policy and development landscape. While the research themes have thus been defined through a careful triangulation process, we present these as a starting point for the SARUA community to undertake further discussion and internal consultation, in order to refine and/or re-work the selected research themes upon which the ensuing SARUA climate change programme will focus, as further recommended below.

The process to develop the proposed research themes has moved from the country-level workshop discussions, summarised into the workshop reports, and to the Country Reports that bring together all the data sources – workshops, questionnaires and initial desktop reviews, further supplemented by Internet research, to the regional syntheses of needs analysis and institutional assessment, as set out in sections 2 and 3 of this report.

The following criteria were used to develop the research themes:

- The extent to which the particular thematic areas have been highlighted in the national-level needs analyses, particularly where articulated needs were repeatedly identified across countries;

- Addresses findings from the regional synthesis of needs analysis and institutional assessment;
- Policy relevance of the proposed research theme;
- Scope for simultaneously enhancing single discipline research and multi-, inter- and transdisciplinary research and engagement on the thematic area, thus furthering the possibilities for knowledge co-production (see below);
- Allows for innovative research approach and the development of innovative solutions;
- Availability of existing nodes and centres of expertise and excellence that could begin to drive the thematic research area – across different countries to ensure that there is sufficient critical mass for a regional ‘start up’ to further engage with clarification, refinement and re-definition of the research areas; and
- Provides for an integration of the social dimensions of climate change into the more technological and infrastructural dimensions – given that the social dimensions of CCD are the least well-researched, as identified extensively in the mapping study.

The proposed research themes have been developed at a broad level¹⁹, only articulating broad *potential* research areas. This is to allow for **discussion and re-framing** amongst the SARUA community across the SADC countries. Once this has been done, then specific objectives, research questions, time frames, partners and anticipated changes can be identified. To proceed to this level of detail in this KCPF would not only be beyond the scope of this mapping study, but would also undermine regional and institutional ownership of the programme.

The research themes need to be considered within the overall landscape of the proposed SARUA climate change capacity development programme, as set out in the figure below. A critical point is the interaction with the following three proposed supportive networks:

- Policy and institutional development network;
- Curriculum innovation network; and
- Capacity development network for CCD researchers and teachers.

¹⁹ This follows similar processes used to design multi-stakeholder research programmes. An example here is the Global Change National Grand Challenge Research Programme in South Africa, and the Future Earth research plan being defined at global level. These, by necessity, must be broadly framed to allow for further contextualisation and more detailed framing at the actualised research partnership and programme level.

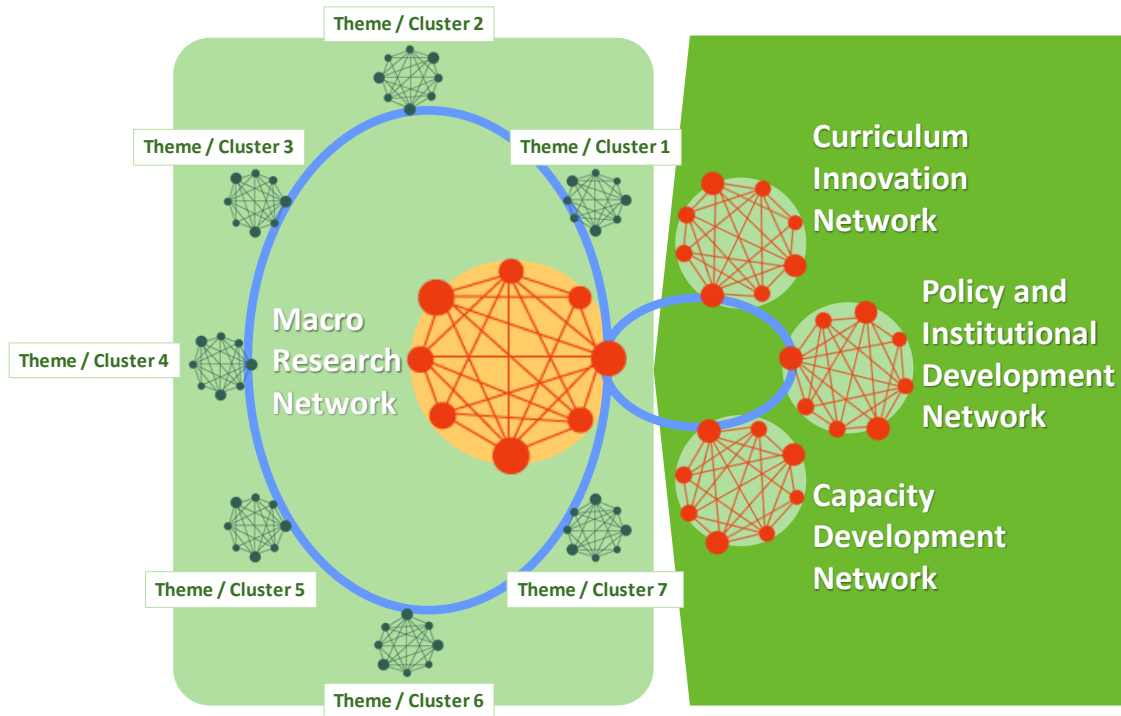


Figure 1: Revised conceptual framework for the SARUA programme (based on Figure 2, and adapted according to the results of the mapping study)

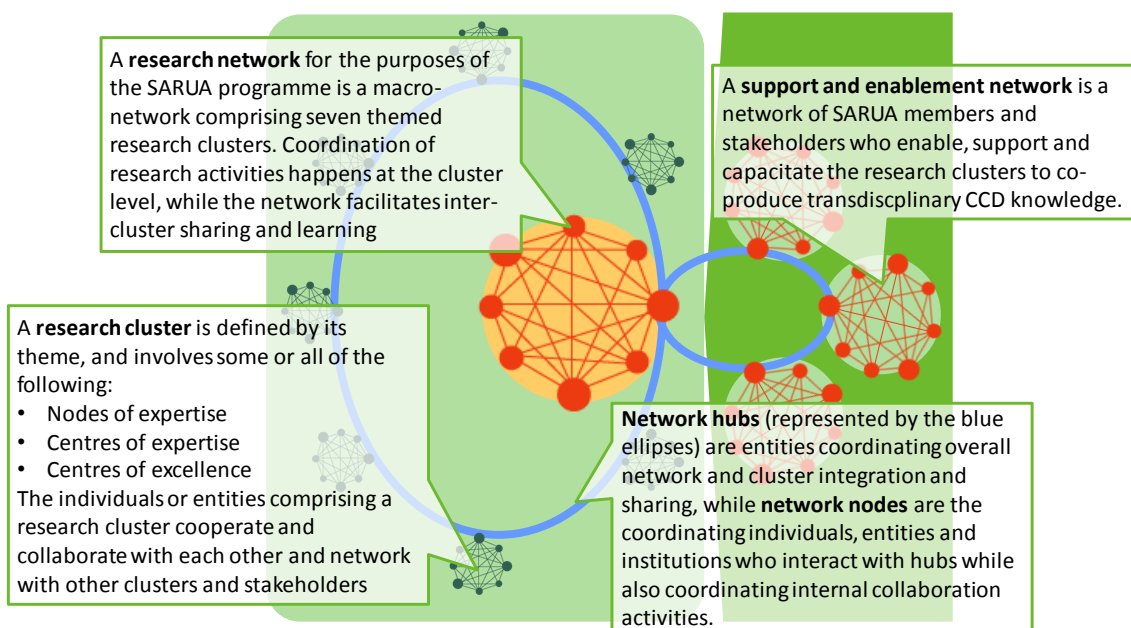


Figure 2: Definitions of key concepts in the revised network model

It is proposed that each of the suggested research clusters²⁰ will provide a thematic area for solution-oriented regional inter- and transdisciplinary knowledge co-production, while also necessitating further expertise development in single discipline priorities. This is in line with the mapping study findings that both specialised single discipline research and more collaborative and holistic research are required for addressing identified knowledge and research gaps. The mapping study found that stakeholders and university staff observe a wide range of priority CCD needs, constituted as a mix of adaptation, mitigation and cross-cutting issues. Cross-cutting issues tended to include two types of needs: knowledge needs that cut across other priorities such as improved observation and vulnerability assessment data; and research oriented towards social system change, most often focussing on the efficacy of systems and/or the need for education, training, communication and engagement with communities.²¹

While the mapping study puts forward research themes that encourage multi-, inter and transdisciplinary approaches to knowledge co-production, it recognises the need for enabling transitions from more mainstream research to these new forms of research. Experience in the SADC region shows that this requires researchers to:

1. Adopt a social-ecological systems / landscape-based / situated contextual (e.g. a common site such as Lake Chilwa in Malawi, or climate 'hotspots') as a starting point for defining research questions in multidisciplinary teams, with stakeholder involvement in the research question definition;
2. Conceptualise the contributions of each discipline to the common research context / question / social-ecological system being studied;
3. Agree on similar / different methodological approaches to the problem, and to adopt a 'methodologically open' view allowing for different ways of approaching a problem;
4. Begin to work in multidisciplinary / interdisciplinary research teams, with a willingness to engage in reflexive dialogue and regular synthesis throughout (this may also involve developing an understanding of different research discourses and ways of knowing); and
5. Add a strong focus on community and policy engagement into their research programming from the start of the programme, regularly sharing insights with communities and policy makers / implementers and obtaining feedback on the research-in-progress, as well as providing for community members and policy makers to articulate research questions and needs, through a two-way process.

²⁰As stated above, these are still open to change and/or further refinement by the southern African research community and their partners.

²¹ Furthermore, existing experience, sectoral interest and level of operation in the system often determines how CCD is viewed and/or how CCD priorities are identified. The diversity of responses from diverse stakeholders and university professionals (in diverse disciplines and management positions) shows that different institutions / disciplines and levels of inter-disciplinary management are needed to develop an holistic view of climate compatible development 'needs'.

These appear to be the five strongest strategies for working towards a transdisciplinary knowledge co-production trajectory, and present a practical pathway for transitioning from single discipline research to more transdisciplinary approaches, without losing the strength of individual disciplinary contributions.

The seven proposed research themes are:

- **Research theme / cluster 1: Resilient landscapes for people, food and ecosystems** – This research theme focuses on developing pro-poor, sustainable and resilient production landscapes. It engages the climate change, energy, agriculture and food security nexus, within the context of sustaining and enhancing ecosystem services and agro-biodiversity. Production landscapes here are conceptualised as integrated ecological-agricultural systems – i.e. the form of agriculture required would be ecological and sustainable agriculture, within a broader landscape focus on enhancing ecosystem services and biodiversity. The theme responds directly to an overwhelming regional priority, expressed as highly significant in all the country data.
- **Research theme / cluster 2: Monitoring and mapping biodiversity and complex social-ecological systems changes for CCD** – This research theme focuses on biodiversity, ecosystems and water within a social-ecological systems perspective, placing emphasis on enhanced observation and monitoring. Many of the knowledge gaps identified in the mapping study needs analysis related to the lack of systematic and reliable long-term data in different sectors to serve as baselines for research, modelling and monitoring.
- **Research theme / cluster 3: Indigenous knowledge, resilience and cultural, social and technological innovation** – This research theme focuses on the potential role of indigenous knowledge in CCD pathways, which was repeatedly raised in the mapping study. Participants across all SADC countries felt that the potential role of indigenous knowledge in building resilience through the cultural, social and technological innovations necessary for transformation to a low carbon, more equitable and sustainable society has been under-valued, and under-developed. There was also recognition that this did not involve an uncritical ‘adoption’ of indigenous knowledge, but rather research approaches that can evaluate the relevance and potential of IK in the changing CCD context.
- **Research Theme / cluster 4: Social dynamics of adapting to environmental change: sense making, social learning and social transformation** – This research theme focuses on the frequently raised point (in the mapping study) that CCD also requires changes in social practice and habits, which in turn require new values and ethics, learning, social innovation and social learning. The research theme further includes education system change, gender and climate change aspects, as well as a focus on the role of media. It addresses a key finding of the mapping study that across universities in southern Africa, even in those that are most strongly engaged with CCD, social science participation in climate change and CCD issues is barely in existence.

- **Research theme / cluster 5: Green economy and sustainable energy and infrastructure technology innovations** – This research theme focuses on important aspects of the Green Economy thrust and the move towards sustainable and renewable energy in the region, and includes energy efficiency and infrastructure development. As such, it has a strong focus on industrial processes, infrastructure and technology development, and in particular aims to strengthen engineering, infrastructure and technology capabilities development, with implications for establishing low carbon energy and development pathways and more sustainable human settlements. It also includes a focus on aspects such as water infrastructure resilience and adaptation, energy efficiency and related research areas. This research theme could contribute strongly to the realisation of aspects of the draft SADC Climate Change Programme, particularly the ‘Research, Technology Development and Transfer’ component (the programme aims to generate evidence-based information, develop appropriate technologies for sustainable development and poverty reduction and disseminate the technologies). The theme also indicates that most of these research areas are complex within a CCD context, and most are engaged in finding technological and/or combined technological and economic solutions that can help societies’ transition to low carbon, climate resilient futures.
- **Research theme / cluster 6: Climate change resilience: A focus on health and well-being** – This research theme focuses on enhancing understanding of the effects on health and well-being of climate change. This was mentioned in all of the countries as a priority area in the national response, yet it has received very little research attention to date. Some aspects, such as the potentially severe effects of heat stress on regional populations and productivity, are almost completely unresearched. This is an important knowledge and research gap to fill, given that the health sector is considered to be particularly vulnerable to climate change, as are the agriculture and water sectors. For the African region as a whole, climate change is seen as a multiplier of existing health vulnerabilities, including inadequate access to safe water and improved sanitation, food insecurity, and limited access to health care and education.
- **Research theme / cluster 7: African futures are resilient (AFAR): Governance, participation and social-ecological system change** – This research theme focuses, inter alia, on an institutional issue repeatedly noted in all mapping study countries: the lack of policy coherence on climate change, and the necessity of developing institutions for adaptation and mitigation, as well as for systemic integration of climate change. These aspects were often linked with the need for greater participation and ethical leadership in decision making on climate change responses and CCD, and greater political will. The research theme would include exploring how adaptive and integrated governance systems can be developed to operate successfully across multiple scales, including issues of co-management and transboundary management arrangements for collective management of natural resources. This governance nexus could be combined with the emerging cutting edge debates on climate change, such as limits to adaptation, loss and damage, and the need for transformational adaptation.

The description of each of these research themes in Volume 1 contains the following:

- The overall rationale and framing for the research theme;
- A highly provisional set of possible research areas to be explored;
- An indicative listing of the range of disciplines that could be engaged in the research theme; and
- An indicative and incomplete list of potential key nodes and centres of expertise for the research cluster (*these are drawn from the mapping study, and from institutions listed in Appendix A, and in Volume 2 Country Reports*).

Given that each of these suggested research clusters (or the final research clusters as decided upon by the SARUA research community) would be conducted within an inter- and transdisciplinary research approach, they would of necessity have a focus on both community and policy engagement. In the initial stages, research proposals would be designed and developed by groups of interested researchers from several universities / HEIs in the region, in collaboration with other knowledge co-production partners, including from the policy community and from users of the research. In some cases, but not all, the primary research users, who would be involved in co-designing the research, would be poor and marginalised communities, thus providing a mechanism for a commonly repeated refrain in the mapping study – that research should be more clearly oriented to specifically benefit such communities. In other cases, users may be the business community, development partners, media partners and/or other societal institutions. The Consultative Group on International Agricultural Research (CGIAR) have recently expressed this shift in research as a ‘paradigm shift’ from Research for Development (R4D) to Research *in* Development.²²

“We see more research on climate change, vulnerability and adaptation. But there are other issues that need to be focused on, such as power balance issues. Are we as researchers focusing on the right issues that will really help the poor people?”

Tanzania university staff member

Regional strengthening of climate information and climate services

Climate information and climate services were enduring knowledge and research gaps, including modelling, downscaling and scenario development. This is a fundamental and cross-cutting gap that is well recognised in most analyses, and is being addressed through numerous international and regional programmes. Addressing this gap requires a long-term and capital-intensive approach that involves building the observational network and the capacities of the national meteorological agencies, which is beyond the scope of the SARUA programme. Therefore, a dedicated research theme on climate information has not been developed for this programme. However, enhanced methods of working with and integrating climate information

²² <http://blog.worldagroforestry.org/index.php/2013/11/29/one-small-change-of-words-a-giant-leap-in-effectiveness/>

do form part of a number of the proposed research themes, such as the assessments of risks, impacts and vulnerability envisaged under research theme 1, and the research clusters would need to partner with other programmes and institutions to obtain the best available climate information for their needs. The SARUA programme would also contribute to the development of climate modelling and scenario development, for example through support to fill the gaps in systematic and reliable long-term ecosystem data to serve as baselines for research, modelling and monitoring, as envisaged for research theme 2, which would aim inter alia to answer the following kind of research question: How could the collection of such environmental monitoring data be better applied into climate change models at regional, national and local levels? A further contribution would be under research theme 7, which could explore enhanced processes for decision making on complex questions, for example by developing an iterative process for decision making using scenario development on complex questions that need to be answered, such as longer-term cropping areas and future hydropower potential. Such research questions would need to be developed through further discussion with existing programmes and institutions with competency.

Curriculum development and innovation

Strategic direction setting for curriculum development and innovation, as proposed in this Knowledge Co-Production Framework involves both: 1) conceptualising what CCD curriculum innovation means (i.e. not simply inserting content into existing courses), but *framing* curriculum development based on knowledge questions, CCD relevant competences, values and ethics, and 'new paradigm thinking', and 2) improvement and design of new courses. A starting framework for these dimensions of curriculum innovation is proposed in section 4 of the document, along with a set of 'start up' partners who have capacity to support and/or contribute to a curriculum innovation network that also builds capacity for curriculum innovation. The suggestion is that this 'start up framework' can be used to guide and support a variety of curriculum innovations at under- and postgraduate levels which include integration of CCD relevant knowledge, competences and values into existing courses, and/or the design of new courses.

A suggestion is that the Masters degree in particular should be a focus of curriculum innovation point in the SARUA programme, together with methodology training in multi-, inter- and transdisciplinary approaches (although undergraduate curriculum development and interdisciplinary curriculum development also require attention). There is as yet no cross-country multi-institutional Masters degree available in SADC for CCD, which also presents a curriculum innovation opportunity. Research methodology training can support Masters and PhD scholars, and can also contribute to supervisor capacity building. Capacity building for curriculum innovation is a priority, as few staff have had opportunities for curriculum innovation professional development focussing on the complex topic of CCD, yet they are trying to integrate this into their courses where possible. As noted above, curriculum innovation, and support for curriculum innovation was identified as a priority for the SARUA programme amongst those participating in the mapping study.

Policy and community outreach

Policy and community outreach strategic suggestions include a strengthening or re-orienting of policy outreach from a period of strong CCD policy *making* to a 'new era' of CCD policy outreach that focusses more on providing for *evidence-informed policy*, and the *efficacy of policy and policy implementation*. Policy studies should also be embedded in the research thematic areas and research clusters.

Community outreach strategic suggestions include making stronger use of service learning approaches and strengthening incentives for community engaged research and outreach. The emphasis on indigenous knowledge and policy-practice links as found in different countries, provides a context in which stronger forms of community engagement can evolve, as does a commitment to transdisciplinary knowledge co-production approaches, but these must be accompanied by system-based support and incentives (e.g. validity in promotion criteria etc.).

Higher education policy and strategy

The mapping study also raised strategic issues and directions for higher education policy and strategy. Key amongst these is the need for re-conceptualising the role of universities in the context of current debates on human development, especially those pertaining to climate change and CCD, and its implications for development. Following this is the need to strengthen science and technology for CCD, and research internationalisation (especially also regionally) in order to strengthen the 'critical mass' required for real development outcomes. Research infrastructure, funding and incentive systems need to be revised with CCD concerns and international research trends and debates in mind (applied of course to the southern African context and related CCD issues as outlined in the Needs Analysis). In sum, CCD needs to be afforded priority at the highest level of educational and science and technology policy.

At university level, it is proposed that universities need to consider the implications of climate change for wider societal development, and use this as a way of reflecting on, and reviewing the education offered in individual higher education institutions. It was agreed across the twelve countries participating in the mapping study that university leaders have a vital role to play in supporting such changes in education. Additionally it was noted that more support should be provided to student involvement, and campus management practices. These have potential to 'demonstrate' transitioning to low carbon, more sustainable, energy efficient futures. This is currently an under-developed area of practice in southern African higher education institutions, although some excellent examples exist of how such practices are developing.

In summary, the strategic directions pointed out in the Knowledge Co-Production Framework require a range of interventions that are research-based (requiring engagement via the suggested research thematic groups outlined above); curriculum and capacity building related (requiring engagement via the curriculum innovation and capacity building networks suggested above); and policy and institutional development (requiring engagement via the policy and institution building network outlined above). The development of suggested strategic direction in section 4 of the KCPF therefore provides the background rationale for the proposed

networked structure of the SARUA programme outlined in Figure 1 above, and the proposed roadmap, which must move the programme into implementation.

Roadmap and system development: Initial steps

The mapping study has provided the knowledge base required for regional CCD network development. A conceptual network development model, which has been adapted to suit the requirements of the SARUA programme, is presented in Appendix E and provides the broader framework in which the immediate action steps need to take place. The network development roadmap focuses on short term actions required to (i) establish sufficient coordinating capacity and to (ii) ensure collaboration and knowledge co-production activities can commence.

The issue of central coordination for the proposed SARUA programme is not yet sufficiently clarified and requires priority attention. Irrespective of the coordination approach preferred, the action steps outlined in the roadmap comprise what is deemed necessary to commence with implementation, with an emphasis on two first stages of network development:

- Initiation of research clusters and networks (defining their purpose); and
- Configuration of research networks and clusters (refining and/or re-defining their content and focus, as well as how they will operate).

The establishment of multiple networks on a regional level also requires a sound governance framework to be put in place, to ensure activities, projects and outputs generated through the SARUA programme meet the required standards of quality and good management.

The figure below illustrates the context in which the short-term action recommendations are made with an emphasis on immediate steps to set the platform, so that after 2014, each network will follow its own defined network development path.

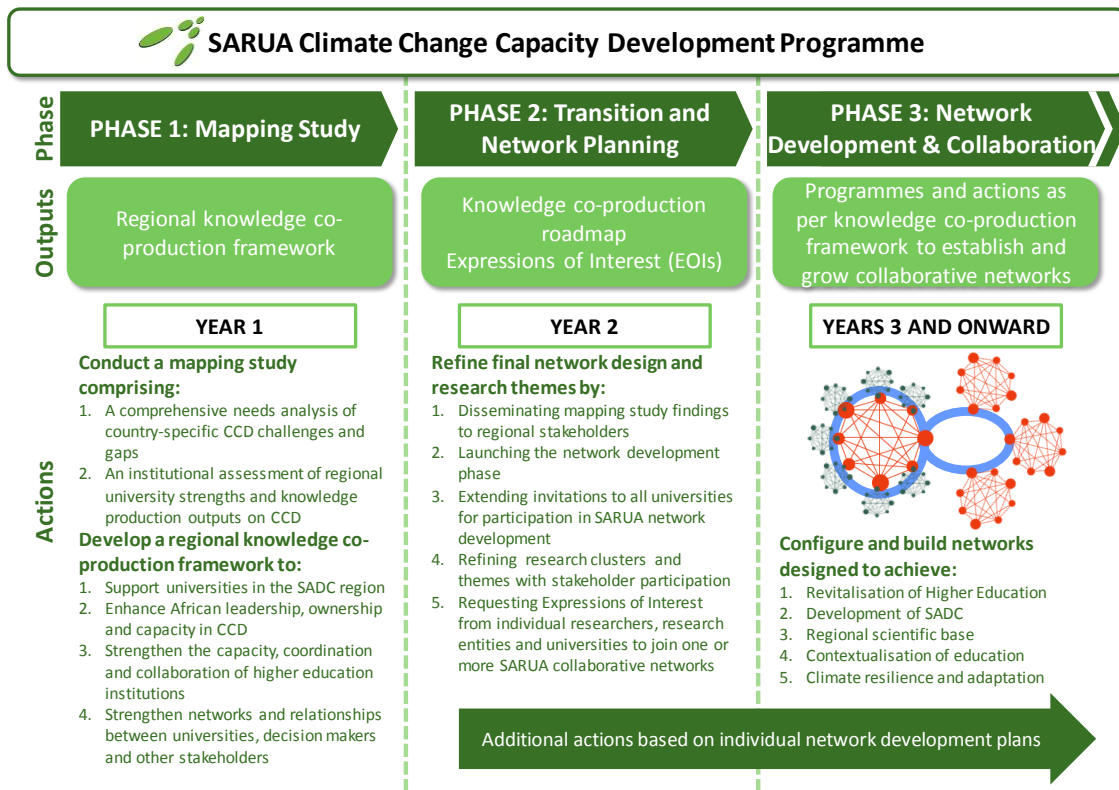


Figure 3: Scope of Knowledge Co-Production Framework roadmap

Network development framework

A detailed network development framework is provided in Appendix E, which outlines the typical network cycle, comprising five potential stages:

initiation → configuration → operation → stabilisation → transformation/ dissolution.

The network development framework is compatible with varying time frames and any type of coordination approach (centralised or decentralised). It provides clear guidelines on the necessary and optional roles to be assigned for successful knowledge co-production and steps to be followed by each research cluster or emerging network.

A key emphasis of this Knowledge Co-Production Framework is the identification of self-initiating activities and while the necessary network *roles* are identified and outlined in Appendix E, flexibility is incorporated so that each network can determine whether it requires separate entities to fulfil these roles and how responsibilities are allocated. It will not be possible, or ideal, to commence with network establishment of all four networks, including all seven research clusters identified, at once. Each network will develop at its own pace depending on a combination of the following factors:

- Relevance of the identified themes to universities;
- Interest and availability of a network coordinator, participating nodes (centres of expertise, institutional management and individuals) in becoming part of a proposed network;
- Funding and budget available for establishment and coordination activities;
- Extent of existing infrastructure / contacts / collaboration activities;

- Maturity of existing research / management practices within participating universities and organisations;
- Extent of policy preparation, lobbying and advocacy to “sell” the idea of the network to other regional stakeholders;
- Ability and capacity of SARUA or another coordinating entity to provide establishment and ongoing coordination support.

Immediate steps

1. After Vice Chancellors of the SARUA network of universities met in Mauritius in October 2010 to agree on a collaborative programme of action, a Deputy Vice Chancellor Working Group on Research, Development and Climate Change was established by SARUA to oversee the development of the programme and to perform a quality review on the outputs of the mapping study. In order to proceed towards Phase 2 of the programme, SARUA's leadership need to engage with the findings and deliberate key mechanisms for implementation. A DVC working group session was held in February 2014 and the outputs of the mapping study were validated from a quality point-of-view. It was agreed that the Phase 2 process would focus on the following:
 - Confirming the revised network structure as recommended in the Knowledge Co-Production Framework;
 - Refining the proposed research themes by engaging the SARUA membership and checking for congruence with the SADC Climate Change Policy and Strategy, when these are released in draft form or finalised. Finalisation of policy directions may also require revision and/or development of new research thematic areas;
 - Accepting/fine-tuning KCPF recommendations and the network development steps to be taken;
 - Identifying any structures required to coordinate from the SARUA side, or individuals to be requested to fulfil an interim coordination role;
 - Development of a programme and timeline for the effective dissemination of the KCPF report; and
 - Clearly setting out the funding requirements for a project development process in a summarised project concept note that could be submitted to a funder to obtain a project development grant, which would be used to develop a full funding proposal and associated log frame.
2. SARUA, through its CEO and executive, will ensure:
 - Endorsement of the reports by the SARUA Executive Committee;
 - Confirmation of any further developments, additions and actions to the proposed road map;
 - Coordination of the programme roll-out through an appropriate structure; and
 - Communication of the programme roadmap, outputs and key network development initiatives.

Critical success factors

- Communication to all universities (SARUA members and non-members) and stakeholders to confirm the network framework, comprising the establishment of:

- Macro research network (comprising proposed seven thematic research clusters);
 - Curriculum innovation network;
 - Policy and institutional development network; and
 - Capacity development network.
- Call for participation in networks to be coordinated and well-formulated;
 - Activities of the coordination role to be clearly defined;
 - Network roles to be appointed as soon as possible (at least coordinators);
 - Network establishment: Memorandum of Understanding document / template to be developed and adopted;
 - Researchers appointed or commissioned as network configuration commences; and
 - Registration requirements to become part of network need to be clearly defined and communicated.

The mapping study as 'foundation' for further expansion of CCD knowledge co-production

The mapping study provides a 'knowledge base' of climate compatible knowledge co-production needs, institutional dynamics, and possibilities in the SADC region (derived from twelve countries), and a database of active CCD researchers and stakeholders in the southern African region. It reveals the diversity of climate change and climate compatible development needs in southern Africa, but also the similarities. Most importantly, it identifies and maps out areas for future collaboration and sets out a roadmap for networked knowledge co-production within the SADC region.

The ability to transcend disciplinary and institutional boundaries on the part of the participants in the mapping study reveals a broad understanding of climate change that bodes well for a more interdisciplinary response in the region, provided the necessary support for this is made available. Additionally, the existence of a variety of research networks, Nodes of Expertise, Centres of Expertise and Centres of Excellence involved in CCD research – identified in all countries – provides a solid 'regional starting point' and institutional base for expanding CCD research, and especially regional and international CCD research partnerships. SADC-wide research system support, combined with international partnership support, is needed to strengthen and expand these Nodes and Centres, and to create an institutional development pathway that expands Nodes of Expertise into Centres of Expertise, and Centres of Expertise into Centres of Excellence, with accompanying career pathway trajectories for SADC CCD researchers. Identification of these nodes and centres is the first step on this road, and an important starting point for the SARUA programme.

The findings of both the Needs Analysis and the Institutional Assessment undertaken as part of this mapping study could be helpful in the ongoing policy development and strategy implementation at both national and regional levels. Several countries are at an opportune stage in this process for these findings to be considered – for example, Botswana is currently developing a National Climate Change Strategy and Action Plan, and Angola is in the process of updating its National Strategy on Climate Change. With additional research-based impetus at regional level, current policy initiatives can potentially also become more strongly evidence-informed, and focussed on implementation efficacy.

1 INTRODUCTION

1.1 Introduction and overview of the Knowledge Co-Production Framework

This Southern African Regional University Association (SARUA) document provides a Knowledge Co-Production Framework for climate compatible development in southern Africa (**Volume 1**). It is based on a **mapping study** that involved a needs analysis and an institutional analysis which was undertaken country-by-country, which is synthesised in Appendix A, and more fully represented in 12 Country Reports, published as a companion monograph (**Volume 2**) to this Knowledge Co-Production Framework.

Climate change and climate compatible development are relatively new knowledge production areas in southern African universities. This **mapping study** is the first of its kind in southern Africa, and brings together information from twelve southern African countries, and a multiplicity of disciplines. It also combines the perspectives of national stakeholders concerned with climate change and climate compatible development, and university professionals, many of whom were gathered in the same forum for the first time during the mapping study workshops. It also produces insight into the contextual and institutional challenges facing southern African countries as they confront the emerging and projected impacts of climate change, on a continent that has been found by the Intergovernmental Panel on Climate Change (IPCC) to be one of the most vulnerable to climate change.²³ The vulnerability of southern Africa to climate change is exacerbated by a range of multiple stressors that are related to poverty and other development concerns in the region.

- **Section 1** of the document outlines the SARUA Climate Change Capacity Development Programme and introduces the key concepts used in this document.
- **Section 2** provides a regional synthesis of the country-by-country Needs Analysis.
- **Section 3** provides a regional synthesis of the country-by-country Institutional Analysis.
- **Section 4** provides strategic direction for knowledge co-production for climate compatible development in southern Africa. It deals with research, curriculum development and teaching, policy and community outreach.
- **Section 5** provides a short 'road map' pointing to the most important 'next steps' for the SARUA programme on climate change and development.

This Knowledge Co-Production Framework forms the basis for the realisation of the longer term objectives of the five-year SARUA programme outlined below, as well as for a SADC-level research programme/s and various country-based partnership agreements. It provides a 'knowledge base' for regional and country-based fundraising for research and knowledge co-production. As such the framework seeks to benefit universities themselves, while also strengthening regional interaction and co-operation.

²³ Boko, M. et al. 2007. "Africa," in *Climate Change 2007*.

1.2 The SARUA Climate Change Capacity Development Programme

The Southern African Regional Universities Association (SARUA) has established a programme for Climate Change Capacity Development, to deliver on its mandate of promoting, strengthening and increasing higher education research and innovation, through expanded inter-institutional collaboration and capacity building initiatives throughout the Southern African Development Community (SADC) region.

The vision of the SARUA programme is to create a system of knowledge co-production that provides southern African researchers opportunities for capacity building and relevant, high quality knowledge production. The programme aims to significantly enhance the climate adaptive capacity and resilience of the SADC region through the development of a collaborative network of higher education institutions capable of pooling resources, maximising the value of its intellectual capital and attracting significant investment into the region. This will involve step changes in:

- Research, teaching and knowledge generation on climate change, adaptation measures, low carbon development options and the associated costs and benefits;
- The dissemination of information and knowledge amongst all stakeholders;
- Sensitising communities, governments and the private sector about the risks of climate variability for development prospects in the region;
- Regional evidence-based policy development and implementation; and
- Regional capacity for active participation in international policy networks.

The inception of the programme was endorsed by a majority of Vice Chancellors within SARUA's 62 public university members (as at December 2013). The programme aims to build capacity for *climate compatible development*, which is emerging as a platform for significant collaboration across the academic sector. This Knowledge Co-Production Framework is the result of an extensive mapping study of current climate-related priorities and capabilities of countries in the region, supported by funding from the UK and Dutch-funded Climate and Development Knowledge Network (CDKN).

The initial five-year plan, to be adapted in the next round of interaction between universities and SARUA, set out annual targets for the programme.

Table 3: High-level view of the SARUA climate change programme

Planned activities per year				
Phase 1	Phase 2	Phase 3		
Year 1	Year 2	Year 3	Year 4	Year 5 and onwards
<ul style="list-style-type: none"> Conduct an extensive mapping study of current priorities and capabilities of countries in the region. 	<ul style="list-style-type: none"> Engage stakeholders and commence with a network development approach aimed at implementing the revised network model. 	<ul style="list-style-type: none"> Fund and set up the first networks. Demonstrate early outcomes in research, teaching and learning and knowledge. Fund and set up additional networks. 	<ul style="list-style-type: none"> Continue with network capacity building and support. Develop and strengthen knowledge base and regional database of expertise. 	<ul style="list-style-type: none"> Continue with network capacity building and support. Develop and strengthen knowledge base and regional database of expertise. Evaluate and report on outcomes.

Within this programme, the mapping study is a key element to create a baseline for network establishment.

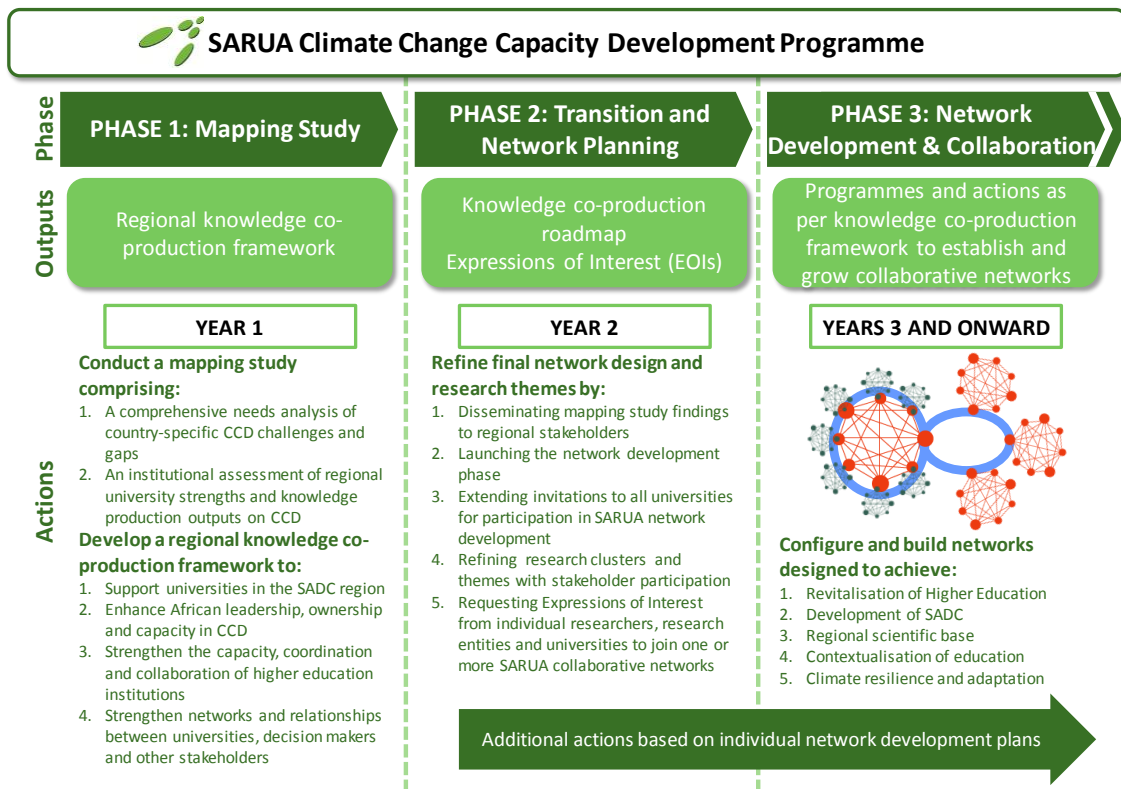


Figure 4: Overview of the SARUA Climate Change Capacity Development Programme

As illustrated in Figure 4 above, the programme seeks to bring about a number of specific outcomes over an initial five-year period, of which the mapping study Knowledge Co-Production Framework (this document, Volume 1) and the country-by-country Mapping Studies (contained in Volume 2) are the main outcomes for the first phase (2013-14). Other outcomes envisaged, which are to be informed and adapted by the next engagements as outlined in the roadmap and recommendations for system development (see section 5), are:

- **Collaborative network development** – Four collaborative networks established, including one macro-network comprising seven themed research clusters, with coordinating capacity and each with agreement for potential growth hubs.
- **Policy and stakeholder outreach** – Agreement of a Knowledge Co-Production Framework with policy makers and community development workers in each country.
- **Research** – Collaborative research clusters/networks operational, with 140 PhD students participating by the end of 2016/7. The PhD training programme offers exchange events and short courses between countries participating in the networks, plus international mentoring for the postdoc and senior staff cadres.
- **Teaching and learning** – Climate change issues have been fully mainstreamed across 50 percent of all development-related undergraduate courses run by universities participating in the SARUA network. A regional portfolio of Masters teaching modules is available, with customised programmes running in 50 percent of member countries, resulting in the graduation of 420 Masters students by the end of 2016/7.
- **Knowledge management** – A regional database or platform of climate-related research and teaching activities across the SARUA network provides the basis for networking and is updated on a regular basis; assigning responsibility for this will be a critical task.
- **Institutional learning and support** – Institutional factors enabling and constraining the development of the programme identified and addressed in development plans of 50 percent of participating universities.

The Knowledge Co-Production Framework provided via this mapping study and its analysis provides clear guidance on how these elements can be taken forward. The suggested key strategic directions and way forward, based on the findings of the mapping study, are contained in sections 4 and 5 of this document.

1.3 Climate compatible development and related key concepts

Climate compatible development

Climate compatible development (CCD) is low carbon, climate resilient development. The concept has been developed in recognition of the urgent need for adaptation, given current climate variability and the severity of projected climate impacts that will affect the region; and the need to reduce emissions as rapidly as possible to avoid more catastrophic climate change in the future. Thus, while CCD can be framed in different ways, given nationally and locally specific development trajectories, it does require that current and future climate risks are mainstreamed into development, and that both adaptation and mitigation are integral goals of development, as indicated by Figure 5 below. Thus CCD not only recognises the importance of both adaptation and mitigation in new development pathways, but, as further explained in

Mitchell and Maxwell (2010), “Climate compatible development goes one step further by asking policy makers to consider ‘triple win’ strategies that result in low emissions, build resilience and promote development simultaneously”. In the southern African context, poverty reduction, as an integral component and goal of regional and national development strategies, would be a desired co-benefit. Uncertainties in major drivers of change, including climate, socio-economic and political risks, necessitate that CCD be viewed as an iterative process, in which vulnerability identification and risk reduction responses are revised on the basis of continuing learning. Climate compatible development emphasises climate strategies that embrace development goals and development strategies that integrate the threats and opportunities of a changing climate.²⁴ Thus climate compatible development opens up new opportunities for interdisciplinary and transdisciplinary research, teaching and engagement with communities, policy makers and practitioners.

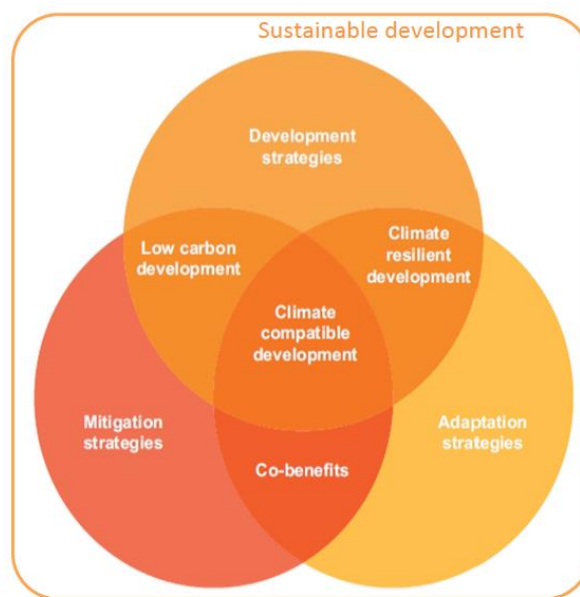


Figure 5: Conceptual framework for Climate Compatible Development (adapted from Mitchell and Maxwell, 2010)

While CCD is the central concept used in the work that is funded by CDKN, it is important that this is understood alongside the concept of climate-resilient development pathways as defined by the Intergovernmental Panel on Climate Change (IPCC) and the wider concept of sustainable development (see definitions below).

Climate-resilient pathways

The following definition of climate-resilient pathways is taken from the glossary of the Fifth Assessment Report prepared by the Intergovernmental Panel on Climate Change (IPCC)²⁵:

²⁴ Mitchell, T and Maxwell, S. 2010. “Defining climate compatible development.” Policy Brief. CDKN. Accessed on 14 April 2014. <http://r4d.dfid.gov.uk/PDF/Outputs/CDKN/CDKN-CCD-DIGI-MASTER-19NOV.pdf>

²⁵ IPCC. 2013. Fifth Assessment Report: Impacts, Vulnerability and Adaptation. Technical Summary, draft October 2013.

“Evolutionary processes for managing change within complex systems in order to reduce disruptions and enhance opportunities. They are rooted in iterative processes of identifying vulnerabilities to climate change impacts; taking appropriate steps to reduce vulnerabilities in the context of development needs and resources and to increase the options available for vulnerability reduction and coping with unexpected threats; monitoring emerging climate parameters and their implications, along with monitoring the effectiveness of vulnerability reduction efforts; and revising risk reduction responses on the basis of continuing learning. This process may involve a combination of incremental changes and, as necessary, significant transformations.” The IPCC highlights the need for a focus on both adaptation and mitigation, as indicated by the following sentence: “Climate-resilient pathways are development trajectories that combine adaptation and mitigation to realise the goal of sustainable development. They can be seen as iterative, continually evolving processes for managing change within complex systems.”²⁶

Sustainable development

The most widely accepted definition of sustainable development, as formulated in the Brundtland Commission’s ‘Our Common Future’ report in 1987, is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. This definition has been highly influential in shaping international environmental and development policy, since the Rio Earth Summit in 1992, where Agenda 21 was put forward as a global development plan for aligning goals of economic development with social and environmental sustainability. Early discussions on sustainable development tended to focus on the triple bottom line concepts of environment, economy and society separately. More recent discussions on sustainable development foreground the need for ‘strong sustainability’, in which society, economy and environment are seen as interacting in an inter-related, nested system. The concept of sustainable development, as used widely today, emphasises that everything in the world is connected through space, time and quality of life, and thus necessitates a systems approach to understanding and solving interlinked social, environmental and economic problems.

The Johannesburg Plan of Implementation, the key outcome of the 2002 World Summit on Sustainable Development hosted by South Africa, re-affirmed commitment to Agenda 21, and the Millennium Development Goals (MDGs). These are currently under review and will be expanded through Sustainable Development Goals (SDGs). In 2012 the Rio+20 Conference was held in Rio de Janeiro; the outcomes of this global summit on sustainable development are captured in a document entitled ‘The Future We Want’. One major shift in discourse and objectives from the early 1992 summit and the Rio+20 summit is a stronger concern for climate change and climate compatible development, especially the emergence of a low carbon future, accompanied and partly implemented by Green Economies. These international commitments, together with ongoing assessment of national sustainable development

²⁶ IPCC. 2013. “Fifth Assessment Report”.

concerns and goals, have driven the development of sustainable development policy and practice. The SDGs now being prepared to guide the post-2015 global development agenda will expand on earlier work undertaken within the framework of the Millennium Development Goals. The concept of CCD highlights the necessity of integrating current and future climate risks into development planning and practice, in the ongoing goal of achieving sustainable development.

1.4 Explaining knowledge co-production within a multi-, inter and transdisciplinary knowledge context

The scope and scale of problems and challenges associated with climate change, and climate compatible development – as shown in the needs analysis and in all the mapping study Country Reports require new forms of knowledge production. Multi-, inter- and transdisciplinary approaches to research are emerging in this context, from an understanding that research modelled on a ‘business as usual’ approach will not drive ingenuity in resolving complex social-ecological challenges like climate change.

Historically, the dominant approach to research is based on research in the single discipline. While single discipline research remains extremely important for development of in-depth and high quality knowledge, there is also a need to expand these approaches over time towards new, institutionally more complex forms of knowledge production.²⁷ Figure 6 shows that over time, research can build towards and include a wider range of research approaches that include multi-, inter- and transdisciplinary research approaches.

²⁷ This is because universities are organised and established around a disciplinary knowledge production structure.

Scales of problem and approach

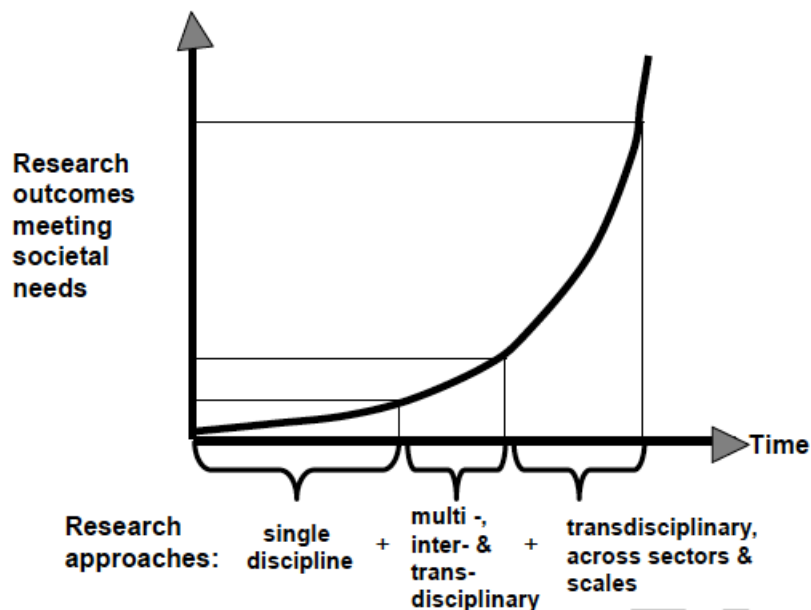


Figure 6: Emerging research approaches

[The diagram above shows research approaches and how they can emerge over time, in relation to outcomes that meet societal needs in the context of complex problems that need to be resolved such as climate resilient development. (Source: Palmer, Lotz-Sisitka, Fabricius, le Roux & Mbingi, in press)]

There is global evidence that more researchers are beginning to expand the single discipline approach to research, to include multi-, inter- and transdisciplinary approaches, and through this, their research is engaging across sectors and scales, and with changing social-ecological systems, complexity and integration.

Researchers working with these approaches argue that research outcomes that are generated in this manner have a greater chance of meeting societal needs.²⁸

These emerging approaches to research are clarified below.

- Multidisciplinarity:** This involves using different disciplinary studies to address a common empirical focus or problem. Existing disciplinary methods and structures are not changed in multidisciplinary research. Multidisciplinary research helps to develop different 'angles' or different understandings of a problem, from the vantage point of different disciplines.

²⁸ There is a growing body of scientific work that reflects this perspective. See for example: Hirsch Hadorn, G., H. Hoffmann-Riem, S. Biber-Klemm, W. Grossenbacher-Mansuy, D. Joye, C. Phol, U. Wiesmann and E. Zemp (eds). 2008. *Handbook of Transdisciplinary Research*. Springer.

- **Interdisciplinarity:** This marks a position between multi- and trans-disciplinarity. It involves multidisciplinary studies, but takes these further by synthesis work that takes place across the different disciplines. It involves the development of a common framework and perhaps the use of discipline-transcending terminology and methodologies while maintaining certain critical disciplinary distinctions. Important in interdisciplinary research are processes of synthesis and a 'blending' or relating of knowledge from different disciplines.

- **Transdisciplinarity:** This entails using strategies from interdisciplinary research, but it also involves taking this further into development of new theoretical understanding and new forms of praxis that are needed across sectors and at different scales. These are based on an inter-penetration of disciplinary perspectives or understandings, and a 'creative re-deployment' of these in contexts of practice²⁹; often contexts that are complex.

It is possible to differentiate between 'weak transdisciplinarity', which only relates existing knowledge to practice and 'strong transdisciplinarity', which goes more deeply into developing new and more complex ways of understanding and engagement in contexts where new forms of theory and practice come together³⁰ across sectors and at different scales.

Transdisciplinarity involves different modes of reasoning: the rational, the relational and the practical. Transdisciplinarity research presents an 'unfinished scientific programme' that offers fascinating possibilities for advanced reflection and research.³¹ This is increasingly being seen as a real opportunity for innovation. Transdisciplinary research, oriented towards knowledge production for societal change, can be seen as a process that can develop over time.

- **Knowledge co-production:** Traditionally (and currently) most research partnerships and funding arrangements still focus on the single discipline. However, international research platforms, especially those dealing with climate change and development related concerns are changing towards inter- and transdisciplinary knowledge co-production. Climate compatible development can be described as a social-ecological science with many intractable and complex dimensions that arise at the interface of environment and societal relations and social practices. Engaging in inter- and transdisciplinary knowledge production (because of its interest in new synthesis and creative deployment of knowledge in contexts of practice across scales and sectors) requires new ways of relating, thinking and doing.

As a result, and resulting from the nature of CCD concerns, new partnerships are needed between researchers and a wider range of societal actors. Movement in this direction depends on: 1) society becoming widely involved in the research domain (this

²⁹ Bhaskar, R. 2010. "Contexts of interdisciplinarity: interdisciplinarity and climate change." In *Interdisciplinarity and Climate Change. Transforming knowledge and practice for our global future*, edited by R. Bhaskar, F. Frank, K. Hoyer, P. Naess and J. Parker. London: Routledge.

³⁰ Max-Neef, M. A. 2005. "Commentary: Foundations of Transdisciplinarity," *Ecological Economics* 53: 5-16.

³¹ Max Neef, "Commentary: Foundations of Transdisciplinarity".

includes researchers, managers, practitioners and civil society); 2) time investments to develop the trust between and competence of research partners and participants; 3) a willingness to recognise that there are different forms of knowledge that need to interact for societal change to occur; and 4) learning by doing, or social learning.³² Knowledge co-production is also referred to as knowledge co-creation. This requires working to bring together different contributions in the knowledge production process.³³

1.5 Methodology and orientation to the Knowledge Co-Production Framework

The scope of CCD is necessarily wide and cross-sectorial. Consequently, the **Knowledge Co-Production Framework** that is derived from the needs analysis and institutional analysis across the 12 SADC countries does not focus on sectoral policy and institutions, but concentrates on overarching policy and knowledge co-production areas or themes that deal with mainstreaming climate change into knowledge production systems, planning and development (see section 4).

As indicated above, the **mapping study** was constructed based on a needs analysis and institutional analysis undertaken country-by-country across twelve southern African countries. The mapping study is **multidisciplinary**, involving active climate change researchers from a range of disciplines including but not limited to the Natural and Environmental Sciences, Agriculture, Engineering, Law, Education, Psychology, Sociology, Gender Studies, Development Studies, Economics and others. It is also **multi-voiced** – involving policy makers; national and regional stakeholders such as government department officials, UNFCCC country co-ordinators, organised business, national research organisations, major national non-governmental organisations and community representatives; and university managers, staff and students.

The mapping study involved 12 of the 15 countries in the SADC region, and 57 of the 62 universities in those countries that are affiliated to the Southern African Regional Universities Association (SARUA) (as at December 2013). Additional universities, not currently associated with SARUA, also participated in the mapping study (see participation details in Table 4 below). In each of the 12 countries participating in the mapping study, the following **methodology** was followed (more details can be found in Appendix B):

1. An analysis of national stakeholders and university researchers involved in CCD policy, practice and research in each of the 12 participating countries was undertaken.





³² Adapted from the Akili Complexity Forum draft proposal, NRF South Africa (March 2010).








³³ This section is adapted from a forthcoming paper by Palmer, Lotz-Sisitka, Fabricius, le Roux and Mbingi (in press) and from a text on multi-, inter- and transdisciplinarity in the UNEP Mainstreaming Environment and Sustainability in African Universities Programme toolkit 'ESD Innovations in universities' authored by Lotz-Sisitka, Rosenberg, Babikwa and Lupele in 2008 (www.unep.org/training).


2. Two questionnaires, one for university professionals (Appendix C) and one for stakeholders (Appendix D) were distributed to all national stakeholders and universities identified.
3. Background document research was undertaken to establish existing knowledge of CCD policy, knowledge and research needs, and institutional arrangements. This was consolidated into a 'Background Information Document' (BID) on a country-by-country basis and distributed to all national stakeholders and university researchers prior to a country workshop, along with information about the SARUA Climate Change Counts mapping study.
4. All national stakeholders and university researchers identified were invited to a national workshop which was co-hosted by SARUA universities in most countries.
5. Detailed workshop reports were produced and circulated to all workshop participants for verification following the workshop.
6. All national stakeholders and university researchers identified were sent reminders to complete questionnaires.
7. The Background Information Document (document analysis), together with questionnaire data received and workshop reports, complemented by additional desktop research where necessary, were used to compile the mapping study.
8. Mapping study reports were produced for each country, which provide background material and further detail to extend the summaries contained in Appendix A. These are potentially useful for supporting country-level climate change and CCD research and knowledge co-production pathways (as mentioned above, these are contained in an accompanying Monograph, Volume 2).

All the above has informed the development of this Knowledge Co-Production Framework. Limitations of the mapping study are outlined in more detail below. A key issue influencing the mapping study was a lack of baseline information on responses to CCD and climate change in southern African universities, as discussed in more detail below. Participation in the study is summarised in Table 4 below.

Table 4: Participation analysis [SH: stakeholders; INS: universities]

SADC member country	Flag	SARUA member institutions [E] indicates endorsement of programme [Host] indicates in-country workshop host	No. of workshop attendees	No. of survey respondents
Angola		Universidade Agostinho Neto [Host] Katyavala Bwila University [E] Universidade Jose Eduardo dos Santos	49	SH: 4 INS: 5 TOTAL: 9
Botswana		Botswana International University of Science and Technology [E] University of Botswana	31	SH: 15 INS: 16 TOTAL: 31
Malawi		University of Malawi [E] [Host] Mzuzu University	55	SH: 10 INS: 27 TOTAL: 37
Mauritius		University of Mauritius University of Technology Mauritius Université des Mascareignes [Host]	45	SH: 9 INS: 17 TOTAL: 26

SADC member country	Flag	SARUA member institutions [E] indicates endorsement of programme [Host] indicates in-country workshop host	No. of workshop attendees	No. of survey respondents
Mozambique		Eduardo Mondlane University [E] Lurio University [E] Pedagogical University	48	SH: 4 INS: 6 TOTAL: 10
Namibia		University of Namibia [E] [Host]	16	SH: 13 INS: 17 TOTAL: 30
Seychelles		University of Seychelles [E] [Host]	21	SH: 13 INS: 2 TOTAL: 15
South Africa		Cape Peninsula University of Technology University of Cape Town [E] University of Stellenbosch [E] University of the Western Cape Central University of Technology University of the Free State Durban University of Technology [E] University of KwaZulu-Natal University of Zululand Nelson Mandela Metropolitan University [E] University of Fort Hare [E] Rhodes University [E] Walter Sisulu University for Science and Technology [E] University of Johannesburg [E] University of the Witwatersrand [E] North-West University [E] Vaal University of Technology [E] University of Limpopo [E] University of Venda [E] University of Pretoria [E] [Host] Tshwane University of Technology [Host] University of South Africa (UNISA) [E]	65	SH: 14 INS: 41 TOTAL: 55
Swaziland		University of Swaziland [E] [Host]	52	SH: 20 INS: 12 TOTAL: 32
Tanzania		Open University of Tanzania [E] Muhimbili University of Health and Allied Sciences Sokoine University of Agriculture University of Dar es Salaam [E] [Host] State University of Zanzibar Mzumbe University [E] Ardhi University	43	SH: 24 INS: 16 TOTAL: 40
Zambia		Copperbelt University [E] University of Zambia [E] [Host] Mulungushi University [E]	53	SH: 16 INS: 10 TOTAL: 26

SADC member country	Flag	SARUA member institutions [E] indicates endorsement of programme [Host] indicates in-country workshop host	No. of workshop attendees	No. of survey respondents
Zimbabwe		Bindura University of Science Education [E] Chinhoyi University of Technology Great Zimbabwe University Harare Institute of Technology [E] Lupane State University [E] Midlands State University [E] National University of Science and Technology [E] University of Zimbabwe [E] Zimbabwe Open University [E] [Host]	85	SH: 16 INS: 22 TOTAL: 38

The engagement associated with the mapping study, in the country workshops, was appreciated by university professionals and stakeholders alike, as shown by some of these citations:

“I received exposure to what others are engaged in and the needs of other stakeholders in CCD.”

“Fully incorporating CCD in teaching curriculum was the highlight for the day.”

University of Namibia participants

“I am amazed at how often SARUA has been mentioned in the exercise in which we identified networks for CCD. So this is a new network that has been established now. Previously this was just at the level of the Vice Chancellors. But now, with this workshop, we see the usefulness of SARUA at our level, and in the country, as a national network.”

Swaziland senior academic

“For once in our lives we felt: why don’t activities like this continue, we would like to collaborate with our university. It was an opportunity for us to say, this is what we do out there, and also to hear the universities’ point of view. So really it was an excellent opportunity to share ideas. As a group we have highlighted issues of improvement, areas in which we believe the university should be innovative. UNISWA as the leading university in the country should take the lead.”

Swaziland parastatal manager

The **needs analysis** identified knowledge and research needs, and institutional and individual capacity gaps relevant to climate change and climate compatible development in 12 SADC countries (summarised in section 2 below, with further detail in Appendix A, and in the individual Country Reports presented in Volume 2). The needs analysis points to implications for knowledge co-production at the regional level.

The **institutional analysis** identified existing research, teaching and community and policy outreach activities that are associated with climate compatible development in SADC universities, as well as core areas of expertise, knowledge networks, and existing centres of

expertise and centres of excellence for climate change and climate compatible development knowledge co-production (summarised in section 3 below, with further detail in Appendix A and in the individual Country Reports in Volume 2). The institutional analysis also points to implications for knowledge co-production at a regional level.

The study provides a ‘knowledge base’ of climate compatible knowledge co-production needs and possibilities in the SADC region (derived from twelve countries), and a database of active CCD researchers and stakeholders in the southern African region. It reveals the diversity of climate change and climate compatible development needs in southern Africa, but also the similarities, and most importantly, it identifies and maps out areas for future collaboration and sets out a roadmap for networked knowledge co-production within the SADC region.

1.6 Limitations of the mapping study




This mapping study was constrained by a) a lack of baseline data on knowledge and research gaps for climate compatible development and university-based responses in all the twelve countries involved in the mapping study, and b) by time and resource constraints that did not allow for **in-depth field visitation, individual interviewing or observation** before, during and after the consultation process. Moreover, the information generated at the country workshops relates to the number of participants, their expertise and the number of different sectors and institutions that were present. Further, while every effort was made to obtain questionnaire responses from as wide a range of stakeholders as possible – in total 1118 individuals were contacted during the course of this study to provide inputs in some way – and follow-ups were made post-workshop to enhance this, the range of questionnaire responses obtained does provide certain limitations to the data set. However, the **best available information was carefully consolidated, reviewed and verified** in the construction of this Knowledge Co-Production Framework. Overall, the mapping study was further constrained by a budget cut imposed mid-way through the study, which impacted on the workshop approach, reduced the depth of analysis possible for some countries, and required in-kind sponsorship as a precondition to hold in-country workshops. While this was achieved, workshop participation was constrained by the fact that no sponsorship for local travel or accommodation was available.

While much information could be obtained on climate change- and CCD-related knowledge gaps, research needs and capacity gaps, there is obviously more to be learned about these. Similarly, as much information as possible was obtained on ‘who is doing what’ and on existing research, knowledge co-construction practice and possibilities, but there is clearly also more to learn about these. This Regional Knowledge Co-Production framework, based on the mapping study, therefore presents as a useful ‘initial document’ and it is hoped that universities and Ministries of Higher Education in southern African countries can take this analysis forward in ongoing mapping and planning activities related to CCD research and knowledge co-production.

1.7 Expanding the mapping study

There are numerous ways to expand this study, most notably by administering the questionnaires (included in Appendices C and D) in a manner that would include a larger percentage of academics at all universities in southern African countries, than we were able to target for this mapping study, and in a way that would allow for aggregate data within and across Universities, Faculties and Departments (Appendix C). The scope of such a detailed analysis lay beyond the capacity of the current mapping study. Data from questionnaires is therefore indicative rather than conclusive. Similarly, the questionnaire for stakeholders can be administered with additional regional, national and local stakeholders (Appendix D) involved in environment and development initiatives in southern African countries to understand the full scope of climate change and CCD responsiveness in the region, and to further develop the knowledge co-production capacity for CCD in SADC. In many ways therefore the SARUA study, as reported in the mapping study Country Report, sets out the pathway forward for more detailed and ongoing reflexive analysis of CCD knowledge co-production capacity in southern Africa, and through the questionnaires and analysis provided for in this document, begins to provide for ongoing monitoring and development capability for CCD knowledge co-production in southern Africa. The following countries were not included in the mapping study due to a lack of budget to cover all 15 countries, and the short duration of the mapping study:

Table 5: Countries not included in the 2013 mapping study

Countries and Universities not included in 2013 mapping study		
Democratic Republic of Congo		University of Goma University of Lubumbashi [E] Official University of Bukavu
Lesotho		University of Lesotho [E]
Madagascar		University of Fianarantsoa [E]

These countries and universities can be added by SARUA in future through a separate mapping study, or they can be incorporated into the regional Knowledge Co-Production Framework by way of an own assessment and voluntary participation in the identified themes.

2 NEEDS ANALYSIS

2.1 Regional climate change risks and need for CCD knowledge co-production

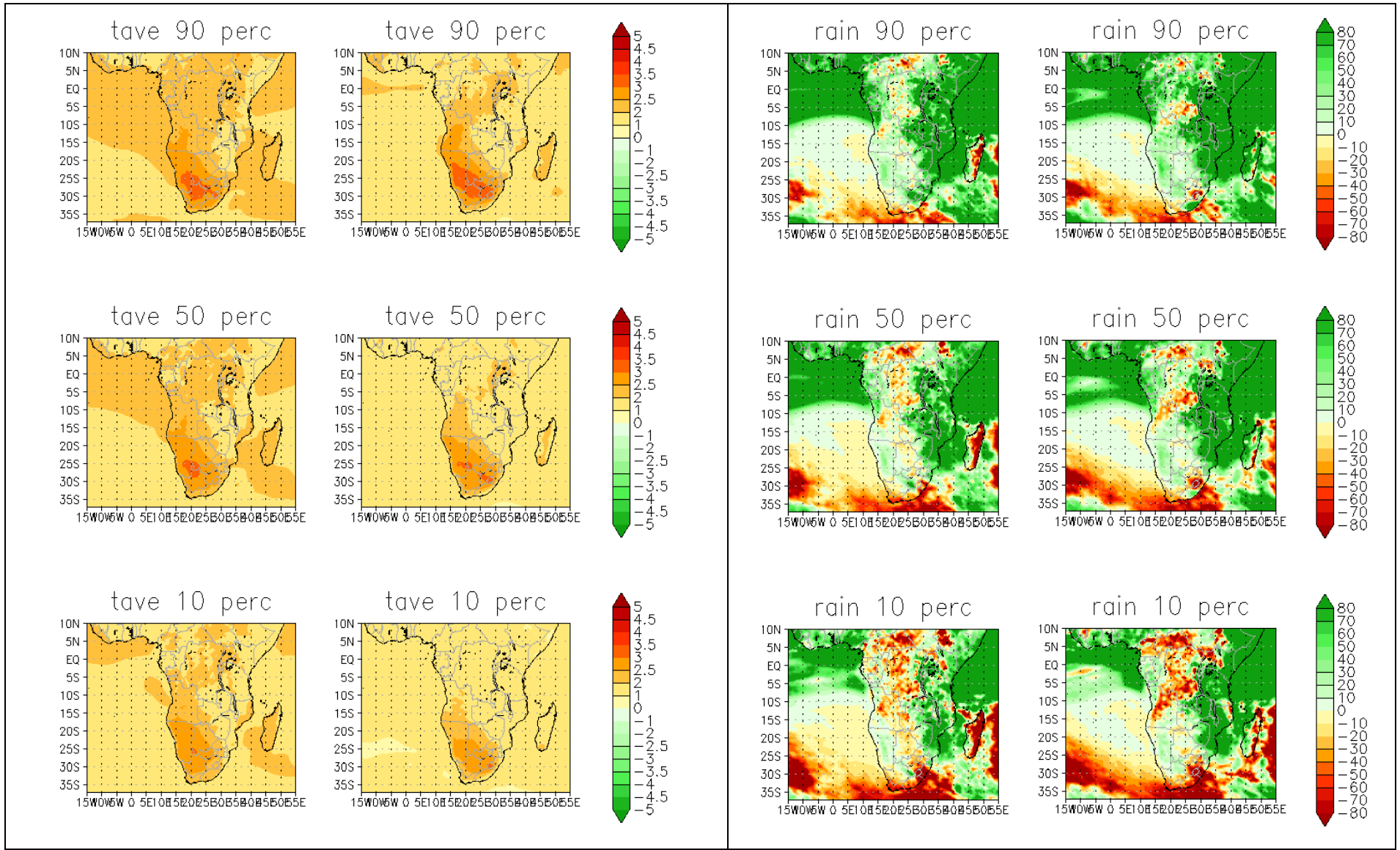
2.1.1 Regional observed and projected climate changes

New risks introduced by climate change arise from the interaction between increased temperature and changes in precipitation. Already the *observed* temperature changes for southern Africa are higher than the increases reported for other parts of the world (IPCC, 2007); *projections* indicate a 3.4°C increase in annual temperature (up to 3.7°C in spring), when comparing the period 1980-1999 with the period 2080-2099. Mean warming over land surfaces in southern Africa is likely to exceed the average global land surface temperature increases in all seasons. Recent analyses show a likely reduction in precipitation in the south-western parts of the region, extending in a north-easterly direction from the desert areas in Namibia and Botswana, with wetter conditions in some parts – for example over the Drakensberg range. Drier winters are projected over large parts of southern Africa by the end of the century, as are drier summers, related to late onset of rainfall in the summer rainfall regions. Further projections are for overall drying for southern Africa, with increased rainfall variability; a delay in onset of the rainy season with an early cessation in many parts; and an increase in rainfall intensity in some parts.³⁴

Figure 7³⁵ shows observed and projected temperature and precipitation changes for the southern African region.

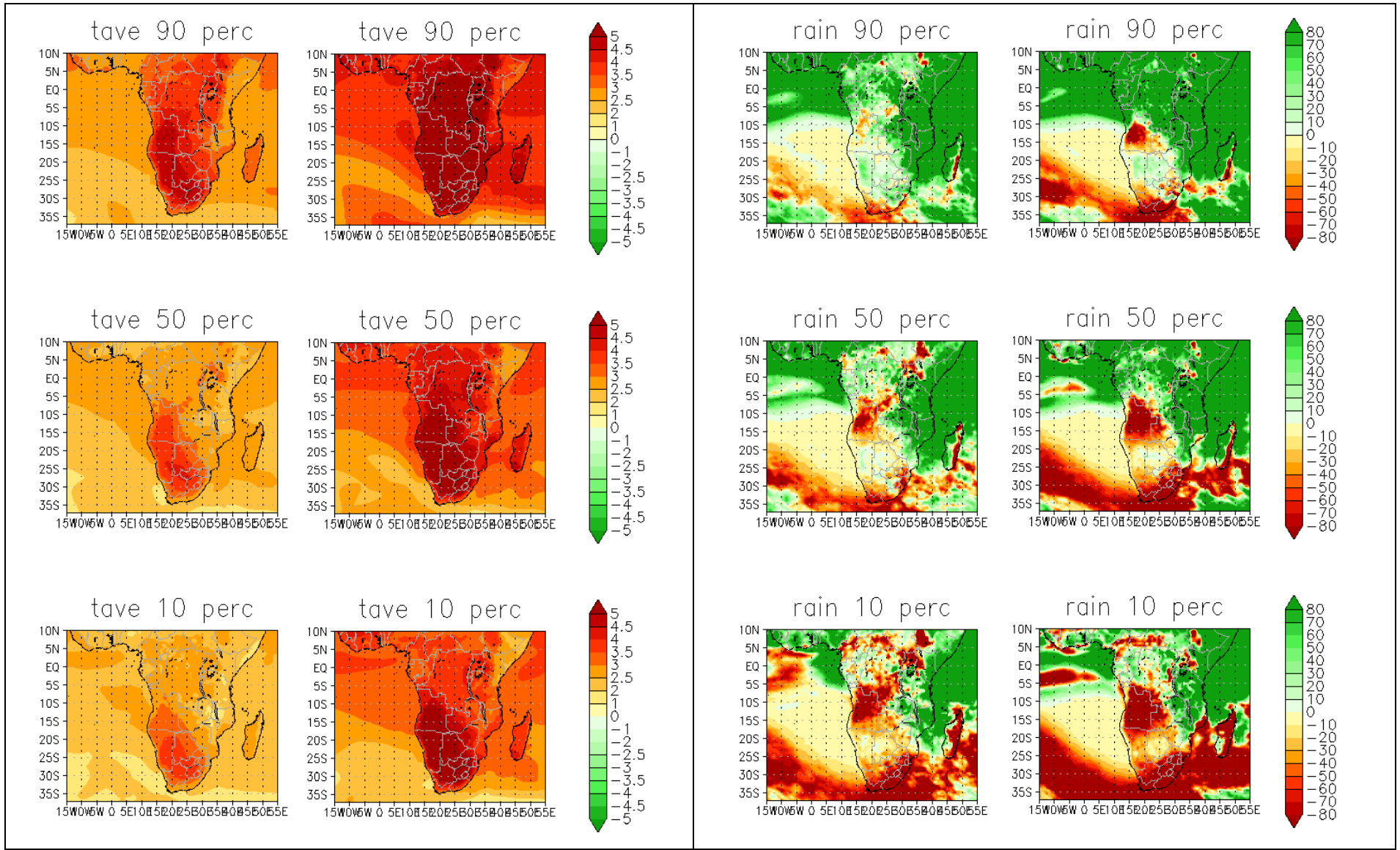
³⁴ The reference for these projections is analysis for southern Africa carried out by the Climate Systems Analysis Group (CSAG) at the University of Cape Town using 21 model simulations; supplemented by findings of the 2007 IPCC 4th Assessment Report [IPCC (2007a) *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller. Cambridge UK and New York, NY, USA: Cambridge University Press]. The CSAG analysis was conducted for the land area falling between 12-35°S and 10-52°E, and for the emissions scenario named "A1B" – see http://media.csag.uct.ac.za/faq/qa_3impacts.html. This area encompasses South Africa, Lesotho, Swaziland, Namibia, Botswana, Zimbabwe, Mozambique, Madagascar, Zambia, most of Malawi and the southern half of Angola.

³⁵ The projections of future climate change displayed in Figures 7 and 8 were provided by the Council for Scientific and Industrial Research (CSIR), and have been obtained through downscaling the output of a number of coupled global climate models (CGCMs) to high-resolution over Africa, using a regional climate model. All the CGCMs downscaled contributed to the Coupled Model Intercomparison Project Phase 5 (CMIP5) and Assessment Report 5 (AR5) of the Intergovernmental Panel on Climate Change (IPCC). Details on these simulations are provided in the LTAS Phase 1 Technical Report no. 1. The regional model used is the conformal-cubic atmospheric model (CCAM), developed by the CSIRO in Australia. For various applications of CCAM over southern Africa, see Engelbrecht, F.A., W.A. Landman, C.J. Engelbrecht, S. Landman, B. Roux, M.M. Bopape, J.L. McGregor and M. Thatcher. 2011. "Multi-scale climate modelling over southern Africa using a variable-resolution global model," *Water SA* 37: 647-658.



Note: The 90th percentile (upper panel), median (middle panel) and 10th percentile (lower panel) are shown for an ensemble of downscalings of three CGCM projections, for each of the time-slabs. The downscalings were performed using the regional model CCAM. All the CGCM projections are contributing to CMIP5 and AR5 of the IPCC, and are for RCP4.5.

Figure 7: Projected change in the annual average temperature (°C) and annual average rainfall (mm) over the SADC region, for the time-slab 2040–2060 and 2080–2099, relative to 1970–2005



Note: The 90th percentile (upper panel), median (middle panel) and 10th percentile (lower panel) are shown for an ensemble of downscalings of three CGCM projections, for each of the time-slabs. The downscalings were performed using the regional model CCAM. All the CGCM projections are contributing to CMIP5 and AR5 of the IPCC, and are for RCP8.5.

Figure 8: Projected change in the annual average temperature (°C) and annual average rainfall (mm) over the SADC region, for the time-slab 2040–2060 and 2080–2099, relative to 1970–2005

Figures 7 and 8³⁶ show the projected change in the annual average temperature (°C) and annual average rainfall (mm) over the SADC region, for the time-slabs 2040–2060 and 2080–2099, relative to 1970–2005. The Figure 7 CGCM projections are for RCP4.5 and Figure 8 projections are for RCP8.5.

Should the trajectory of global emissions not be curtailed, and global temperatures rise to 4°C above pre-industrial levels, southern Africa will be likely to see decreases of up to 30 percent in rainfall each year, and declines of 50-70 percent in groundwater recharge (UNEP 2013).³⁷ Additionally, coral reefs are projected to be entirely extinct before we even enter a “4°C World”, thus resulting in the loss of the essential support systems for marine fisheries, tourism and coastal protection against sea-level rise and storm surges that they provide (ibid.).

2.1.2 Regional climate change impacts and vulnerabilities

Globally, southern Africa is one of the most vulnerable regions to the impacts of climate change. Current climate variability and vulnerability to extreme events such as floods and droughts is high, and a range of existing stressors, including water availability, land degradation, desertification and loss of biodiversity constrain food security and development. Reduction of the region’s structural poverty is further challenged by health threats such as malaria and HIV/AIDS, as well as institutional and governance aspects. Climate change will compound many of these interlinked problems for regional livelihoods, which are often based on subsistence agriculture, and for regional economies, which are often dependent on natural resources. The region’s high vulnerability to climate change is a function of the severity of the projected physical climate impacts and this multi-stressor context, as further discussed below, which heightens both exposure and sensitivity to the impacts.

The southern African region faces considerable impacts from the projected physical climatic changes mentioned above. Additional climate-driven risks, in addition to the direct effects of increased temperature and increased incidence and/or severity of extreme events like floods and droughts, include more wind storms, hot spells and wild fires. Both the heightened and the new risks will act at the local level to compound other stressors and development pressures faced by people, and at the national level on the region’s natural resource-dependent economies. The all-encompassing nature of the impacts highlights the fact that climate change is not a narrow environmental problem, but a fundamental development challenge that requires new and broad-based responses, emphasising the need for additional research across the range of disciplines, and for an interdisciplinary approach to research within and amongst universities and research institutes in the region.

³⁶ Engelbrecht et al. 2014. “Multi-scale climate modelling”. Climate trends and scenarios for South Africa. Long-term Adaptation Scenarios Flagship Research Programme (LTAS). Phase 1, Technical Report no. 1.

³⁷ UNEP. 2013. “Africa’s Adaptation Gap Technical Report: Climate change impacts, adaptation challenges and costs for Africa,” available at <http://www.unep.org/pdf/AfricaAdapatationGapreport.pdf>

A recent exercise to map current and future climate-related vulnerability in southern Africa found a current band of high exposure lying between 12° and 25°S, which is projected to extend south to the 30°S latitude and into the north-western parts of the region by 2050.³⁸ This analysis found that vulnerability to climate impacts would intensify in the following areas: eastern and northern Angola, parts of the Democratic Republic of the Congo (DRC), southern Malawi, the highveld of South Africa, parts of Madagascar, and southern and western Zambia. A key factor in the water-stressed region is the impacts of climate change on water availability and access – as Schulze (2007) points out, water poverty is already acute in many meso-scale catchments and will in all likelihood be exacerbated by climate change.³⁹

Climate change impacts will manifest in a locally specific way, highlighting the need to build resilience broadly, in addition to narrower interventions that target specific aspects of the problem. Nevertheless, in the southern African context, in which many livelihoods depend directly on natural resources like non-timber forest products, rainfed agriculture and livestock, common widespread impacts are likely to be increased likelihood of crop failure; increased livelihood insecurity; more hunger, diseases and mortality; forced sales of household assets such as livestock; indebtedness, migration and dependency on food aid; and a downward spiral in human development indicators like health and education.⁴⁰ These interlinked causal chains highlight the need for additional research on the social dimensions of how climate change will manifest in the region.

Additionally, the SADC region is highly vulnerable to existing and potential global processes and shocks such as the financial crisis, oil and food price increases, and the regional energy crisis. This calls for building institutional capacities for conflict management, mediation and (speaking broadly) forecasting capabilities.⁴¹ Such capacities will also be of value in enhancing the regional response to climate change, and constitute an important element of climate change capacity development, within and beyond the higher education institutions.

These regional impacts and vulnerabilities can be further contextualised within the findings of the Africa Environment Outlook-3 (AEO-3), a flagship publication prepared by UNEP on behalf of AMCEN, which made a critical analysis of the link between environment and health. The report revealed that 28 percent of Africa's disease burden is directly related to the decline in environmental integrity, with diarrhoea, respiratory infections and malaria accounting for 60 percent of known environmentally related diseases in Africa. It emphasised that climate

³⁸ Midgley, S.J.E., R.A.G. Davies and S. Chesterman. 2011. *Climate Risk and Vulnerability Mapping in Southern Africa: Status quo (2008) and future (2050)*. For the Regional Climate Change Programme for Southern Africa (RCCP), UK Department for International Development (DFID). Cape Town: OneWorld Sustainable Investments.

³⁹ R.E. Schulze. 2007. "Some foci of integrated water resources management in the "South" which are oft-forgotten by the "North": A perspective from southern Africa," *Water Resources Management* 21:269–294.

⁴⁰ Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds). 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.

Midgley et al. 2011. *Climate Risk and Vulnerability Mapping in Southern Africa*.

⁴¹ Giuffrida, L. and H. Müller-Glodde. 2009. Strengthening SADC institutional structures – capacity development is the key to the SADC Secretariat's effectiveness. Chapter 6 in *Monitoring Regional Integration in Southern Africa Yearbook 2008*, available at http://www.kas.de/upload/auslandshomepages/namibia/MRI2008/MRI2008_06_Giuffrida.pdf.

change is adding new challenges as it occasions emergence and re-emergence of diseases in areas previously free of diseases, and showed increasing implementation challenges due to weak institutional structures and poor sectoral coordination.⁴²

Notwithstanding these severe projected impacts, there are significant opportunities for moving towards more resilient livelihoods and economies in the region. For example, through social, behavioural and technical changes to safeguard the important agricultural sector through scaling up agroforestry and conservation agriculture and developing more heat- and drought-tolerant crop and livestock varieties, or to harness potential developmental benefits through retro-fitting old and designing new infrastructure to be resilient to projected climate impacts. Harnessing these opportunities will require targeted research, knowledge dissemination and technology innovation; this is where the higher education sector can play a valuable role, for example through the SARUA climate change programme.

2.1.3 SADC level priorities for CCD co-operation

This section summarises the main SADC level priorities for climate change and CCD, as expressed in key regional policies, frameworks and other documents. These priorities can be further contextualised within the ethos of the Gaborone Declaration on Climate Change and Africa's Development, developed at the fifth session of the African Ministerial Conference on Environment (AMCEN), which took place in Gaborone, Botswana from 15 to 18 October 2013. The declaration reaffirmed adaptation as an essential priority and necessity for Africa, and urged developed countries, and the Green Climate Fund Board, once it becomes operational, to quickly scale up support for the implementation of adaptation plans and measures in Africa. The declaration called for an international mechanism to address loss and damages associated with the adverse effects of climate change, including particularly its impact on agriculture; and the development of a comprehensive work programme covering a range of areas from finance to technology transfer and capacity building, to support sustainable agricultural production. Institutions, including African centres of excellence, were called upon to support the elaboration of the research agenda in support of the African common position.

Environment is a cross-cutting issue in SADC's Regional Indicative Strategic Development Plan (RISDP)⁴³ where together with sustainable development it is represented as a priority cross-sectorial intervention area (number 6). The SADC Environment Protocol is at the final draft stage and awaiting Ministerial approval. In 2012, SADC developed a Policy Paper on Climate Change.⁴⁴ Subsequently, SADC has developed a draft Climate Change Programme, awaiting finalisation. The Programme has the goal of increasing the region's resilience to climate change effects, and to align climate change initiatives, nationally and regionally, through an integrated

⁴² http://www.unep.org/roa/Portals/137/Gaborone_declaration.pdf, accessed 27 November 2013.

⁴³ SADC. 2004. *Regional Indicative Strategic Development Plan*. Gaborone: SADC Secretariat.

⁴⁴ Lesolle, D. 2012. *SADC Policy Paper on Climate Change: Assessing the Policy Options for SADC member states*. SADC Research and Policy Paper Series, 01/2012.

approach.⁴⁵ Capacity development is a key component, with a focus not only on acquiring knowledge, skills and capacity to understand and address climate change, but also to promote attitude and behavioural change.⁴⁶ These elements of the SADC Climate Change Programme highlight the importance of the proposed focus on different aspects of capacity development in the SARUA programme, as discussed further below and in subsequent sections, including the importance of further involving ‘non-traditional’ social science disciplines such as psychology, sociology and communications, to research methodologies for promoting changes in behaviour. Both adaptation and mitigation are key components of the programme, the latter in the context of encouraging countries to embrace low-carbon development pathways, indicating congruence between SADC climate change priorities and the focus on climate resilient or climate compatible development of the SARUA programme. Under the ‘Research, Technology Development and Transfer’ component, the programme seeks to generate evidence-based information, develop appropriate technologies for sustainable development and poverty reduction and disseminate the technologies. Regarding funding, the programme aims to establish a regional fund on climate change, and to facilitate access to climate funding on the part of member states. These priorities point to the need for additional research and action in the technological, sociological and economic/financial spheres and disciplines.

SADC has recently held a Regional Climate Change Symposium (in September 2013), and is currently engaged in developing a Regional Climate Change Strategy (ongoing as at September 2013).

In addition to the forthcoming Climate Change Policy, key policy/legal frameworks and programmes in the prioritised SADC sector of water are indicative of SADC’s approach to and priorities for climate change, namely the *Protocol on Shared Watercourses*, the *Regional Strategic Infrastructure Development Support Programme* and the 2011 climate change and water strategy set out in the document *Climate change adaptation in SADC: A strategy for the water sector*. The climate change and water strategy has the goal of improving climate resilience in southern Africa through integrated and adapted water resources management at regional, river basin and local levels. Key adaptation strategies set out for a regional approach comprise water governance, infrastructure development, and water management. The strategy also highlights the need to build on indigenous knowledge when developing adaptation measures for the water sector, and focuses on the implementation of both “no-regret” and “low-regret” measures, with a 20-year time frame. It calls for adaptation measures at different levels, at different stages of the adaptation process and in different areas of interventions.

Despite positive recent developments in developing relevant policies and strategies, there are concerns that SADC as a regional entity has been weak in translating policy statements and

⁴⁵ Information on the programme is drawn from a presentation made by Sibongile Mavimbela-Dlamini, entitled ‘SADC Overview of Climate Change’. Where? More detail...

⁴⁶ The draft SADC Climate Change Programme further supports the implementation of climate change programmes in member states guided by the indicative conceptual outline of a comprehensive framework of African climate change programmes (AMCEN, 2009), Southern Africa Climate Framework and national circumstances.

declarations into concrete implementation plans,⁴⁷ and has until recently lacked a clear agenda on climate change.⁴⁸ It is hoped that the forthcoming Climate Change Policy and the Regional Climate Change Strategy will go a long way towards addressing these constraints, as could the implementation of the SARUA Knowledge Co-Production Framework.

Key regional capacity development programmes on climate change include the following:

- SADC Climate Risk Capacity Building Programme, which seeks to build the capacity of planners to understand and address climate risk in their planning and decision-making processes at regional, national and sub-national levels;
- CLIMTRAIN (Climate change mitigation and adaptation) Project, which seeks to strengthen in-house knowledge on climate change issues in rural development; develop resource material; and build partnerships;
- SADC Regional Environmental Education Programme (SADC REEP), which has facilitated climate change education in a number of universities and colleges through the Mainstreaming Environment and Sustainability in African Universities (MESA) programme between 2009 and 2013; has co-facilitated the writing of a book on Climate Change Education in schools in SADC to be published by UNISA in 2013; and is currently facilitating a Climate Change adaptation and mitigation training course in SADC Trans-frontier Conservation Areas through a project funded by GIZ (2013 – 2014).⁴⁹

The SADC REEP has been working with the SADC Education and Skills Development Programme on enhancing mainstreaming of education for sustainable development, in which climate change education has been a factor. The SADC Education sector and Education Ministers are in favour of an approach to education for sustainable development that integrates climate change among other cross-cutting and emerging issues in school, teacher education and curriculum development. A holistic approach is implied here, and SARUA could play a key role in providing policy briefs in this direction, and through the implementation of proposals for curriculum innovation and mainstreaming on climate change – see sections 4 and 5. Such an initiative would be supported by the SADC Environment sector which would like to see mainstreaming of climate change in Higher Education and the school system.

Moving outwards from the region, the Common Market for Eastern and Southern Africa (COMESA), the East African Community (EAC) and SADC signed a Tripartite Agreement for the Implementation of the Programme on Climate Change Adaptation and Mitigation in Eastern and Southern Africa on 15 July 2012, after the Rio+20 Summit held under the auspices of the United Nations Conference on Sustainable Development (UNCSD). Following the piloting of the Climate Change Initiative, the three Regional Economic Communities (RECs) agreed to address

⁴⁷ Richards. 2008. Assessing progress on climate change policy and practice: Observations from South Africa and SADC. Policy: issues and actors Vol 21 no 1. Johannesburg: Centre for Policy Studies. Available at http://www.cps.org.za/cps%20pdf/pia21_1.pdf

⁴⁸ Ruppel, O.C. and K. Ruppel-Schlichting. 2012. "Climate change and human security: relevant for regional integration in SADC?" (Chapter 2) in *Monitoring Regional Integration in Southern Africa Yearbook 2011.*, 32-71. Trade Law Centre for Southern Africa / Konrad Adenauer Stiftung.

⁴⁹ This list is indicative, rather than comprehensive, in line with the scope limitations of the mapping study.

the threatening challenge of climate change in eastern and southern Africa, and thus have jointly developed a programme on Climate Change Adaptation and Mitigation in COMESA-EAC-SADC Region. The overall objective of the Programme is to address the impacts of climate change through successful adaptation and mitigation actions aimed at building socio-economic resilience of communities through climate-smart agriculture (CSA). The programme aims to increase investments in climate resilient and carbon efficient agricultural practices and strengthen linkages between agriculture, forestry, and other land uses (AFOLU) and renewable energy practices in the COMESA-EAC-SADC Member/Partner States.⁵⁰

The signing of the Tripartite Agreement demonstrates the collective efforts of the RECs to address climate change in the region, within the framework for follow-up action agreed by the Rio+20 Summit. The Summit acknowledged climate change as a cross-cutting and persistent crisis and resolved to increase sustainable agricultural production. The signing of the Agreement also provides an opportunity for the inclusion of climate change as one of the areas of cooperation under the COMESA-EAC-SADC Tripartite framework.

Drawing together these various agreements, protocols, strategies and programmes, it appears that key priorities for action on climate change in the SADC region lie in the areas of climate-smart agriculture and food security, including a focus on resilience as well as carbon-efficient agriculture; water, including enhanced adapted and integrated water resources management; health; and integrating climate change into educational curricula. There is an important emphasis on the social dimensions of responding to climate change, including understanding the multi-stressor context, understanding of what would constitute resilient livelihoods, and in the areas of attitudinal and behavioural change. This, however, is only a partial list and will need to be checked against the emerging SADC Climate Change Policy and the Strategy.

There are a number of regional research programmes on climate change, such as the JICA Research Institute Programme on Climate Change, which focuses on adaptation research on the impact of climate change; measures for community adaptation; and mitigation research, focusing on carbon dioxide emissions. A further example is the DfID-funded Regional Climate Change Programme (RCCP) for southern Africa (2009-2014), which aims to increase regional participation in globally funded adaptation projects and improve resilience. Within this context, the Africa Climate Conference 2013 (ACC2013), organised by the World Climate Research Programme (WCRP), the Africa Climate Policy Centre (ACPC) and the University of Dar es Salaam, held in October 2013 in Arusha, Tanzania, identified current gaps in climate knowledge; identified priority areas and outlined an agenda to advance the frontiers of African climate research that will inform development and adaptation decisions; drafted a road map for mainstreaming climate information into decision making; and identified key African institutions to nurture research ideas and further develop them into pan-African research programme proposals that enhance climate services. The conference developed a priority

⁵⁰ The Programme is funded through a multi-donor financial commitment equivalent to US\$90 million from the Government of Norway, the European Union Commission and the Government of the United Kingdom and Northern Ireland over a five-year period.

African Agenda on Climate Research for Climate Services and Development, specifying critical Pan-African research proposals under four main areas: (i) co-designed multidisciplinary research for improving climate forecast skill and reliability, across temporal and spatial scales; (ii) filling the data gap – tailoring for sector decision-making; (iii) capacity-building, at all levels; and (iv) mainstreaming climate services into decision-making: linking knowledge with action, improved and more effective communication between climate science and policy to identify end user needs.⁵¹ While this research agenda focuses more narrowly on climate services, there is good congruency between these research areas and the findings and recommendations of this mapping study, as will be further discussed.

2.2 Needs analysis: key findings per country

A detailed analysis of needs and gaps related to climate change and CCD was carried out for each of the 12 countries included within the mapping study. Appendix B of the Knowledge Co-Production Framework (Volume 1) summarises the key outcomes of the country-by-country needs analysis. Full details of each country's needs analysis can be found in a standalone monograph (Volume 2), containing all Country Reports. Section 2.3 provides a regional synthesis of these country-by-country findings, highlighting commonalities and diversity of needs between countries, as well as the regional implications for CCD knowledge production.

It is possible that this needs analysis could be extended in future, and readers of the mapping study are advised to use the information provided here as best available information (produced within the constraints of the study outlined above), rather than definitive information.

The Needs Analysis focused on identifying country priority areas for responding to climate change, as well as knowledge, research and capacity gaps. The following differentiation of gaps was used:

- **Knowledge gaps** (e.g. insufficient knowledge of appropriate CCD technologies);
- **Research gaps** (e.g. no research on cultural uptake of CCD technologies);
- **Individual capacity gaps** (skills needed) (e.g. for technicians / systems thinking etc.); and
- **Institutional capacity gaps** (which have inferred knowledge and research gap implications) (e.g. resources to implement large scale technology change programmes).

The summary analysis for each country is delineated according to these aspects in Appendix B. The needs analysis synthesis (section 2.3) highlights commonalities across and diversity between countries for needs relating to adaptation, mitigation and cross-cutting needs.

⁵¹ <http://africaclimateconference.org/wp-content/uploads/2013/10/ACC2013-FINAL-Declaration.pdf>, accessed 27 November 2013

2.3 Needs analysis: regional synthesis

2.3.1 Different contexts, but commonality between countries on broad findings

Despite the greatly different national contexts, there is a high degree of commonality across the countries included in the mapping study regarding some of the broader results. General findings are that despite progress on policy development and implementation of climate change initiatives in all countries in the region, as well as some attention to identifying related research and capacity needs, *the status of CCD knowledge and research and both individual and institutional capacities will need to be enhanced significantly in all countries, in both specific and cross-cutting ways, to address the considerable observed and projected climate impacts.* This is even the case for countries in which there is some level of sophistication and attention to detail in identifying knowledge gaps and research priorities for addressing climate change, such as Namibia and South Africa, both of which have conducted several analyses in this regard, and are beginning to implement related strategies. Thus it is useful to view the 12 countries included in this mapping study as lying along a continuum with respect to both identification of knowledge, research and capacity gaps for CCD, as well as with respect to the wide-ranging capacities that will need to be developed to address country and regional climate change priorities.

In this regard, the findings of both the Needs Analysis and the Institutional Assessment undertaken as part of this mapping study could be helpful in the ongoing policy development and strategy implementation at both national and regional levels. Several countries are at an opportune stage in this process for these findings to be considered – for example, Botswana is currently developing a National Climate Change Strategy and Action Plan, and Angola is in the process of updating its National Strategy on Climate Change.

Many of the study participants strongly linked addressing climate change with survival, particularly when considering the long-term projections for the region. The study has revealed that while understandings of CCD differ amongst and between stakeholders and university staff involved in the field, there is generally a *close conceptual association between climate compatible development and adaptation and mitigation, and climate compatible development and sustainable development.* For example, in the Zambian workshop, climate change was stated to be a major threat to sustainable development, with participants noting that attaining CCD would require coordination of all of the pillars of sustainable development, as well as integration of current and future climate risks, necessitating actions across sectors and disciplines.

While across all countries the *concept of CCD was felt to be broadly appropriate for the region,* the mapping study has found that all three data sources support *skewing the emphasis more towards adaptation.* This clearly relates to the developmental status of the region and the low GHG emissions of most countries. Most national policy documents do prioritise both adaptation and mitigation actions, with some framing this as resilient and low carbon development. However, a general framing is that *adaptation should be the main priority in the country's development goals, while at the same time embracing any developmental opportunities of cleaner energy and other low carbon technologies.* South Africa with its high

per capita GHG emissions is a clear exception,⁵² but it is notable that the emissions of several of the other SADC countries have been rising rapidly in the past few decades, and some countries, such as Swaziland, are net sources of GHG emissions. Despite the recognition of developmental opportunities in the mitigation arena, national policy documents very seldom explicitly consider integrated adaptation-mitigation approaches, or the triple-win possibilities inherent in the concept of CCD – for example, they largely delineate renewable energy as a mitigation option. The workshop and questionnaire data sources across countries contained a more nuanced approach to this point, highlighting for instance the role of conservation agriculture and agroforestry as dual purpose mechanisms for both adaptation and mitigation.

“CCD is an excellent concept, I really like it. Climate is not going to go away. It will remain with you for the rest of your life, it is not a transient issue. The globe has to fix this problem. Our priority remains adaptation, but there are many opportunities that we can embrace as a win-win situation.”

Experienced university professional, Zambia

The *broad priority areas for addressing climate change reflect to a large degree the region’s high dependency on natural resources, but also include cross-cutting priorities and those concerned with energy, infrastructure and industry.* The study found agreement between all three data sources (policy documents, workshops, questionnaires) on the importance of responding to climate change within the areas of agriculture and food security, water management, biodiversity and ecosystems, health and social infrastructure, and climate-proofing physical infrastructure and transportation systems. Countries also placed emphasis on land use and sustainable forest management, while only a few, perhaps surprisingly for the region, specifically cited wildlife as a broad priority area to be addressed. When discussing climate-proofing smallholder agricultural production, the need to diversify livelihoods was often not specifically stated in policy, and only covered to some degree in the other data sources. Making the economy resilient through low-carbon growth was less commonly cited in national policies as a broad priority area of action for adaptation, but was at least mentioned in the other data sources for most countries, as was the need for a focus on human settlements, including urban areas. The coastal countries also prioritised coastal zone management, particularly within the context of increased storm surges and coastal erosion; Mozambique and Seychelles emphasised the need for enhanced disaster risk reduction and response in this regard. Common *cross-cutting broad priority areas were education, capacity development, policy and institutional strengthening, integrating adaptation and disaster risk reduction, governance, participation and empowerment.* *Mitigation-related priorities centred around ensuring that mitigation actions were implemented in the most greenhouse gas-intensive sectors of land-use (agriculture and forestry), energy, including switching to*

⁵² In this regard, South Africa’s Second National Communication to the UNFCCC (2011) speaks of balancing mitigation and adaptation responses and, in the long term, redefining competitive advantage and facilitating structural transformation of the economy by shifting from an energy-intensive to a climate-friendly path, as part of a pro-growth, pro-development, and pro-jobs strategy.

renewable and cleaner energy sources such as solar power, transport, and mining (in some countries). In general, when emphasis was placed on industry-related priorities in national policy documents, this was often phrased at a high level in terms of low carbon development, with little detail on specific economic sector measures (with the exception largely of South Africa). While this rural bias does reflect to some extent the reality in the region, with large and poor rural populations, it does also suggest *inadequate consideration of the need to adapt economies and industry* to the projected climate change impacts.

Despite a broad agreement with the concept of CCD, workshop and questionnaire data from the different countries identified *specificities that should be included in this concept, to make it more locally/regionally appropriate*. Thus a number of countries highlighted the importance of *integrating the poverty dynamic* into the CCD framework, while a further addition proposed in the data from a number of countries was for a *more specific engagement with governance, leadership and management in the concept*. While these points indicate commonality of approach across the SADC region, they are likely to be quite different from specificities that would apply across North America or Europe, for instance, showing the *need for a more regionally grounded approach to further developing the concept*, as well as the larger point of moving away from what may be seen as a subtle or implicit top-down dissemination of concepts through donor initiatives. A further commonality emerging from the mapping study data was that while CCD involves being responsive to the ongoing process of climate change, this should be broadened to include *coordinated responses between countries*. Thus the *process of iterative learning and change should also be a regional process, for an effective and sustainable response*.

A further broad commonality identified in all countries is that out of the numerous and complex knowledge, research and capacity needs expressed by stakeholders and university staff, as well as to some degree in policy documents, the *lack of national institutional capacity for climate change*, including a *lack of support for CCD research and development*, are arguably the most significant needs, highlighting the appropriateness of the SARUA mapping study and proposed regional research support programme.

2.3.2 Knowledge needs are diverse and yet also systemic

Within these common broad findings, a diverse range of knowledge needs was identified in each country, providing a more nuanced understanding of the context within which the broader priorities would need to be addressed. The scope of the specific knowledge needs identified across the 12 countries reflects a range of disciplines, spanning the physical, natural, social, agricultural, educational, engineering, health and economic sciences. This highlights the need for a more systemic response to developing capacity for climate change-oriented research across the range of sectors and institutions. Within the higher education institutions (HEIs), it emphasises the urgent need for mainstreaming climate change into under- and postgraduate curricula across faculties and departments, to firstly create the awareness of the knowledge (and research) gaps, and then to develop research interest and capacity in filling these knowledge gaps.

In general, knowledge needs identified tended to follow the broader CCD priorities expressed; there was, however, greater specificity and divergence between countries, showing the

importance of a contextualised approach for identifying specific areas that would require additional research to fill the knowledge gaps. All countries tended to identify a range of knowledge gaps within the agriculture, food security, natural resources management, health and energy priority areas; many of the knowledge gaps related to the lack of systematic and reliable long-term data in different sectors to serve as baselines for research, modelling and monitoring.

As an example of the scope of knowledge needs identified at the country level, the mapping study in Zimbabwe highlighted a lack of knowledge on the effects of climate change on health, water reserves, agriculture and other natural resources management sectors at different levels, in addition to comprehensive climate change information to adequately support decision making across the range of sectors. Knowledge gaps at the local level included household vulnerability to climate change, local climate risks and sensitivities, and local coping strategies, innovations to hydrological stress, and community-based adaptation. Key cross-cutting knowledge gaps were the need for improved meteorological data sets to establish modelling scenarios and other baseline data to shape monitoring mechanisms; and the inadequate incorporation of indigenous knowledge systems across sectors. A lack of knowledge to inform disaster preparedness for flooding and drought specifically was highly prioritised by participants, while knowledge on how the private sector can participate in greening the economy was also identified as a gap.

By contrast, and indicating the different socio-economic and environmental context, knowledge gaps identified in Mauritius encompassed adaptation, mitigation and larger cross-cutting themes. Energy and industry-related knowledge gaps lay in transport sector energy consumption, renewable energy, energy efficiency and building design; while education-related gaps included the need for increased public awareness and related to how best to mainstream climate change into curricula at all levels, engage communities and build capacity of all stakeholders at all levels. Broad marine and coastal management knowledge gap priorities included marine biodiversity management (mining and fishing industries), and exploring the effects of climate change on marine ecosystems, the coastal zone and on fisheries. In South Africa, detailed knowledge needs have been identified according to sectoral foci and according to an integrated national research plan focussing on global change, which encompasses the full scope of knowledge needs, ranging from in-depth earth systems sciences and detailed modelling and observation studies, to studies on social innovation for sustainability, and includes studies on social learning and resilience. Despite this comprehensive approach, an additional and important knowledge need was identified by workshop participants, relating to the need for *systemic, integrated perspectives* on global change and climate compatible development concerns at multiple scales and levels.

Refer to Appendix 2 (containing the detailed country needs analysis summaries) and Volume 2 of this report for additional specificities on the knowledge gaps identified.

Despite the articulation of a wide range of disciplinary needs, data from the workshops and questionnaires in many of the countries showed a strong understanding of the need for CCD and of the gaps in the national response that went beyond the disciplines of participants or the mandates of their institutions. For example, in Zambia the priorities expressed throughout the workshop and questionnaires were not aligned along institutional or disciplinary interests, but

rather seemed to be well related to the particular needs of Zambia, with regard to youth, energy, the need for increased awareness, education, capacity development, information sharing and partnerships, and development and policy challenges. In Malawi, CCD knowledge needs were conceptualised by stakeholders in terms of the need to explore social-ecological interlinkages at the interface of poverty alleviation and livelihoods sustainability, and to locate these within, or to influence, national priorities for agricultural expansion and improved management of natural resources, especially fisheries, forests, soil and water.

This ability to transcend disciplinary and institutional boundaries on the part of the participants in the mapping study reveals a broad understanding of climate change that bodes well for a more interdisciplinary response in the region, provided the necessary support for this is made available.

2.3.3 Research capacity gaps are largely correlated with knowledge needs

The research gaps identified in the mapping study largely followed the knowledge needs, and thus were related to the broad priority areas for action identified, but also contained greater specificity and nuance, related to the contextualised knowledge needs, and to the level of capacity for climate change research in the country. A regional commonality was the significant need for fundamental research on vulnerability and impact assessment across a range of sectors and at different levels, highlighting inadequacies in these understandings that would need to be addressed in order to develop adaptation strategies and enabling environments for these to be implemented. For example, knowledge gaps identified in this area in Malawi included assessments of ecosystem services, biodiversity change monitoring and assessment, and research for new technology and practices (e.g. aquaculture, renewable energy, clean technology, and eco-health approaches); while Swaziland highlighted the need for observational data to underpin climate assessments of impacts and vulnerability on water resources, agriculture, biodiversity and the health sector; as well as data to underpin such assessments in the energy, industry and waste sectors. Climate services were an enduring research gap, including modelling, downscaling and scenario development. An example of a research gap related to integrated adaptation-mitigation approaches was the need to explore the critical role of ecosystem services for enabling both adaptation and mitigation, and in underpinning the important tourism industry, as expressed in the data from Tanzania. Moving upwards from the knowledge gaps, the identified research gaps also focused on higher-level and more cross-cutting issues, such as how best to communicate research findings on climate impacts, methodologies for curriculum review and innovation to enhance inclusion of climate change issues, data and knowledge management of climate change knowledge in general, and research on the potential contribution of indigenous and local knowledge to adaptation, as discussed further below.

While priorities for action on climate change were not necessarily aligned along disciplinary or institutional mandates in most countries, the workshops in particular highlighted the value of engaging specialists across the spectrum in needs analysis, as they provided a more complete and nuanced description for knowledge and research needs relating to key priority areas than did most of the national policy documents. While this may seem to be a self-evident point, the national policy documents and strategies on the whole do not indicate any detailed specialist

engagement in the articulation of knowledge and research gaps, with the exception usually of the frequently cited knowledge and research gaps on climate data. In particular, the workshops were able to highlight some of the important social research needs such as cultural change, gender and climate change, and community participation in climate change and CCD, which were not always as well articulated in national climate change policy and strategy (see section 3).

2.3.4 Regional similarity of cross-cutting knowledge and research needs

Across the 12 SADC countries included in the mapping study, there was wide agreement on the most important cross-cutting knowledge and research needs for responding better to climate change and implementing CCD. This was striking, given the vastly differing contexts of the countries, but does highlight the potential importance of an integrated regional strategy to address these fundamental needs. These largely relate to information and education-related knowledge and research gaps, while additional cross-cutting issues are considered under the discussions of individual and institutional capacity gaps below. The need for research to identify innovative and creative approaches to enhance national and regional responses to climate change was also widely mentioned.

Information and data-related gaps were found to be critical cross-cutting issues underpinning sectoral action, and include inadequate baseline information (on the subject under study, usually on ecological and/or social conditions), lack of long-term data and time series data (on the subject under study, usually on ecological and/or social conditions), inadequate climate projections and weather prediction, the need to digitise data that does exist, and lack of a national climate change database to house climate-related information across the range of sectors and disciplines. The need to improve access to and sharing of knowledge, and expanding knowledge resourcing across sectors was highlighted in every country. Standardisation and harmonisation of data between research institutions was also required – for example, in the context of the impacts of climate change on marine biodiversity.

Cross-cutting educational concerns involved the lack of climate change education programmes in universities, research on improving the curricula content relating to climate change and CCD, and the lack of curriculum innovation for CCD related concerns. Similarly, there was concern about the lack of postgraduate programmes that focus on CCD issues, and very little professional development of existing university lecturers and educators to engage with CCD concerns. These educational concerns at HEI level were extended to a concern for a lack of adequate curriculum innovation in basic and further education, and in some cases in vocational education and training too. Community education and empowerment were also high on the agenda for cross-cutting educational concerns.

Low levels of *research capacity* for CCD also reflect a need for research capacity development. Overall the need to harmonise and consolidate research efforts was highlighted, as well as raising awareness and research on how to consolidate and harmonise research efforts. These point to underlying human capacity and resource constraints, including a significant need for training to develop the necessary skilled personnel across sectors and at all levels, as well as capacity development of Higher Education staff, as will be discussed in more detail in the institutional analysis synthesis in section 3 below. Discussions on addressing fragmentation of

efforts and research that is insufficiently long-term to allow for the development of a good understanding of the problem being studied, and of emerging trends – for example, to explore the impacts on marine biodiversity of ocean acidification; and the lack of value placed on researchers in general, were related to the need for improved policy/research/practice linkages. These, it was highlighted across countries, were necessary for more evidence-based policy making, backed up by long-term scientific studies, for example on impacts on specific ecosystems / sectors.

Additional research was also identified as necessary to *enhance monitoring and evaluation* of the environment and of the implementation of emerging climate change policies and strategies, which would require research on developing and monitoring appropriate indicators.

In some countries, interesting and specific cross-cutting knowledge and research issues were identified. For example, Malawi participants discussed the links between population growth and climate change, and the knowledge gap associated with indigenous forms of family planning, as well as exploring the acceptability of contraceptives among youth and society. The question of what the ideal family size might be, considering the constraints placed on Malawian society by climate change, was an interesting and controversial knowledge and research question raised in the workshop.

2.3.5 Contextualisation and localisation of climate change research

The mapping study shows that CCD has *contextual meanings that are diversely framed*, based on different practice and spatial contexts. This finding was most clearly identified in the workshop and questionnaire response data, in which the *need for contextualisation and localisation of climate change solutions pointed to the need for targeted and localised research*. For example, the Seychelles data pointed to the need for access to and adequacy of methodologies to assess climate impacts and develop localised adaptation strategies; while the Zambia data emphasised the importance of contextualising and localising technology development through national/local research; participants further noted that this could improve policy development and implementation. Localisation of climate change research includes developing and disseminating climate change literature in local languages, as particularly highlighted in Mozambique and Angola, as well as downscaling climate projections for enhanced understanding of climate impacts on different sectors and activities. Localisation also applies to how climate change is mainstreamed in curricula. Models to assess local impacts are needed, as well as developing national and local best practices for adaptation and mitigation, including through learning from the region.

“It is easy to produce a guide for teaching, but whatever you produce has to be in the syllabus, so you have to have it in the syllabus, and in a localised way, it has to be for Tanzania, not for China. I would go for short courses for teachers, so they know what to teach, and I would go for including this in the syllabus.”

Tanzanian university participant

2.3.6 Understanding and valuing indigenous knowledge systems for resilience

A cross-cutting knowledge and research gap highlighted was the lack of valuing, studying and understanding of local and indigenous knowledge, and the need for more research to understand its potential contribution to adaptation and mitigation. This would also be important for developing integrated adaptation-mitigation approaches, although this was not often specified, given that a number of uses of indigenous knowledge, for example in community forest management or conservation agriculture approaches, have the potential to advance practical integrated adaptation-mitigation approaches. The Tanzania data highlighted the need to understand the potential role of indigenous knowledge in climate proofing agriculture and food security; while in Malawi this key research gap was framed as the need for capacity to document and evaluate the relevance of indigenous knowledge in relation to western scientific knowledge and to work with both knowledge systems. Similarly, in Zimbabwe it was noted that for centuries indigenous knowledge and its role in African development had been neglected; given the severity of CCD issues, all knowledge forms should be carefully reviewed and assessed for their potential to support change. It was also noted that this should not be simplistically approached, as not all indigenous knowledge would necessarily be valid given the changing contexts and contemporary challenges. Added to this was a strong view that indigenous knowledge had much to offer that was as yet unexplored, and that indigenous knowledge in itself is dynamic and changing. In many countries, it was felt that overall much needed to be done to fully understand the value of indigenous knowledge in the context of new CCD challenges and new sustainability practices. This, it was noted, should be viewed as a ‘serious’ research programme across the SADC region, which also had potential for curriculum innovation, as was shown in the case of the Malawi.

“Scientists from Universities should not behave like they know it all on climate change, hence they need to recognise that the local people have traditional ecological knowledge that scientists can tap from which can be used in climate change adaptation strategies.”

Botswana university participant

2.3.7 Individual capacity gaps require a system-wide response

The mapping study has found that individual capacity gaps for responding to climate change across the region are multidisciplinary and multi-sectoral. Given that relevant individual capacity gaps are to be found in many disciplines and across the range of sectors, this will require a wide ranging, or system-wide response. Workshop and questionnaire data from most countries, and some policy documents, highlighted that there is in general limited research capacity and expertise across the sectors on climate change within the countries. In some cases, this research capacity on climate change, speaking broadly, simply does not exist, while in others it is a question of an insufficient level of contemporary, up-to-date knowledge in certain specialised areas.

National-level identification of individual capacity gaps extended across a wide range of sectors and disciplines, highlighting needs in three main groupings: discipline-specific skills,

what may be termed more cross-cutting skills, and new skills sets for integrative thinking that will need to be developed.

“We need specialists trained on climate change issues, adaptation and mitigation in each and every Ministry or organisation. Universities need to introduce programmes on climate change long term or short term in order to capacitate communities. Communities must be well informed on issues of climate change and survival skills.”

Spokesperson from the Ministry of Agriculture, Swaziland

Concerning discipline-specific skills, country responses all included the need for more climate scientists and better skills for developing and downscaling climate change projections, as well as for modelling. In addition to the need to develop skills for systematic observation and modelling of climate change, the technical competence of key officials involved in assembling and interpreting climate data needs to be enhanced, as well as the capacity to translate and transmit expert knowledge to local communities. Individual discipline skills include the need for more climate modellers and climatologists, epidemiologists, environmental scientists, EIA scientists and social scientists, environmental and clean technology engineers, environmental landscapers, forestry development experts, biodiversity scientists, community development and social innovation experts, nutritionists, skilled educationists, hydro-meteorologists, agro-meteorologists, disaster risk reduction specialists, infrastructure and sustainable development planners, extension officers, oceanographers, and climate finance specialists (amongst others – more detail can be found in Appendix A).

Key findings are that CCD capacity must be developed cross-sectorially, and that much wider enabling competencies and support are needed, over and above specific knowledge, to engender action. More cross-cutting individual capacities required are for financial and resource mobilisation, project development, monitoring and evaluation competencies, technology management competencies, conflict resolution skills, information sharing and database management capacities. Cross-cutting individual skills included gaps clustered around the area of community outreach and education, which included targeted training of extension officers and building capacity at the community level, especially of community leaders who are the land allocators, including being able to better communicate the impacts of climate change at the local level, and thus provide enhanced leadership and guidance on addressing climate change. Improved collaborative capacities are required at different levels, as is improved leadership and management skills across institutions, and enhanced political will to address the scale of the challenges.

In general, more climate change and CCD-informed managers, researchers, service providers and modellers are required, as well as a more active involvement of institutions in enabling climate change and CCD research. Re-training of local experts in cross-cutting issues and holistic thinking within disciplines involved in environmental management emerges as a priority for strengthening individual skills. Related to this is the point of focusing on the capacities needed to fine-tune and implement EIAs, as an existing mandated tool, as adaptive measures. Finally, also along the lines of developing skills for more integrated approaches, negotiation capacities and social exchange capacities were highlighted. Critical thinking skills

and skills for responding to change and uncertainty were also mentioned variously across countries.

2.3.8 Mismatch between skills supply and demand, and need for integrative skills

Individual capacity gaps and institutional capacity gaps contribute to the situation in most countries in which there is a mismatch between the skills that graduates have and the market demands – this is a general shortcoming, not restricted to responding to climate change, but the complexity and knowledge intensity of CCD requirements will exacerbate this situation. One example, across a range of scientific disciplines, was that graduates are not being provided with the necessary practical skills. This was highlighted in many, if not all the countries. The practical side of scientific training, for example in botany or biochemistry, or in community engagement across the range of disciplines, is suffering in many countries, related to the limited and declining facilities for practical training, such as laboratories, and funding for fieldwork, as well as inadequate student internship opportunities and service learning programmes. This relates to the availability of funding for higher education, and is a broad and complex issue. A related point is that graduates are not necessarily being trained to see the business opportunities inherent in responding to climate change, as highlighted by the following quote.

“The whole issue is: what are the business opportunities? We know it is there, it is already coming, it will come more and more. Perhaps I have the privilege in having knowledge across a wide range of sectors. As private sector of Seychelles, it is important that we are confident in the future – there will be a transformation of the economy, and there will be more opportunities. When we talk about environmental conservation, we need to do a lot more, including research. We are already paying to support this in our taxes.”

Senior business and industry stakeholder, Seychelles

Concerning the need for more integrative skills, mentioned above, a critical overarching shortfall is the lack of a coherent approach to tackle the climate change challenge in the development context. There is a need for cross-scale, integral systems thinking and enhanced capacity for dealing with complexity. The South African data highlights that systems innovation skills are important for CCD, while discussions in the Malawi workshop emphasised the need for the skills (political, negotiation, critical thinking) for critical engagement with climate change related issues at a national-global level. Integrative skills are also needed at the local level, including enhanced skills across sectors and institutions to translate strategies into action at the community level – i.e. a more action-oriented approach is needed, in addition to greater integrative skills.

2.3.9 Research and capacity development to engender social change

Some research gaps identified pointed to the need to *understand what would engender the necessary transformations to move societies and economies to a resilient and low carbon development pathway*. In Mauritius, these included the commonly cited need to *change mind-*

sets, including a sense of stewardship towards the environment, which would engender *social and behavioural change*. An enabler for this would be developing a fuller understanding of the implications of climate change, and taking the necessary action to reduce carbon footprints and build one's resilience – by citizens broadly, as well as across sectors and institutions. Participants highlighted that awareness raising is a necessary, but not sufficient, step for this. The Malawi data highlighted the need for *socio-cultural change research*,⁵³ which was identified as being particularly lacking. This appears to be a regional issue: climate change research and practical initiatives have in the past tended to focus on more technological approaches, but this is now shifting to a greater emphasis on participatory social learning and more process-oriented approaches to complement and strengthen technological interventions, as is now apparent in the peer-reviewed literature. This points additionally to the need for more social-ecological systems research⁵⁴ linked to ecosystem services approaches to research. These more integrative research approaches were not widely practised, as researchers tended to work in disciplinary silos. This point is further discussed in the Institutional Assessment (section 3).

“While climate change is the favourite term of politicians and scientists, the layperson is indifferent to climate change. The reason is due to the fact that the layperson is unaware of the gravity of the situation.”

Mauritius government stakeholder

While workshop and questionnaire data from all countries highlighted the need, to greater or lesser degrees, for social and behavioural change as a necessary condition for CCD, this was not frequently explicitly captured in policy. The South African National Climate Change Response White Paper does set out broader objectives for systemic change, including policy and regulatory alignment, co-ordinated sectoral response, integrated planning, *facilitated behaviour change (using incentives and disincentives)* and resource mobilisation, as well as choice-oriented social and behavioural changes via education and awareness. Taking this further, workshop and questionnaire respondents in South Africa engaged in discussions on a broader social change agenda, such as *“Changing social values and aspirations - shift from 19th century political ideologies to a political ideology that is relevant to the challenges of the 21st century”*, and *“Restructuring of law and economics and social change with a specific emphasis on poverty alleviation and protection of vulnerable people to increase human and environmental security and resilience”*.

⁵³ Socio-cultural change research explores the change experienced or required in a combination of social and cultural factors. Socio-cultural factors are the larger scale forces within cultures and societies that affect the thoughts, feelings and behaviours of individuals, such as attitudes, cultural identity and cross-cultural differences.

⁵⁴ As defined by the Stockholm Resilience Centre, “A key concept in the resilience framework is the concept of social-ecological systems. There are no natural systems without people, nor social systems without nature. Social and ecological systems are truly interdependent and constantly co-evolving.”

“How many of us in this hall want to act differently? It is just a question of changing our mindsets and habits, this is a cultural transformation that we need to do, and I don’t think it is going to be very easy, but we have to embark on it.”

Mauritius government stakeholder

This links with the need to design CCD research so that it addresses the needs of poor and marginalised communities, commonly mentioned in the country workshops. In Tanzania, this was also specifically related to the need for integrated adaptation-mitigation approaches, so that mitigation initiatives such as REDD+ do not impact negatively on access rights and livelihoods of people. Related points are how data and knowledge is shared, and how research is responded to by decision makers, and how such research benefits communities. Namibian workshop participants were clear that CCD could not emerge without giving attention to social and cultural change, and that educational quality and ethical political leadership were important dimensions of this process.

“There is also the issue of cultural aspects of adoption. Remember there was a very concerted effort by the British colonial government to introduce sorghum in central Tanzania and those other dry areas. But people could not adopt these crops – and today everyone is farming maize.”

Tanzania university staff member

These important ethical and equity dimensions of the problem have implications for the form of knowledge co-production on CCD that could be stimulated in the region, as further discussed below.

2.3.10 Significant institutional capacity gaps require a concerted response

The mapping study shows wide-ranging institutional capacity gaps that act as barriers to responding to climate change and CCD in the region, with a great deal of commonality between countries, despite differing contexts and stages of response to climate change. Some of these reflect fundamental institutional and governance shortcomings, not specific to climate change and CCD.

A common theme from all of the countries was that existing mechanisms and capacity are insufficient to deal with the complex and diverse climate issues, which will require a strategic, coordinated and harmonised approach to increase the effectiveness of actions. Many constraints related to a *widespread lack of coordination and holistic approach*. Data across all three sources indicated that government ministries are working in silos and university departments are frequently working with a narrow focus. There is often limited collaboration within departments, not to mention across departments and faculties, or between HEIs in a country, or across the region. While there are complex reasons for this, as further discussed in section 3, there is undoubtedly a strong call for collaborative approaches and increased networking.

“We are all coming from different faculties, different universities, different sectors, but systems of governance force us to operate in silos. We get the satisfaction of fulfilling mandates. But climate change makes it necessary for us to move out of the silos, we need to cross the disciplinary boundaries, and have a systemic and holistic approach to challenges. There are also language boundaries – we need to be able to articulate the climate change challenges in the local languages.”

Regional SADC ESD programme manager

The mapping study found that knowledge co-production for CCD requires developing institutional capacities for improved multi-sectoral coordination and collaboration, policy harmonisation and enforcement, and integrated approaches to development. An *effective research-policy interface would be critical for science-based and evidence-based decision making* (as also discussed in sections 3 and 4 below). To address the identified needs, teaching facilities and curricula need to be extended and better institutional repositories and information centres developed. In addition, conflicting institutional mandates were identified as a key institutional capacity gap that serves to prevent a coherent response to climate change – for example, there are no real incentives for academics to engage in community engagement or policy outreach. Research funding and incentive systems also need to be developed in a way that promotes and supports inter-institutional collaboration. These concerns were raised across the twelve SADC countries, and are discussed in more depth in section 3.

Knowledge management emerges as a significant institutional capacity gap. As highlighted in the Botswana data (amongst others), the need for information sharing, collaboration and integrated approaches to environmental management and climate change point also to the fragmented nature of the current institutions, and the insufficient communication and knowledge sharing needed to prepare the country for CCD research and development. Most countries cited the limited knowledge and research on what types of CCD responses exist in the country, calling for the need for a database / informational management system that would collate inter alia research on different aspects of climate change and CCD, and climate change implementation projects and programmes.

Action is needed to overcome *institutional capacity gaps in the policy and legislative arena* too. Mainstreaming was raised in all countries – for example, the Seychelles workshop identified the *inadequate integration of climate change across the board*, including the gender-differentiated and HIV/AIDS aspects, into *policies, plans and strategies at all levels*, including *economic development planning*. In Botswana, both the Second National Communication to the UNFCCC (2011) and participants in the mapping study have highlighted the need for a national policy to add a level of coherence and support for CCD action, in this way pulling together the stakeholders – government, NGOs, universities and private sector – into a common framework. Malawi data indicates that policies contain limited innovation and there is a noticeable lack of favourable policies that promote innovation. Workshop participants felt that existing policies were limited in their implementation and enforcement, due to a lack of robust policy and legal instruments. While countries are at different levels with respect to policy coherence on climate change, *even those with relatively advanced policy and legislative frameworks highlighted the need for better coherence and coordination in practice*.

A more *coherent and supportive research framework, with enhanced funding* to enable all forms of research on climate change is also needed, as discussed further in sections 3 and 4 below. Zimbabwe data pointed to the need for a *holistic approach towards consolidating interdisciplinary research outcomes* across different disciplines. *Documentation and publication of research* was consistently referred to by participants as a vital research need that can enhance the climate change and CCD-related research culture in the region, but also improve how research feeds into policy and implementation. The South African data highlighted the need for more sustained, longer-term and substantive funding for real impact to emerge in social-ecological systems research, and a stronger commitment to social science and systems-based research. Mauritius workshop participants called for local networking of climate change researchers and the development of institutional synergies within this field – in other words, looking for areas to collaborate on in which different institutions bring different skills sets to the table to address a common problem. They also highlighted the need for improving arrangements for transboundary marine environmental plans; developing institutional structures for improved feedback loops on environmental outcomes; and institutional prioritisation to develop a curriculum framework incorporating CCD.

“Yes, there are networks. But they are scattered and fragmented because of the absence of a centre of excellence or a coordinating body.”

Mauritius expert stakeholder on climate change

The mapping study has further identified that while there are a number of climate change-related knowledge networks operating nationally and regionally, they are limited as they often do not have a specific focus on climate change – for example many focus on environmental education or environmental conservation. There is also usually *no focal point for these knowledge networks*. Given that many donor-funded programmes in the region have included establishing knowledge networks and climate change repositories in their objectives, and given the plethora of web-based knowledge networks, there is a need to better understand what the limitations have been with these already implemented initiatives, towards addressing this constraint.

The mapping study findings strongly underpin the need for *significant capacity development across sectors and institutions and at different levels*. Overall the data sources unearthed the critical need for improved education, public awareness, participation and access to information. A commonly cited institutional capacity gap was the *current weak climate change and CCD related curricula* and efforts to enable the development of new curricula across disciplines in tertiary, middle and primary education. As the Botswana data showed, developing a *networked critical mass of scientists and other expertise* to provide needed services in the entire spectrum of emerging climate change-related challenges is a priority in the country’s ongoing response to climate change. What is needed is *a well-funded human resource development and comprehensive CCD capacity development strategy*. Workshop participants in Zimbabwe noted the same need. The South African National Climate Change Response White Paper proposes development of such a strategy, but this is yet to be done at a national level. No other examples of well-funded human resource development and comprehensive CCD capacity development strategies were found in the countries participating in the SARUA mapping study. This issue is discussed in more detail in sections 3 and 4 below.

Related to the points raised above with respect to individual capacities and skills-mismatch between supply and demand, a key gap identified across a number of countries is for *a more professional and career-driven approach to climate change higher education*, which would also need to encompass emphasis on practical skills and developing technological abilities, and would necessitate better partnerships between HEIs and the private sector in curriculum development. For example, Mozambique workshop participants felt that institutions needed to improve their capacities for offering professional careers associated to climate change, which would also include providing professional internships for recent graduates. South Africa's National Climate Change Response White Paper also prioritises education, training and public awareness and recommends actions to integrate climate-resilient development principles into national curricula and into higher education curricula and teaching programmes, to strengthen research capacity in universities, and to undertake labour market research to inform the emergence of a green technical vocational education and training (TVET) system.

The mapping study data sources across all the countries consistently highlighted the *need for improved financial resources to build capacity, carry out research and implement adaptation and mitigation measures*. The Malawi data highlighted the limited funding for longer-term climate change research and programmes, which created further barriers to CCD implementation, as most funding cycles were short term, leading to a project-based approach to dealing with CCD instead of a longer term, more sustainable approach. This problem was identified in most other countries that rely heavily on donor-funded interventions to resource CCD research and development.

Governance-related institutional capacity constraints include the *lack of political and corporate will* to support CCD research, and frequently mentioned the need for *greater leadership on addressing climate change*, as well as the need for more *meaningful and broad-based participation*. Coordination and partnerships between government, NGOs and the private sector, as well as between these stakeholders and academia/research institutes, is generally felt to be poor. Some countries noted that top-down decision making may not result in appropriate and climate-resilient infrastructure, given that local perspectives or the necessary environmental and climate-related information, including climate projections, is often not considered where decisions are taken in a top-down fashion. A further requirement is for an *auditing/monitoring system* to both track donor funding going into climate change and CCD-related projects and research, and to track the effectiveness of the response. Data from the Seychelles revealed that research and governance systems require improved knowledge co-production, and *collaborative responses that are embedded in stronger networks regionally and internationally, including across the SADC countries*.

These institutional capacity gaps have a direct effect on the individual, knowledge and research gaps identified, as insufficient levels of CCD capacity in the education institutions reduces the opportunity for CCD knowledge and research to flourish, subsequently reducing individual capacity opportunities. Clearly, institutional capacity constraints in other types of institutions will similarly impact on individual, knowledge and research gaps, but again, the role of educational institutions is pivotal here, as they are training the workforce of the future.

The mapping study has thus identified significant and systemic institutional capacity gaps for responding to climate change in the SADC region. Addressing these will require curriculum innovation at different levels (see section 3 and 4 below), so that the necessary climate change-related as well as broader and more cross-cutting necessary skills to overcome institutional capacity constraints are imparted to scholars and graduates. As respondents in the Mauritius workshop noted, many of these are longstanding gaps that have been identified in efforts to move towards sustainable development; in the words of one workshop participant, *“these critical constraints in the enabling environment need to be identified and addressed once and for all!”*

2.3.11 The cyclical relationship between individual and institutional capacity gaps

Generally, a knock-on effect can be detected between individual and institutional capacity gaps, with institutions not carrying enough funding to make climate-related jobs attractive to professionals, which in turn keeps the institutions weak and incapacitated. This then results in inadequate research agendas being set, with the consequence of reduced overall quality of climate change and CCD-related knowledge in almost all countries. An integrated approach to knowledge, research, individual and institutional capacity development is needed, where improved resourcing, and more active and attentive government and legislative support is needed. From this, appropriate research agendas and curriculum development can be developed, further feeding and nourishing the wider climate change and CCD-related research community in southern Africa, ultimately benefitting communities who are facing the severe impacts and implications of climate change.

“There is a gap between theory and practice or activation in the pursuit of CCD related activities. There is lack of collaboration and exchange of information among institutions and organisations dealing with climate change. The lack of capacity among institutions of higher education and training was the bottleneck in the uptake of CCD related technologies and training programmes.”

Report-back from government and parastatals group, Swaziland workshop

2.4 Implications for CCD knowledge co-production

2.4.1 The identified regional needs call for a strategic and integrated approach

As previously noted, CCD not only recognises the importance of both adaptation and mitigation in new development pathways, but necessitates considering multiple benefit and cross-cutting strategies that build resilience, promote development and result in low emissions

simultaneously.⁵⁵ The mapping study has revealed the relevance of this approach, with certain caveats and recognising the different perspectives on what CCD could and should constitute at country level, but also regionally. While the study has revealed contextualised knowledge, research and capacity needs, the divergences between countries are, in general, less than the similarities. For example, all countries, with the possible exception of South Africa (due in all probability to its several related centres of excellence), highlighted the need for greater localisation of climate projections, models, research on impacts, and application of relevant technology.

The wide-ranging nature of the knowledge, research and capacity needs, together with the high level of commonality across countries, calls for *a strategic and integrated approach to capacity development*. A regional approach to this can provide an efficient modality for building capacity for CCD knowledge co-production (see sections 4 and 5 for recommendations in this regard).

“I am 55 years old, I am in the troisième age. I trained as a food inspector, I went to university relatively late to do a Masters degree. The reality is that you cannot study anything in an isolated context anymore. You cannot study anything by avoiding CCD. So it is very important, you cannot treat a subject in isolation. If you are to survive, because we are evolving so fast, you need to connect.”

Senior business and industry manager, Seychelles

There are already some steps in place to begin to address these research and capacity needs at a country level especially, although these are not that widespread regionally. For example, the National Climate Risk Management (CRM) Capacity Development Plan (CDP) for Namibia comprises a detailed five-year strategy and a longer-term vision for addressing climate change adaptation capacity needs in Namibia. Key findings in the Namibian context, but also in other countries, is that CRM / CCD capacity must be developed cross-sectorially, and that much wider enabling competencies and support are needed, over and above specific knowledge, to engender CRM / CCD action. While this is the case, there are also very specific CCD knowledge needs that will need to be addressed sectorally and from within specific university disciplines as discussed above.

Likewise, the analysis of capacity needs outlined above also shows that while there is a need to integrate climate change and CCD into a variety of disciplines to produce the specific knowledge necessary, CCD capacity must *also* be developed cross-sectorially; and should involve multiple stakeholders at all levels of society. The needs analysis also shows that much wider enabling competencies are needed besides those competencies related to the priority thematic areas for CCD, such as agricultural adaptation knowledge, or water management knowledge. Such wider enabling competencies include new financial management skills, new

⁵⁵ Mitchell, T and Maxwell, S. 2010. “Defining climate compatible development.” Policy Brief. CDKN. Accessed on 14 April 2014. <http://r4d.dfid.gov.uk/PDF/Outputs/CDKN/CDKN-CCD-DIGI-MASTER-19NOV.pdf>

policy formation and networking skills, leadership and ethical competencies, as well as knowledge dissemination competences.

This need for strategic and integrated approaches reveals the need for multi-, inter- and transdisciplinary approaches to research and knowledge co-production, as integrated approaches cannot be developed via silo-based approaches to research only. This does not mean that the individual disciplinary contributions to CCD knowledge are not necessary or valued, but that there is an *additional need* for a broader range of approaches to research and knowledge co-production, as introduced in section 1 above, and discussed in more detail in sections 3, 4 and 5 below.

2.4.2 Capacity building for providers of CCD education, training and capacity development

From the insights shared above, it is clear that there are many diverse needs for CCD-related research and capacity building, including capacity building programmes (education, training and public awareness programmes). These involve a range of societal actors / groups, and different agents will need to take responsibility for the education, training and community awareness programmes (e.g. women's groups, farmers, parliamentarians, local government officials, planners etc). What is interesting to note, however, is that *very little mention is made in policy documents of capacity building for those who are to offer all of these intended education, training and capacity building programmes to address the individual and group-based capacity needs*, although this point was raised in the workshops. Section 4 of this report, the Knowledge Co-production Framework, addresses this issue of capacity building of educators, especially university educators. University professionals noted the importance of building capacity for curriculum innovation. With regard to this point, the SADC REEP regional capacity assessment (SADC REEP 2010) *emphasised the need to give attention to the capacity building of research, environmental education and training professionals at all levels* (in universities and higher education institutions, in TVET colleges, in NGOs and CBOs, and in government extension units) if southern African countries are to address their research and capacity development needs, as articulated in the needs analysis undertaken for this mapping study.

Universities also raised the issue of research skills and research capacity development, especially for using new forms of ICT-based approaches to modelling and use of models for downscaling, but also general research methodology training for multi-, inter- and transdisciplinary approaches to research. *Little is said in any of the policy or strategy documents, or even in national research plans where these exist, about research methodology and research training, yet this is core to the development of new approaches to CCD research and knowledge co-production, and remains a key need in southern African universities*, where research methodology training (with few exceptions) tends to be somewhat traditional, whilst CCD research requires new forms of methodology and research training. This issue is discussed further in sections 3, 4 and 5 below, as it is critical for the success of CCD research and knowledge co-production.

3 INSTITUTIONAL ANALYSIS

3.1 Orientation

3.1.1 Institutional context for climate change and CCD research at the SADC level

Section 2.1.3 has described the broad policy context for addressing climate change at the SADC level, and provided a summary of broad priorities for responding to climate change as set out in SADC documents. Institutionally, SADC has a Climate Change Inter-sectoral Technical Working Group (CTWG). The Working Group has noted the lack of coordination across SADC sectors, with no framework for developing workplans cross-sectorially to ensure harmonisation of all SADC climate change activities. This is seen as the role of the Working Group at this stage, as well as facilitating implementation in the various sectors and within Member States. So far one of the achievements of the CTWG has been the production of a Climate Change Strategy for the Water Sector in 2011. The CTWG workplan will be aligned with the COMESA/EAC/SADC Tripartite Programme on Climate Change. The working group is keen to incorporate other climate change initiatives taking place in the region, which provides an opportunity for the SARUA CCD initiative to be located within SADC level policy frameworks.

The CTWG is a key institution in SADC as very few inter-sectoral collaborative initiatives are in place. It is worth noting that the SADC Education and Skills Development Programme which oversees regional coordination on Higher Education, skills development and knowledge exchange among others is also participating in the working group, and has already expressed a commitment to Education for Sustainable Development, which would incorporate climate change / CCD education. SARUA has also been engaged with the SADC Education Ministers and is recognised as a SADC Subsidiary Organisation. This relationship between SARUA and the SADC Education sector is significant for the implementation of this Knowledge Co-Production Framework, and for development of higher education in SADC more broadly.

While the mapping study did not focus specifically on identifying institutions outside of the SADC region, unless these were identified as key existing networks for researchers in SADC (see section 2), notable African institutions and networks for climate change and CCD beyond the region include for example the African Climate Policy Centre (ACPC) and ENDA Energy, Environment and Development Programme. Further afield, the Future Earth research framework and network was identified as an important network for the SARUA climate change programme as it sets out a broad Global Sustainability Research Plan, which is closely aligned in purpose and intent to this SARUA Knowledge Co-Production Framework. A number of the researchers involved in the SARUA mapping study have also been part of the conceptualisation of the Future Earth research programme, and are contributing to its unfolding trajectory. Most recently, Professor Cheryl de la Rey, Vice Chancellor of the University of Pretoria, discussed the

importance of multi- and interdisciplinary research, and the importance of greater synergy between the social and natural sciences within the Future Earth research programme context at the World Science Forum⁵⁶ in a panel hosted by the International Council for Science (ICSU), confirming also southern African research partnership interests in the Future Earth research programme. This is a potentially important wider research framework for the SARUA Knowledge Co-Production Framework, as the Future Earth research programme also seeks to establish regional 'nodes' of which southern Africa is likely to be one such node.

Further development of the SARUA programme framework could include identification of potential key partner organisations for networking and research support within the whole of Africa, as well as further afield to enhance the currently undeveloped area of South-South collaboration on climate change and CCD research and capacity development. It is recommended (see section 5 below) that international partnership mapping be included in the next phases of the SARUA programme, particularly as these pertain to the key research thematic areas and roadmap priorities identified in sections 4 and 5 below.

3.1.2 Institutional context: Universities in SADC

According to SARUA research published in 2009, SADC had 66 public universities, 119 publicly-funded polytechnics or colleges and 178 private universities or colleges.⁵⁷ Since 2009 these numbers have increased slightly, as has the original SARUA profile data of southern African universities. For example, at the time (2009) Botswana had one national university, it now has two; Malawi had two national universities, but with the recent changes to Bunda College of Agriculture, it now also has the Lilongwe University of Agriculture and Natural Resources (LUANAR; the old Bunda College of Agriculture). This is indicative also of growth in the higher education sector in southern Africa.

South Africa has 23 of the public universities and 70 percent of overall enrolments in the region. Some countries have only one public university (Lesotho, Seychelles, Swaziland). In other countries, numbers range from two (Botswana, Mauritius, Namibia – includes the Polytechnic of Namibia currently transforming to the Namibia University of Science and Technology) to nine in Zimbabwe. Zambia and Malawi have three public universities, Democratic Republic of the Congo and Mozambique have four, Madagascar has six and Tanzania has eight. Private higher education institutions outnumber public institutions in all SADC countries (see Table 6 below) but most enrolments are in public institutions and 72 percent of students are in contact study.

There are also a range of other higher education institutions such as Colleges of Agriculture and Colleges of Natural Resources, which have an important role to play in CCD capacity development, especially in the training of extension services. Many of these, however, are

⁵⁶ www.sciforum.hu

⁵⁷ SARUA. 2009. *Leadership Challenges for Higher Education in Southern Africa*, Leadership Dialogue Series. www.sarua.org. NOTE: This section (3.1.2) draws on the SARUA 2009 report, but also adds insights gained from the mapping study.

associated with the national universities and their key associated faculties. For example, the Malawi College of Fisheries (an important government tertiary training institution for fisheries extension services) is associated with the Bunda College of Agriculture / now the Lilongwe University of Agriculture and Natural Resources for accreditation and quality assurance. In Botswana, Zambia, Lesotho and other countries, the universities design curricula for teacher education colleges, and also play a role in accreditation and quality assurance of the College curricula. This is a pattern across the SADC Region. Curriculum innovation at university level therefore, has a much wider impact than on teaching done in universities: there is an important knock-on effect across the wider education and training system (see section 3.2 and sections 4 and 5 below where curriculum innovation is discussed in more detail).

SADC has very low gross tertiary enrolment ratios, calculated as the proportion of 18 to 24 year-olds in post-secondary education. According to SARUA's 2009 research most countries fall into the 2-4 percent range. Only Mauritius (16 percent in 2005) and South Africa (14 percent) have tertiary gross enrolment ratios of above 8 percent. In comparison, the world-mean on this statistic for lower and middle-income countries currently stands at 19 percent. This is a direct result of earlier structural adjustment policies that were designed to curb spending on higher education. Another factor influencing this is the fact that many universities in southern Africa are 'new' and were established only in the post-independence era. All these historical factors further shape the quality of education on offer in universities and the teaching: research balance in universities, which tends to be skewed on the whole towards teaching rather than research, as is shown by research output statistics.

Research output is low and is a major challenge. South Africa produces 79 percent of research and its output of articles per million of the population is 119.3. Botswana follows at 85.5 but no other country has figures above 40. Output has been increasing since 1990 – in seven countries by 100 percent or more – but SADC is not keeping pace with world research growth. The improvement of research data collection and access, and increase in publication remains a high priority, as was also identified in this mapping study (section 4). There is a need for research capacity development at all levels, including governance, institutional research management, funding and staff capacity, and mechanisms to improve regional collaboration, such as networks and specialist centres are regarded as essential (see also section 4).

As an illustration of the size of the Higher Education sector covered by the scoping study the following table provides some basic data where this is available; more complete profile data sets are available from www.sarua.org. In respect of Table 6 below, it should be noted that data for Angola was not available.

Table 6: SADC HE profile – countries included in mapping study

Country	No. public universities	No. other HEIs		Total size of student body	% Research funding by government	% Research funding other sources
		TEVETA	Private			
Botswana	2	23	7	15 628	5	95
Malawi	3	-	7	7 927	No data	No data
Mauritius	2	9	55	14 883	No data	No data
Mozambique	4	9	13	60 412	No data	No data
Namibia	2	-	2	24 039	64	36
Seychelles	1	-	-	300	No data	No data
South Africa	23	50	118	829 912	45	55
Swaziland	2	-	2	5 523	20	80
Tanzania	8	11	22	52 723	No data	No data
Zambia	3	282	32	23 037	38	62
Zimbabwe	9	-	5	44 372	46	54
TOTAL	59	384	263	1 078 756		

Source: SARUA (2011)

The SARUA 2009 report points out that the notion of regional cooperation in higher education in Africa is not new. The earliest agreement was the 1981 Arusha Convention on the recognition of qualifications. The 1997 SADC Protocol on Education has sections devoted to cooperation in higher education and to research and development. The same goals are set by the 2007 African Union Harmonisation Policy for Higher Education. SARUA also has a history of supporting regional co-operation; this mapping study and the associated five-year SARUA Programme for Climate Change Capacity Development constitute further action in support of regional co-operation and capacity building across southern African Higher Education Institutions (HEIs).

3.1.3 Universities and development

Universities have complex roles to play in national and regional development. In recent years there has been renewed attention given to the relationship that exists between higher education and economic development, an interest that has been driven by the need for greater participation in the globalising knowledge economy. Through education and research, higher education can enable countries to raise economic growth and increase participation in the knowledge-based economy. For developing countries, strategies that link higher education and economic development can facilitate wider links within the global economy, and broaden economic options from production of primary commodities and manufacturing goods requiring school level skills, to value adding goods and services requiring the knowledge and skills provided by higher education.

Such views of higher education have, however, also been critiqued for being overly market-oriented especially if all objectives for higher education are oriented to economic objectives only. This, it is said, tends to reduce the need to give attention to other aspects of the relationship between higher education and development, notably social development needs and other aspects of sustainable development. In other words, a broader view of development is needed in African contexts, which encompasses both objectives to contribute to economic development and science and technology innovation, as well as to the wider objectives of society's development, which include giving attention to issues of social justice, sustainable development, and responding to climate change. Universities should not only serve the economy, but also the public good.⁵⁸

Pillay⁵⁹, reviewing the relationship between universities and economic development, suggests that in Africa, higher education is closely linked to development through its education and training role as the provider of 'human capital' (graduates) for growth and development, especially to provide graduates for the post-independent state's developmental objectives. Under this model, the role of higher education institutions in research and innovation has been minimal. There are a complex array of factors that shape the relationship between African Higher Education systems and research and innovation capacity, amongst them are the influence of earlier structural adjustment programmes that reduced spending on Higher Education just as many universities were being establishing in post-independence states (mentioned above), rapid expansion of student numbers due to a generally inadequate overall system of provisioning of Higher Education facilities and institutions, and the links that exist between inadequate access to good quality schooling. This raises the importance of giving attention to issues of quality in teaching and research programmes in African universities, as many are still striving to improve quality of education, both in relation to generally inadequate quality schooling systems, and within their own practices. These issues surfaced across the southern African universities involved in this mapping study.

There are currently various programmes and initiatives that are seeking to support university engagement with sustainable development at global and regional levels; most of which also include a focus on climate change. Key here are initiatives such as the Global Universities Environment and Sustainability Partnership Programme that emerged out of the UNEP and African Association of Universities (AAU) Mainstreaming Environment and Sustainability in African Universities Partnership Programme (MESA), and the African Teacher Education Network on Education for Sustainable Development (AFRITEIS). The Global Universities Network for Innovation has recently also given attention to universities and sustainable development and published *Higher Education in the World 4: Higher Education's Commitment to Sustainability: from Understanding to Action*⁶⁰ which carries in-depth analyses of universities

⁵⁸ Singh, M. 2001. Re-inserting the 'public good' into higher education transformation. Kagisano (Council on Higher Education Discussion Series) 1 (Summer 2001): 7-21.

⁵⁹ Pillay, P. 2011. "AFRICA: Lessons in universities and development," *University World News*, 6 March 2011. www.universityworldnews.com

⁶⁰ www.palgrave.com

and their response to sustainability concerns (including climate change) from all continents, including Africa. The AAU hosted a special discussion on this at their 12th Annual General Conference, and most recently the African Association for the Development of Education in Africa (ADEA) also gave attention to the relationship that exists between universities and sustainable development. A key message from the ADEA Triennale in 2012 is that “*Africans must have control over the means and resources needed for the continent’s sustainable development*”.⁶¹ This depends on regional co-operation and the building of South-South partnerships, in addition to more traditional South-North partnerships. It requires substantive investment in research, and curriculum innovation, or what ADEA refer to as:

“... a revolution in teaching and learning in the sense that teachers need to develop their approach to the curriculum in cooperation with, and with the involvement of, the stakeholders, in order to provide access to the knowledge and skills that ensure inclusion and integration into everyday life, including as citizens and in the workplace.”⁶²

Reflecting similar orientations to educational transformation are a range of new initiatives emerging to support climate change education and research in universities, such as this SARUA programme on universities and climate change and development (of which this mapping study forms a part) and the Open Society Foundation (OSF) Programme for African Universities on climate change based at the University of Dar Es Salaam. UNESCO has also recently started to develop country-based climate change education case studies to influence education and training policy in some southern African countries. The African Union Commission (AUC) are currently in the process of establishing the Pan African University (PAU) consisting of five centres of excellence and additional interlinked research centres in five thematic areas in five regions of Africa. With German Financial Cooperation, the North African hub of PAU based at the University of Tlemcen (Algeria), will be supported in the fields of Water and Energy Sciences (including climate change) (PAUWES); its aim is to contribute to the development of higher education and applied research in the fields of water and energy (including climate change) for sustainable development in Africa. These initiatives all show commitments to climate compatible development within the broader framework of sustainable development.

As indicated above, as part of their societal objectives, universities have always been encouraged to engage pro-actively with broader development agendas, including the Millennium Development Goals. Piyushi Kotecha, CEO of SARUA, argued in 2010 that “Education is one of the foremost Millennium Goals, but education in turn can be used to drive their achievement”⁶³. While this is the case, it was found that even though the MDGs have to do with wider goals of human and social development, their uptake in higher education had

⁶¹ Association for the Development of Education in Africa (ADEA). 2012. Triennale. Promoting the critical skills for the accelerated and sustainable development of Africa. The key messages of the Triennale. Ouagadougou, Burkina Faso, February 13-17, 2012. http://www.adeanet.org/triennale-followup/sites/default/files/the_key_messages.pdf

⁶² ADEA. 2012. Triennale.

⁶³ McGregor, K. 2010. “GLOBAL: Higher education as a driver of the MDGs,” *University World News*, 2 May 2010. www.universityworldnews.com

been 'sparse', and where they were included, they related mainly to the use of existing courses across various disciplines to give effect to individual goals. Examples were in agricultural sciences, engineering, rural development, literacy, community service, teacher education, open and distance learning, gender policy and mainstreaming, and using faculties such as social work and medicine to train communities.⁶⁴ A similar response pattern to CCD concerns was found within universities involved in this mapping study (discussed in more detail in section 4 below).

Analysis of university roles in responding to the socially constituted moral commitments embedded in development initiatives such as the Millennium Development Goals suggests that more could be done in universities within the framework of their mission and responsibility of contributing to the public good. Kotecha⁶⁵ argues that regional co-operation could be a significant and important strategy for ensuring maximum use of collective resources and capacities, which is also the purpose of this mapping study. Another key point made in the discussions on universities and development goals such as the MDGs is the need to promote intellectual engagement with such concerns, as this is necessary for regional meaning-making and contextualisation, and for boosting research and innovation pathways, a point also made by ADEA.

These insights will be important too for university participation in the post-2015 Agenda, in which climate change and climate compatible development is likely to feature strongly. The post-2015 Sustainable Development Goals (SDGs) seek to integrate economic, social and environmental sustainability and equity into a new post-2015 development agenda. The argument is that development issues such as water, agriculture and food security, energy security and urbanisation need to be conceptualised in a way that integrates their environmental, economic and social dimensions, including climate change responsiveness and resilience. Universities are already being called on to make contributions to the SDG development process. Additionally, the SDGs are also being shaped by multi-, inter- and transdisciplinary research findings and approaches, and a body of research is emerging regionally and internationally that deals with the 'nexus' or the inter-relationships that exist between economy, society and environment, as is also shown in this mapping study. The Knowledge Co-Production Framework presented here is directly relevant to the emergence of the SDGs as it presents a mechanism for regional engagement on core dynamics of the emerging SDGs, and provides a Knowledge Co-Production Framework that can be used within the SADC region to strengthen engagement with the SDG processes and intentions. This document should be read in this light, as should further engagement with the SARUA programme as climate resilient development pathways or climate compatible development integrates the environmental, economic and social dimensions of development. As mentioned

⁶⁴ McGregor, "GLOBAL: Higher education as a driver of the MDGs".

⁶⁵ Kotecha, P. 2010. "Interrogating the Role of Higher Education in the Delivery of the MDGs" (reported on by McGregor, "GLOBAL: Higher education as a driver of the MDGs")

above, such approaches are central to a post-2015 sustainable development agenda. As stated by the members of the Independent Research Forum (IRF) 2015⁶⁶:

“The MDGs articulated a global vision of development around a common set of goals and priorities. The next era of international cooperation should focus action at local, national and global levels on the deeply entwined economic, social and environmental challenges that confront the next generation”.

The post-2015 development agenda is based on an understanding that the world has changed fundamentally since the adoption of the Millennium Declaration, and that it is faced with new challenges and opportunities, many of which require collective action. The IRF2015 argues strongly that the post-2015 agenda must be a **knowledge-based** and **inclusive** process. This must balance equitable political engagement with expertise and perspectives from science to business, NGOs and communities, involving knowledge co-production processes in which universities must play a central role. The 2013 UNESCO / International Social Science Council World Social Science report⁶⁷ emphasises the role of collaboration in knowledge production and states that:

“Social scientists need to collaborate more effectively with colleagues from the natural, human and engineering sciences to deliver knowledge that can help address the most pressing of today’s environmental problems and sustainability challenges. And they need to do so in close collaboration with decision-makers, practitioners and the other users of their research.”

Most recently, the 2013 World Science Forum, with delegates from over 100 countries, agreed that there is an urgent need to advance the science for global sustainable development, which includes a strong focus on CCD. The World Science Forum declaration and the conference as a whole indicated the importance of education (including Higher Education) in addressing inequalities, and in promoting science that can contribute to sustainable development of societies. There was also a strong recognition of the need for improved dialogue with governments, society, industry and media on sustainability issues, and on the role that science can play in achieving global sustainability.⁶⁸ Of interest for this Knowledge Co-Production Framework, is the global attention that is being given to climate compatible development, sustainable development, and new approaches to knowledge production from the wider scientific community – social, natural, engineering, agricultural, educational and other scientific areas.

The IRF 2105 researchers, and other major international scientific reports, policy and strategy documents such as the Rio+20 documentation, the World Social Science Report (UNESCO

⁶⁶ Independent Research Forum 2015. March 2013. “Policy Paper: Post-2015: framing a new approach to sustainable development,” www.sustainabledevelopment.un.org. NOTE: The IRF2015 is an Independent Research Forum consisting of 12 major international research groups involved in sustainable development research including (from Africa) the Council for the Development of Social Science Research in Africa (CODESRIA) and the Open Society Initiative for Southern Africa .

⁶⁷ UNESCO / ISSC. 2013. *World Social Science Report 2013. Changing Global Environments*. Summary (www.oecd-ilibrary.org/).

⁶⁸ World Science Forum, Rio de Janeiro, 24-27 November 2013. <http://www.sciforum.hu/declaration/index.html>

2013), the Future Earth Global Sustainability Research Plan⁶⁹, and the World Science Forum Declaration (2013) all propose a re-orientation of development thinking for the post-2015 period, which has relevance for this mapping study and its objectives, and the Knowledge Co-Production Framework (see Figure 9 below).

FROM		TO
Fragmented approaches that view economy, society and environment as separate entities	→	Integrated approaches that recognise the interlinkages between environment, society and economy
Development assistance	→	A universal global compact
Top-down decision making	→	Multi-stakeholder decision-making processes
Growth models that increase inequality and risk	→	Growth models that decrease inequality and risk
Shareholder value business models	→	Stakeholder value business models
Meeting 'easy' development targets	→	Tackling systemic barriers to progress
Damage control	→	Investing in resilience
Concepts and testing	→	Scaled up interventions
Multiple discrete actions	→	Cross-scale co-ordination
Reliance on the single discipline and individual 'expert'	→	Stronger inter-disciplinarity and transdisciplinarity and reliance on multidisciplinary teams

Figure 9: Summary of shifts required for a new way of approaching development (the last row highlights changes in knowledge production approaches) (Adapted from IRF 2015)

3.1.4 Universities as knowledge producers and knowledge co-producers

As noted above, there is a long standing understanding that universities have a strong role to play in knowledge production; indeed, their history is based on their combined role of research and teaching. However, as noted by Pillay (cited in section 3.1.3 above), universities in Africa have tended to play a stronger role in education and training, as providers of 'human capital' (graduates) for growth and development primarily in the post-independent state. This emphasis on education and training (teaching) has affected the role of higher education

⁶⁹ www.icsu.org/future-earth

institutions in Africa to contribute to research and innovation, which to date, has been minimal.

However, with renewed attention being given to the revitalisation of the university in Africa, there is renewed emphasis not only on the education and teaching role of universities, but also on their role in research and innovation, and in community and policy engagement. Today it is widely accepted that the university has ‘three core functions’, namely teaching, research and community engagement which, in an African context, most often also involves policy engagement (as many academics are called upon by governments to provide inputs into national policy processes). This mapping study found, for example, that in all southern African countries, university research and expertise was a strong contributor to CCD policy processes; there was also frustration that policy processes as yet lacked synergy and coherence, showing the possibilities for policy innovation. Increasingly there are calls from governments and the international development community for evidence informed policy development processes⁷⁰, which requires research and high quality knowledge production. Most universities in Africa are in the process of strengthening their capacity for contributing to research and innovation, and their links to policy making processes and communities via community engagement / outreach programmes. This has implications for knowledge production, and especially also for knowledge co-production processes, and the role that universities play in knowledge co-production.

While this is occurring, there is also an emerging understanding that science systems are in transformation as more calls for inter-disciplinarity and collaboration in the knowledge production process emerge in response to intractable problems such as climate change, as shown in the UNESCO 2013 World Social Sciences Report⁷¹, the 2013 World Science Forum declaration⁷², and in other major scientific frameworks such as the Future Earth Global Sustainability Science Plan.⁷³ As stated in relation to the Future Earth Global Sustainability Science Plan:

“Future Earth will bring together natural scientists, social scientists, engineers and the humanities with funders and policy makers to align research agendas, understand and anticipate environmental change, and develop innovative solutions ... The key to success will be research that is more interdisciplinary, more international, more collaborative and more responsive to the users of research...”⁷⁴

⁷⁰ Policy engagement and innovation is a recognised study area in its own right. Universities can therefore not only contribute to policy, but also assist with re-thinking policy processes in critical and socially relevant ways. Policy studies are therefore an important contributor to CCD related concerns, not only from an applied perspective, but also from a policy critique and innovation perspective.

⁷¹ UNESCO/ISSC .2013. *World Social Science Report 2013*.

⁷² World Science Forum, Rio de Janeiro, 24-27 November 2013. <http://www.sciforum.hu/declaration/index.html>

⁷³ www.icsu.org/future-earth

⁷⁴ Professor Diana Liverman, co-chair of the Future Earth design team and co-director of the University of Arizona’s Institute of the Environment, cited at the launch of the Future Earth research plan at the Rio+20 Conference, 2012.

An extensive review by Hessels and van Lente (2008)⁷⁵ of new knowledge production literature states that there is a general trend towards orienting science systems towards strategic goals, and the production of relevant knowledge to address pressing societal needs, as is also proposed in this CCD Knowledge Co-Production Framework.

A variety of approaches to understand, explain and theorise such trends have emerged, and it is important to note that these directions in science systems are not uncontested. A key scientific debate that shows up the contestation surrounding the changes in the scientific system towards 'new knowledge production' paradigms, surrounds the work of Gibbons et al. (1994)⁷⁶, who produced a text on 'The New Production of Knowledge'. This suggested that while knowledge production used to be located primarily in scientific institutions and structured by scientific disciplines, its location, practices and principles are much more heterogeneous. Gibbons et al.⁷⁷ suggested that knowledge ought to be produced 'in context of application' via transdisciplinary collaborations or via knowledge co-production processes. Such approaches to knowledge need not, however, replace the importance of knowledge produced in disciplinary contexts, but can rather be seen to *supplement and expand* the disciplinary foundations of knowledge production, creating new knowledge production approaches and formations.

Critiques of transdisciplinary approaches also exist, and it is useful to heed these in CCD related research and knowledge co-production. For example, there is a tendency to see transdisciplinarity in opposition to disciplinarity which may be erroneous, as transdisciplinarity cannot simply attain independence from the disciplinary sciences. The two are intertwined and mutually dependent. There is also a tendency to conflate knowledge production and use and/or deployment in transdisciplinary discourses, and clearer distinctions may need to be made here. Transdisciplinary approaches are also critiqued for being 'anti-differentiation' because they tend to blur the boundaries between academic, technical, industrial and sociological institutions. This can lead to the said conflation noted above, although there is also a strong counter-argument for stronger integration. Transdisciplinary approaches, like all knowledge co-production approaches, may also suffer from an uncritical blend of descriptive and normative content in knowledge co-production processes, requiring a reflexive engagement with such approaches.⁷⁸

Additionally, there are implications for universities and university systems related to knowledge co-production approaches:

⁷⁵ Hessels, L.K and H. van Lente. 2008. "Re-thinking new knowledge production: A literature review and research agenda," *Research Policy* 37: 740-760.

⁷⁶ Gibbons, M., C. Limoges, H. Nowotny, S. Schwartzman, P. Scott, and M. Trow. 1994. *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London: Sage.

⁷⁷ Gibbons et al., *The New Production of Knowledge*.

⁷⁸ Partially adapted from Hessels and van Lente, "Re-thinking new knowledge production", but also reflective of the consultation in this mapping study.

- How to engage with and enhance the validity of inter- and transdisciplinary research activities, with their dynamic integration of theory and practice from various disciplines, and the extent to which these are recognised as a substantial part of contemporary science systems;
- How to engage with the reflexivity that is required of university scientists to become more aware of the potential societal effects of their research and to take these into account as they select research objects, methods and approaches; and
- How to engage with new criteria for research related to societal relevance, and how these can be integrated into systems of scientific quality control e.g. peer review, funding frameworks, and also into evaluation systems of individuals, projects and organisations.⁷⁹

All these issues need to be critically considered by university systems, taking into account **the heterogeneity of science**, and the differences that exist between scientific fields and national contexts, priorities, policies and societal change concerns.

The mapping study, together with related international scientific plans and debates, show that climate resilient pathways or CCD is clearly a critical societal change concern that is influencing systems of knowledge production in ways that view universities not only as knowledge producers, but also as co-producers of knowledge and participants in societal formations oriented towards the public good. There are some useful lessons for considering the role of universities as knowledge co-producers that have emerged from projects such as the United Nations Development Programme (UNDP) coordinated Africa Adaptation Programme (AAP).⁸⁰ It was found that **scientific data alone was insufficient when talking to decision-makers**, and that *“While essential, this data must be placed within a national context to influence the decision making process. Climate change policy makers proved to be most receptive to a combination of scientific-based information, socio-economic baselines and vulnerability assessments including the integration of economic impact assessments, indigenous knowledge and gender issues”*. This finding is important as guide for a regional Knowledge Co-Production Framework as it suggests that local scientists need to integrate their findings into national development contexts and priority concerns.

From a capacity development perspective, the UNDP AAP findings indicate that *“Capacity to plan for and integrate (the how to) climate change in national and sub-national planning was very limited”*. The AAP found further that *“learning tours or knowledge exchange activities were found to be vital in sharing lessons and experience in coastal adaptation measures”*. Significantly too, the AAP found there was greater impact in resilience creation if policy and programme actions at national level were **mirrored** at sub-national levels. This involved sub-

⁷⁹ Partially adapted from Hessels and van Lente, “Re-thinking new knowledge production”, but also reflective of the consultations in this mapping study.

⁸⁰ Mwebaza, R. 2013. Lessons learned from innovative resilient national and local government planning and policy. UNDP. www.locs4africa.iclei.org/files/2013/11 (downloaded 16 November 2013). The findings in this section from the UNDP AAP are from this source. They are foregrounded here as this has been one of the major CCD initiatives (focused on adaptation) that has been implemented in the SADC region. There are other studies that show similar findings, but a detailed analysis of these falls outside of the scope of the mapping study.

national government structures and associated stakeholders in development of local level responses. Significant to the role of universities as knowledge co-producers is the finding that **“knowledge generation and management to support planning at implementation at national and sub-national levels are crucial”**.

Examples of programmes initiated by AAP to support this include supporting use of **systems dynamic modelling** to support assessment of climate change and vulnerability mapping, establishment of **knowledge centres** (in the case of Mozambique this was located in the Science Academy of the Ministry of Science and Technology which is now included in the national climate change strategy); supporting the development of **e-infrastructure on climate data and information data** which included the installation of High Performing Computer (HPC) for generating models and facilitating access to data, and **by creating information links between climate, forecasting and early warning systems**. Creating enabling infrastructure for wireless connection sharing information between Ministries such as Forestry, Agriculture, Health and Disaster Management Authorities was another strategy employed. Such strategies can be and need to be extended to universities in each country, as they have potential to contribute to especially national and sub-national level engagement with CCD knowledge production and management processes, and also to contribute to capacity building goals for CCD. Here it is important to note that programmes such as the UNDP AAP tend to produce models and approaches which then need to be integrated into national systems of development, knowledge flow and institutional structures.

The mapping study findings, together with the AAP programme results, both show that countries need reliable and up-to-date data for moving development towards greater resilience. In the AAP, this involved supporting national meteorological services to provide reliable, detailed and up-to-date weather monitoring and forecasting. National engineers were trained in climate data and information management and climate modelling, highlighting this as a key area for curriculum innovation in the engineering sciences. Capacity for understanding the importance of downscaled climate data to make informed adaptation decisions was also found to be crucial. Countries were taught the importance of this data, given access to datasets such as CORDEX, and provided with training on analysis and application of such datasets. This indicates a further area for curriculum innovation and knowledge production in universities.

The AAP findings also emphasise the importance of the role of faculties that train public management officials, financial managers and policy makers, as accessing and integrating climate change financing into national planning and development was found to be a key enabling factor influencing CCD. The UNDP AAP findings report that having good climate policy and action plans are not adequate; they need national funding to mature them. This is consistent with the findings of the mapping study. Capacity building and training was required in accessing the financial mechanism for CCD. This has implications, for example, for Faculties of Commerce, who traditionally have been less involved in education for sustainable development innovations.

All of these findings, together with the discussion on knowledge production and co-production outlined above, point to the kinds of ‘new priorities’ that CCD brings to the knowledge

production environment in universities, and highlight the kinds of institutional changes, research and curriculum innovations that are required.

3.2 Institutional analysis synthesis

3.2.1 Overview of the country-by-country institutional analyses

As indicated in section 1 above, this mapping study involved an institutional analysis undertaken country-by-country (summary in Appendix A, published as individual Country Reports in Volume 2). The institutional analyses for each country include the following:

- Policy and institutional arrangements for higher education and for climate change responses;
- Research and development frameworks at national level, especially as these relate to CCD;
- A rapid analysis of some current CCD initiatives and programmes in countries;
- An analysis of the existing status of CCD research, education, outreach and networking in each country, with an emphasis on
 - Understandings of CCD amongst university professionals and stakeholders;
 - Current research related to CCD;
 - Nodes of Expertise, Centres of Expertise, Centres of Excellence and Research Networks identified;⁸¹
 - Curriculum innovations and teaching for CCD;
 - Community and policy outreach;
 - Student involvement in CCD;
 - University policy and campus management;
 - University collaboration and networking; and
 - University leadership, with all of the above feeding into an analysis of what existing practices could be strengthened and what could be done differently.

The institutional analysis also included an assessment of current knowledge co-production practices via multi-, inter- and transdisciplinary approaches to research. It identified examples of such research where they existed, and also commented on the constraints and benefits of such research approaches, as discussed in workshops with universities and stakeholders. Additionally, it provided some insight into possibilities for such approaches to knowledge co-

⁸¹ **Nodes of expertise** as used in this document refers to 'clusters of expertise' related to a specific CCD related research area, involving at least one high performing academic with post-graduate scholars. **Centres of Expertise** refers to already established research centres or institutes most often operating at university level, or between a number of universities with networked partnership links (these may be national or international). A **Centre of Excellence** as used in this study refers to a multi-institutional partnership framework that addresses a key CCD research area involving multiple universities, and formalised national and international partnerships. A **research network** refers to interest-based research groupings that convene regularly to discuss or debate research concerns. See section 4 (Table 5) for a more detailed explanation of how these terms are used in this document.

production at national level, but also within SADC, pointing out where possible research links and partnerships can be formed across countries.

There are a number of aspects that stand out from the country-based mapping studies and the institutional assessments that were undertaken as part of these. These relate to a number of key areas that are relevant to knowledge co-production for CCD, and for this Knowledge Co-Production Framework.

3.2.2 Building a common understanding of CCD within and across institutions

As noted in the Needs Assessment (section 2), in all countries involved in this mapping study, there was general agreement that CCD involves both mitigation and adaptation as well as a range of cross-cutting societal and social-ecological system change dimensions. The definition of CCD as used in the project (see section 1) above was used in all workshops, and there was also clear agreement that CCD must be part of sustainable development (see section 1), and that it was a concept closely related to the concept of climate resilient development (see section 1). It was also noted that in all climate change policy documents reviewed relating to climate change that there is a clear conceptualisation of climate change responses being closely linked to sustainable development, and that dealing with climate change was a cross-sectorial and multi-levelled issue, affecting all institutions in society. Climate change in southern Africa is not seen as an environmental concern, but rather as an urgent development concern with social-ecological and social-economic consequences that cannot be left unattended. It therefore has significant institutional development implications, for all institutions in society, including Higher Education Institutions, which are the focus of this mapping study.

While this general agreement existed, it was found that in many cases, stakeholders and university professionals tended to interpret CCD *in relation to their sectoral, institutional and/or disciplinary interests*, and in many cases, they also *interpreted CCD at the level of how climate change would affect their enterprises, institutions or sectors, or key constituents* (e.g. the mining industry in Namibia, or coastal communities in Tanzania or Mozambique), not carrying through to conceptualisation of new development paths and alternatives. However, as noted in the Needs Analysis (section 2.3.2), data from the workshops and questionnaires in many of the countries showed a strong understanding of the need for CCD and of the gaps in the national response that went beyond the disciplines of participants or the mandates of their institutions.

Some participants felt that through the programmatic influence of the UNDP and other global development organisations involved in climate change, e.g. the Africa Adaptation Programme there tended to be a bias towards adaptation discourse and practice. However, this may more be due to the emphasis in national policy on the very real and urgent adaptation need in southern African countries, a process which has greatly influenced the institutional responses to climate change to date. Important to future institutional development of CCD was the insight that the bias towards adaptation, while important and necessary, also tended to marginalise or obscure a focus on mitigation, and other cross-cutting concerns such as cultural, social and economic system change. Workshop participants and questionnaire respondents

were in agreement that *all* these aspects needed to be viewed in relation to each other for CCD to emerge as a clear development trajectory within wider sustainable development objectives, and that all universities and other knowledge and policy institutions needed to take the full scope of concerns on board.

For many who attended the workshops, it was also the ‘first time’ they had considered the full meaning of the concept of CCD, showing that it is an important concept to develop further through ongoing engagement within and between institutions. This does also highlight some degree of confusion generated by the tendency of donors and programmes to develop their own conceptualisations of responding to climate change.

A key issue for universities and stakeholders to engage with is the fact that CDKN is promoting the concept of CCD, developed with partners in the United Kingdom’s Overseas Development Institute (ODI)⁸², while the IPCC uses the concept of climate resilient development pathways, which also integrates adaptation, mitigation and development. Thus it would seem appropriate for the region to further engage in discussions on this point, and to perhaps be guided to some extent on the conceptualisation of this kind of integrated response to climate change that will be present in the forthcoming SADC Climate Change Policy.

In the mapping study university responses across all countries there was an appeal to ‘mainstream’ the essence of the concept of CCD, or a different formulation of the same integrated approach, since it was said that CCD was seen to be the ‘territory’ of Geographers or Scientists, which hindered wider uptake of CCD research. Findings were that university leaders needed to engage more responsively with the concept of CCD and the issues and vulnerabilities posed to southern African societies by climate change, highlighting the need for a major drive to engage university leaders and academics across faculties with the process of understanding CCD and its implications for university education.

3.2.3 The science-policy-practice interface

A number of issues emerging from the institutional analysis have relevance to the science-policy-practice interface, as also noted in section 2. The southern African mapping study consultations showed a strong concern for a *science-policy-practice* interface, shown by equal concern for how science can and should influence policy; and how science can and should and influence practice. The SARUA mapping study showed that the relationships between science and policy, and science and practice *both need attention*. Participants were often of the opinion that it is not possible to assume that if science influences policy, that practice changes will automatically occur; as it is well known in southern Africa that policy efficacy often

⁸² The Overseas Development Institute (ODI) is the UK’s leading independent think tank on international development and humanitarian issues. Here it should be noted that the CDKN were funding this SARUA mapping study, hence the emphasis on climate compatible development, and its introduction into SADC university discourse.

remains a problem, hence there was also emphasis on science-practice relationships, especially a concern for beneficiation at community level.

Discussions on the science-policy-practice interface in the mapping study also included critical engagement with dominant development discourse. Here concern was raised about the internal paradox that exists between sustainable development / CCD related policy making oriented towards longer term goals and the public good, and the strong influence of neo-liberal economic development trajectories driven by shorter term growth paradigm gains. The Malawi and South African workshops in particular indicated that critical engagement with development and scientific paradigms and approaches should be included in CCD policy research and practice. The problem of global development trajectories that continued to produce carbon emissions without adequate policy resolution and/or social justice commitments (e.g. the failure of the international climate negotiations process to deliver the required action to date) was raised more than once in the workshops, and in more than one country. This is a macro-level issue that is yet to be adequately addressed at a global policymaking level. Workshop participants in Malawi suggested that stronger activism and negotiation skills are needed for enhancing regional / global South solidarity in climate negotiations.

“The road that is going to be built through the Serengeti National Park ... so there are many voices saying that this road should not be built. But the politicians have very different ideas, and recently I have heard that this is going to happen. So there is this challenge ... is it possible for these people from the universities to push the politicians and make sure that something should be done. But do they have that power?”

Tanzania stakeholder

There was also much concern that while good policies are being developed for CCD at country level, these are not translated into practice, and that they lacked synergy and inter-sectoral coherence and integration. Here it should be noted that while many climate change policies are relatively new, the gap between policy and implementation is true for other sustainable development policies too, indicating more systemic failures. There was also concern with the fact that while scientific findings are being produced, these are poorly disseminated and often remain un-used. There was widespread concern across the countries participating in the mapping study that science is not benefitting communities, and that science should contribute more pro-actively to community well-being, especially in the face of ongoing poverty challenges that are now further exacerbated by climate change risks and vulnerability. How this is to be done was not discussed in great detail, beyond a sense of the need for ‘strategies to make science relevant’ and to ‘improve communications’, and a feeling that transdisciplinary research could help in this regard (see also section 4). The strong expression made about drawing more on indigenous knowledge in relation to scientific practices and in adaptation solutions, and on strategies to engage community knowledge (see section 2 above) is a response to this concern (see section 4). In practice, this strategy (i.e. engaging IK in relation to science and new adaptation practice) is as yet under-developed, especially in university scientific contexts (NGO and development organisation research approaches are more oriented to these approaches than university scientific practices at present).

“Being an economist, and working with scientists, you need to respond to a concept that is not clearly defined. Climate change impacts on the existing system / variability, such that it becomes difficult for us to know, at least in the short term, what is going to happen tomorrow. (draws graph) So we need to focus on our adaptive response – building our resilience to increasing variability. We don’t have the data for precise response, we are looking at spikes in the system. So there is not going to be one specific answer. This means it is important to look at indigenous knowledge systems and other systems and strategies.”

Botswana stakeholder from an international agency

Community engagement in some countries appears to be providing an important interface between scientists and the wider community, but this is generally poorly actualised in universities, due to time pressures and other institutional constraints (e.g. low salaries) that affect the motivation, time and commitment of academics to engage in community-engaged scientific practices. Nevertheless, there are many excellent examples of community-engaged research across SADC countries, but these tend to be driven by committed individuals, rather than by sectoral policy or incentives. In South Africa, the NRF has established a Community Engagement research programme, the Council of Higher Education has released guidelines for universities on community engagement, and many universities have strongly established structures for and are actively reporting on community engagement. These elements are facilitating the science-practice relationship in universities, and show that such structural interventions at research policy, Higher Education sector and university management and structural levels can be helpful in pushing forward new agendas and practices in universities, such as those required for CCD.

International development organisations and donors also appeared to play a key role in enabling the science-policy-practice interface. These organisations, especially the UNDP and large international NGOs such as Oxfam, Action Aid, World Wide Fund for Nature (WWF), and the International Development Research Centre (IDRC), which have a strong presence in CCD policy and practice framing in the southern African region, tend towards supporting situated research that is solution-oriented, and can also inform policy. They are drawing in policy makers, as well as national university researchers (where relevant nodes or centres of expertise exist), international consultants and researchers (where national research capacity does not exist), and they also show community level and/or system level outcomes. They are potentially important ‘boundary partners’ but suffer at times from the problem of lack of continuity, as their programmes tend to be shorter term, innovation centred, and then rely on government and local stakeholders to sustain, upscale and expand them, which most often does not occur in the manner envisaged due to structural constraints and inadequate knowledge transfer systems.⁸³ University researchers refer here to the need for ‘better contextualisation’. Such programmes *do* however provide fertile ground for university-

⁸³ See examples and discussions in the Volume 2 Country Reports.

programme research training partnerships as they model and can generally support the kinds of research at the science-policy-practice interface that contribute actively to CCD knowledge co-production.

At another level, and perhaps referring to the development of more *national* capacity for boundary mediation, was the repeated point of needing to build the capacity of 'boundary organisations' who can facilitate climate change feedback loops between science institutions, policy makers, communities and land users. Such work, currently mainly being filled by international organisations and NGOs, requires capacity to access, interpret, translate and communicate climate change science and relate it to local contexts and CCD relevant indicators / change practices. The most widely cited national institutional role players for this work were the extension services (e.g. forestry, fisheries, agricultural and health support extension services operating from government departments), but in almost all countries these were seen to be generally weak and in need of training to understand and mediate complex climate change knowledge, which has situational specifics that cannot always be pre-determined. This presents universities involved in extension services training with new curriculum and research challenges, if such capacity is to be built at a national level to service the science-policy-practice interface related to CCD and provide the feedback loops necessary for the extension systems to remain informed and relevant.

3.2.4 Universities as contributors to policy knowledge

An interesting relationship was found to exist at the *science-policy* interface in most countries, which points to a significant, if relatively 'silent' role being played by university academics in providing scientific knowledge support for policy. While the disconnect between research and policy, and decision making, was often mentioned, this appears to be a poorly articulated issue, especially when it comes to the way in which research *is* informing climate change policy making. While evidence was found in most countries of a good presence in the internationally published research on the part of leading national researchers in climate change-related fields, the number of active researchers publishing regularly in the peer-reviewed literature tended to indicate a relatively small sub-set of researchers in most countries, with the exception of South Africa and Zimbabwe. However, in all of the southern African countries, leading researchers at universities have contributed *significantly* to documents like climate policies and strategies where these exist, and the First or Second National Communications to the UNFCCC (tracked via the reference lists of these documents, and in workshop and questionnaire data), although this research was not widely published, except in 'grey literature' form (see below).

The mapping study revealed that government in almost all SADC countries was a significant driver of research on climate change, and that they employ university researchers, often via consultancies (academics also work in partnership with independent consultancy companies), to contribute research knowledge to the policy process. The same can be said for research-oriented international NGOs such as WWF and the International Union for the Conservation of Nature (IUCN). Research demand is created via the contextual needs, as well as UNFCCC and other multi-lateral agreement processes such as the UN Convention on Biological Diversity (UN-CBD) and the Convention to Combat Desertification (UN-CCD). Through these processes,

countries commit to producing and updating national reports, hence government's need to 'drive' research to inform this reporting.

In almost all SADC countries, the research processes needed to inform the First and Second National Communications and other policy processes such as the development of National Programmes for Adaptation (NAPA) in least developed countries (LDCs)⁸⁴, appear to have 'ignited' existing small research communities focusing on climate change, and have enlarged these to some extent. This was reflected in questionnaire data showing that many researchers working on climate change and CCD-related research had only been doing so for a few years, although they had been active in their disciplines for much longer. Thus it seems that for these national policy processes, governments are drawing on national researchers in universities. They are assisting them, via this process, to re-orient their research interests and trajectories towards CCD, thus in the process also developing the national scientific base for CCD research, which in turn has curriculum innovation and other effects (see below). These insights also challenge the taken-for-granted view that research must drive policy, as it shows that there is a more iterative relationship between the need for research-based policy knowledge (based on contextual demand) and policy-related research knowledge production (commissioned to respond to this demand), especially in areas that require new forms of knowledge production such as CCD. This is an important process to understand better, and provides a strong motivation for involving university academics in programmes that can enhance their research knowledge and skills for CCD.

University researchers, and where they exist, members of university-based climate change and CCD Research Centres (e.g. the Multidisciplinary Research Centre in Namibia; the LEAD SEA in Malawi, the University of Cape Town's African Climate and Development Initiative, Wits University's Global Change and Sustainability Research Institute) serve on National Climate Change Committees, are thus also helping to set the climate change research and policy agenda.⁸⁵

3.2.5 Research institution building and co-ordination

3.2.5.1 *Research organisations: who is doing climate change and CCD research in SADC countries?*

Besides **university researchers** making contributions mainly to policy and national reporting processes⁸⁶, the mapping study identified a range of other institutions that were also engaged in research, although this was not the main focus or mandate of the mapping study. However,

⁸⁴ National adaptation programmes of action (NAPAs) provide a process for Least Developed Countries (LDCs) to identify priority activities that respond to their urgent and immediate needs to adapt to climate change – those for which further delay would increase vulnerability and/or costs at a later stage (www.unfccc.int).

⁸⁵ See details in the Country Reports (Volume 2). Findings are from consolidated data sets as included in the Country Reports. Note that these are illustrative examples and do not reflect the full scope of researcher participation in national policy processes. Such a detailed analysis is outside of the scope of this study.

⁸⁶ An exception here is South Africa which produces much higher volumes of internationally peer reviewed research than other SADC Countries.

given that they relate to the main focus of this report on knowledge co-production, they are included here to provide a fuller picture of the potential landscape for collaboration involving universities. These other institutions also provide platforms for knowledge sharing, co-operative learning and placement / sites for research for university students and professionals.

- **International organisations and donors:** International organisations and donors are a key group actively involved in climate change and CCD research in SADC and across the African continent, especially GEF-funded programmes and those affiliated to UNEP and the UNDP, who work in partnership with national governments and often mediate and link up a range of donor organisations and practitioners in site-specific climate change and CCD interventions. Examples here are the case of the UNDP led Cuvelai River Basin programme in Angola; and others conducted through the 20-country Africa Adaptation Programme. There are also other examples such as the Lake Chilwa basin research programme being implemented by LEAD SEA with support from the Norwegian government in Malawi.⁸⁷ As CCD knowledge is in its infancy, there is often need for a sophisticated array of multidisciplinary research to inform such development programmes as shown in the UNDP-led Cuvelai River Basin programme in Angola.⁸⁸ This programme involves downscaled modelling, construction of geospatial flood maps, hydro-meteorological data collection, livelihood and vulnerability assessments, germplasm experimentation and field trialling for crop varieties, capturing of traditional knowledge and so on. International development organisations have the financial ‘muscle’ to pull together teams of local / national and international researchers to undertake such studies, creating model knowledge co-production environments. Bilateral donors such as the UK Department for International Development (DfID), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), IDRC and others also play similar roles.
- **NGO research:** In many SADC countries, and indeed across Africa, NGOs, often in partnership with international organisations and funders such as GEF and IDRC, are driving and carrying out innovative forms of research on climate change and CCD. Examples are Oxfam, Action Aid, WWF, IUCN, and others. Good local examples include Indigo Development in SA and Development Workshop in Angola. Often these are interesting and well-executed pieces of research, which are also published in peer-reviewed journals. These research projects tend to be situational, and use community-based action research approaches. They work directly with local communities, and sometimes policy makers, on processes to carry out local vulnerability and impact assessments, and to develop local adaptation strategies, in a way that has many of the characteristics of transdisciplinary research.⁸⁹ One example that stands out however, is the Desert Research Foundation in Namibia which is currently hosting the SADC Gobabeb Centre of Excellence, providing leading facilities and opportunities for

⁸⁷ See Country Mapping Studies for further examples (Volume 2).

⁸⁸ See Angola Country Mapping Study for a summary of this initiative (Volume 2).

⁸⁹ As noted above, it was not the brief of this mapping study to survey NGO research so specific examples are not provided here. However there are some examples noted in the Country Reports where these were found to be relevant (see Volume 2).

university, development partner, and private-public sector partnerships in energy and biodiversity related CCD research.

- **Research consultants:** There are also a large number of research consultants that contribute to climate change and CCD research in southern Africa. In a number of countries, these may be former staff of environment departments, who have significant experience in the field and good understanding of institutional constraints. Research consultants are often contracted by universities to work with them on funding programmes that the universities have been awarded, or vice versa, and many have substantive research – and policy – experience. Such consultants may often also play the role of project leaders for donor programmes. They further play a role in knowledge brokerage between governments, donors, universities, NGOs and communities, and in some country contexts they also serve the role of ‘institutional knowledge repositories’, particularly in the common situation of high staff turnover in key government departments.
- **Independent / parastatal research councils and institutes:** The study also identified a number of influential independent or parastatal (part state-owned and supported research councils and institutes that are playing a critical role in CCD research at country level, but also at regional level. Some examples here are the South African Energy Development Institute in South Africa, the Water Research Commission, the Centre for Scientific and Industrial Research in South Africa, the South African National Biodiversity Institute, the Africa Biomedical Research Institute in Zimbabwe, and the SADC Climate Services Centre located within the Botswana Department of Meteorological Services (amongst others). A number of countries were using / beginning to use this approach to national scientific innovation development for CCD, and in some countries proposals for new research institutions of this kind were being put forward (e.g. in Mozambique a Climate Knowledge Centre was being proposed, while in South Africa a Climate Change Council is being proposed). As shown in the Country Mapping Studies, such institutions have the capacity to leverage national and international funding, bring researchers from a variety of institutions (including universities) together and play an important bridging role between researchers, government and sector institutions. These dedicated research institutions tend also to employ highly skilled researchers, and they also tend to be involved in co-operative capacity development partnerships for PhD and postgraduate scholars.

The above highlights the fact that research is, in practice, not solely in the ambit of universities. New forms of research partnership are possible between university researchers and other researchers in society, and indeed already exist. This also raises the issue of the university role in a research environment characterised by multiple research partners.

The mapping study identified questions of research ‘ownership’ and contextualisation of the climate change and CCD research agenda, which was felt to be best done at a national level. This raises questions about whether universities lead the research agenda, co-operate with others on nationally set research agendas, take responsibility for training new researchers, become part of research networks and wider systems of knowledge production, or play a mix of these roles. Currently, the policy system relies on both – research produced within universities, and research produced outside of universities in science councils, dedicated research institutes, the private sector, and NGOs and development agencies. It was said

numerous times during the mapping study that research tends to be limited to ‘research silos’ and that there is a need for much stronger relationships with the private sector, and other research partnerships. This is not just a matter of seeking research funding, but genuinely collaborating to produce new knowledge, as was said in Botswana, Malawi and Zimbabwe (amongst others). In other countries, a need was also expressed for stronger research partnerships with the public sector (for example, in Swaziland, Botswana, and Seychelles).

Universities may be well positioned to take up a leadership role in facilitating such multi-sectoral research partnerships, and in many cases they do play this role. It may also be desirable for universities to be open to playing different roles in the research process, at different times.

“The core business of universities is reflected accurately here, research is coming out very clearly. The assumption that may be problematic is that research should remain at universities. Universities may come up also with research frameworks, which other stakeholders could take up. We at universities also rely on research that is produced outside the universities – for example, government documents, private sector sources etc.”

Senior academic, UNISWA

3.2.5.2 Research policy and national infrastructure for research

In most countries, there was a commitment to research and innovation at government level, and as shown in the institutional analysis of each country⁹⁰, the CCD policy environment tends to emphasise research and knowledge generation as a key aspect of CCD responsiveness. In most countries there is also a ministry responsible for research, often either the Ministries of Higher Education or the Ministries of Science and Technology, and these are targeted in national CCD policy as being responsible for enabling CCD research. In some national CCD policies, there was also an acknowledgement (e.g. in the case of South Africa) that the current research infrastructure is inadequate for addressing the CCD challenges. Workshop consultations showed, however, that while there was national commitment to research and development (R&D), and that many countries realised that this was an important dimension of CCD, the realities of how this ‘plays out’ on the ground in terms of real commitment to sustained climate change and CCD research programmes was not always as positive as it could be. The mapping study therefore shows that further effort is needed to realise the policy commitments to R&D within a CCD framework, in almost all countries involved in the mapping study.

⁹⁰ See Appendix A and Volume 2 Country Mapping Studies.

3.2.5.3 *Research co-ordination, data sharing and knowledge management*

When there are multiple research organisations all with a slightly different interest and orientation to research, the need for **research co-ordination and knowledge management** emerges as important, especially when the research area is new, there is a high demand for knowledge and research, and when the research systems are generally under-resourced. As was stated in one of the country policies:

“Climate change research must be properly coordinated and the benefits optimised to meet the needs of policy makers and communities. National Climate Change Policies make provision for international cooperation, collaboration and networking to achieve effective responses, including the promotion of international North-South and South-South collaborative research that will facilitate generation of climate change adaptation and mitigation evidence-based information. Attention must be focused on projects that will assist with mitigation of, and adaptation to climate change, and address specific areas of vulnerability. Further, development and demonstration projects are required to show the advantages and acceptability of a variety of technologies.”

Namibian draft National Climate Change Strategy and Action Plan, 2013

The issue of knowledge management, research co-ordination and data sharing was raised across all the countries that participated in the mapping study. Some of the climate change policies included clauses on research co-ordination and most included clauses on knowledge management. In a few countries, specific new structures were being set up to facilitate research co-ordination and knowledge management, as in Mozambique where a **Climate Change Knowledge Centre** is being established by government, and in Namibia, whose policy also included plans for a **Climate Change Research Centre**. However while the issue of knowledge management was raised over and over, there were very few suggestions made as to *what this entailed and/or how this was to be done*. There was, however, a broad understanding that this required research planning, research leadership, and research infrastructure, as well as communication and outreach functions, and appropriate ICT systems, hardware and software, and skilled operators of these systems. Establishing such climate change research co-ordination centres or systems therefore appears to be a resource and capacity intensive endeavour, and one of the questions that might arise in the context of a regional programme such as the SARUA climate change development programme is whether research co-ordination could not also be considered at sub-regional or at the level of research clusters that operate across countries. Some examples of this practice are already in existence in the form of the SADC Climate Services Centre in Botswana, and in SADC level plans for a SADC Centre of Excellence in Renewable Energy Research.

Research co-ordination and knowledge management also had other dynamics that became visible via the consultative process, such as the mediation and facilitation of permission to use data that existed amongst diverse stakeholders in the national interest. For example, in Namibia it was said that due mainly to a lack of co-ordination, business and local government had valuable datasets but that these were not being shared amongst stakeholders and with universities, while in Zimbabwe university researchers showed concern about having to pay for

data that was held by the Meteorological office. A Climate Change Research Co-ordination Centre would have to take on board this kind of a role if its core function was to facilitate CCD research and knowledge co-production.

Additionally, a research co-ordination and knowledge management function would also need to ensure that adequate structures and systems were in place to facilitate awareness of, and use of up-to-date climate information. It is interesting that in South Africa, the National Research Foundation has recently called for a South African Research Chairs Initiative (SARCHI) research chair in the public communication of science, as a direct response to poor systems of scientific communication and interaction with the public, an issue that was raised in most countries participating in the mapping study. As stated in Namibia's Second National Communication to the UNFCCC (GoN 2011): "*Public awareness raising using accurate up-to-date information is required to empower stakeholders, especially local subsistence and commercial farmers, to participate in adaptive response activities*". One of the key responsibilities of such a function would be to develop strategies (and possible training programmes) that can facilitate the work of extension services in using climate change and climate risk and vulnerability data.

3.2.5.4 *New institutions for CCD research and knowledge co-production*

Another interesting finding of the mapping study was the number of *new institutions*, mainly in the form of research centres, which are being established to address climate change knowledge management and research needs. The intention to establish these was found in national policy documents in some countries (e.g. Namibia, Mozambique and South Africa). In some cases these were being conceptualised as national facilities (as in Mozambique and South Africa) to which universities contribute. In other cases they were being established in universities as partnerships with international organisations, such as in Angola's Centre of Excellence for Sciences Applied to Sustainability (CESSAF), and /or by universities themselves, in the case of the Centre for Climate Change and Tropical Ecology in Angola, the Centre for Study in Renewable and Sustainable Energy (CSRSE) at the University of Botswana, the African Climate and Development Initiative (ACDI) at the University of Cape Town and the University of Fort Hare's Institute of Technology (which is establishing itself as a Renewable Energy Centre of Excellence), the Risk and Vulnerability Science Centres at the Universities of Fort Hare, Limpopo and Venda in South Africa, and so on. Additional details can be found in Appendix A. These centres all have climate change and/or climate compatible development and/or sustainable development (which includes a CCD focus) research, knowledge management and capacity building / training as their 'core business', or as an increasingly key focus of their work. It is also interesting to see that existing centres focussed more broadly on sustainable development, such as the Sustainability Institute at the University of Stellenbosch, and the Environmental Learning Research Centre at Rhodes University, are re-orienting their programmes towards the strong imperative for climate change and CCD-related teaching and research; most are including aspects of CCD in their work that are more widely oriented to sustainable development.

These centres allow for the development of *specialised expertise*, and also allow for development of *critical mass*, and appear to be an important element of building the knowledge base necessary for dealing with critical concerns such as CCD and sustainable

development more broadly. In most cases, these centres are relatively new, with the most established ones, for example the Sustainability Institute at the University of Stellenbosch in South Africa, and LEAD Southern and Eastern Africa located at Chancellor College, University of Malawi, having life-spans of approximately 10-15 years only. Most of the climate change and CCD-related centres are newer than this and have been in existence for five years or less. This interesting phenomenon on the university landscape could benefit from closer examination of the role of such centres. These emerging centres often need to be supported with capacity building interventions, given the complexity of the issue to which they are responding, its multi-disciplinarity, and its requirement for new forms of knowledge production and management. The SARUA programme could place considerable attention on the capacity building of such centres, as well as on facilitating knowledge exchange amongst such centres, given its regional convening power. In South Africa it was also noted that the SARCHI Research Chairs constitute an important stimulus for specialised areas of research related to climate change and CCD – for example, the Chair in Biofuels or a Chair in Climate Change.

3.2.5.5 Centres of Excellence, Centres of Expertise and Nodes of Expertise

Another key finding of this mapping study lies in the identification of nodes of expertise that are significant for a CCD Knowledge Co-Production Framework in almost every country. See Appendix A of this volume, and Volume 2, for more detail on these. Nodes of expertise, as used in this report, refer to clusters of researchers who are working together on a focussed research area that has relevance to climate change and CCD (see definitions in section 5). These exist in both the natural and social sciences, and in most countries strong nodes of expertise relevant to CCD were found in environmental science, agriculture and natural resources management areas. There are some emerging nodes of expertise in social sciences but these are generally under-represented and still emergent. There is a need for a strategy that can strengthen these emerging nodes of expertise, especially in the social sciences in all countries to develop critical mass for CCD research.

A number of centres of expertise were also identified with specific capacity for climate change and CCD-related research, as shown in the institutional analysis tables compiled for each country, summarised in Appendix A, with more detail in Volume 2. Centres of Expertise, as used in this report, refer to already existing Centres or institutes focussing on key research areas relevant to CCD where some ‘critical mass’ for CCD related research exists in the form of experienced researchers working with postgraduates and/or national and international partners. These, as noted above, provide an important resource for strengthening CCD research co-operation at a regional level. As noted above, some are still in their ‘infancy’ and require capacity building. Of interest here is the finding that most energy research centres identified in universities are focussing on energy efficiency, clean technology, and renewable energy (see Appendix A). Potential exists to link these together via the proposed SADC Centre of Excellence in Energy research. There is also potential to link up research centres focussing on environmental / CCD related health concerns; centres focussing on urban related CCD concerns; social learning and CCD and so on (see section 4 for recommendations in this regard).

In some cases, Centres of Excellence (CoEs) (defined in section 5 below) were also identified. Centres of Excellence as used in this report refers to research institutions that involve multiple university and multi stakeholder partners and that have strong national and international partnerships. In most cases these also had strong national government support, as in the case of the Applied Centre for Climate and Earth System Sciences in South Africa (ACCESS), and were also linked to wider structures such as SADC, in the case of the Namibian CoE at Gobabeb, or NEPAD in the case of the Water CoEs, and involved multiple stakeholders and partners, often across universities and countries. These are important centres of innovation for CCD research, and efforts should be made to link these to various centres of expertise and nodes of expertise to facilitate a dynamic research environment. The model of the Angolan Centre of Expertise (i.e. twinning with an international CoE) could also be investigated more widely within the SADC region, as a possible strategy to consider for the SARUA programme.

Countries are urged to consider strategies that can facilitate the strengthening of nodes of expertise so that these may emerge into centres of expertise, eventually contributing to more widely networked Centres of Excellence that can facilitate expanded research supervision and capacity building for CCD in southern Africa. Organisations such as the SADC, NEPAD, the AU and other international partners should also be brought on board to assist with strengthening the capacity of nodes, centres of expertise and Centres of Excellence. It is notable, for example, how the link to the United Nations University *coupled with* support from the SADC Regional Environmental Education Programme (which involved Sida funding) during the UN Decade of Education for Sustainable Development (2005-2014) has facilitated a regional network of Education for Sustainable Development (ESD) Centres of Expertise across the SADC Region. Interesting too from this case, is that not much external funding was injected into this system of Centres of Expertise, and if further funding *had* been allocated to them, with a stronger research capacity building focus, these would no doubt have additional capacity at a higher level, as is now needed to take the CCD agenda forward. As education, training, capacity building and social learning for CCD has been identified as a key issue across SADC countries, this network of Centres of Expertise offers a strong baseline resource for this component of the Knowledge Co-Production Framework (see section 4). While regional programmes such as the Southern African Science Service Centre for Climate Change and Adaptive Land Use Management (SASSCAL) are beginning to play an important role in climate change and CCD knowledge production, it is not clear how these are linked into Centres of Excellence and Centres of Expertise for CCD in the SADC region. Such synergies, however, have clear benefits and potential.

3.2.5.6 Research incentives and system development

A further issue raised across the countries involved in the mapping study was the issue of research incentives and research system development. Few countries have well-developed research systems that provide an enabling environment for university-based research. Research funding was repeatedly noted as a critical limiting factor. Where research funding was available, as in South Africa, it was cited as being insufficient for the type and scale of research that is needed. In some countries, like Namibia, the national research systems are still in formation, and are contested. SARUA 2009 data shows that in many countries the bulk of research funding is provided by government – where such data is available, see Table 2 in

section 1. However, other sources of funding also resource research in universities, and in a number of countries the issue of private-public sector partnerships for research was mentioned. In South Africa, the timescale of research funding was also highlighted, as research funding tended to be released in three-year cycles, which again was seen to be inadequate for the scope, type and scale of research that is required. This issue needs to be taken up at a wider level, and also needs to be considered for the proposed SARUA climate change and development programme.

National research policy that incentivises researchers to publish in international journals can have a significant impact on research outputs, as was shown in the South African case.⁹¹ This is, however, a policy issue at a wider level than CCD research only. However, as shown in this study, research incentive policies and practices (e.g. promotion policies at university level) as well as wider incentive policies at institutional and/or national policy level influence CCD research practice in substantive ways. CCD research therefore cannot be de-linked from wider institutional research policies and practices.

3.2.6 Research capacity building and platforms for research innovation

The mapping study further revealed a number of issues that need to be dealt with at the level of research capacity building and practice. These include issues of methodology, research approaches, and ICT-facilitated research approaches and capacity building. Knowledge sharing and participation platforms were also identified as a key area that needed attention, especially for induction of new researchers and for exposure to new approaches.

3.2.6.1 New research approaches, methodologies and challenges

CCD research is both disciplinary, involving the introduction of new approaches to research within existing disciplines, and within multidisciplinary formations. Added to this is the challenge of introducing inter- and transdisciplinary approaches to research. Findings in the mapping study included few examples of inter- and transdisciplinary research ‘on the ground’, although in most countries some examples could be identified. There was also some evidence of interdisciplinary research co-operation, especially amongst departments in the same faculties. For example, in the University of Namibia, the Faculty of Science’s Department of Biological Sciences was collaborating with the Department of Geology and the Department of Plant Sciences in conducting research, contributing research-based policy inputs, co-publishing; and teaching; while in the Faculty of Humanities, Departments of Sociology and Geography were collaborating on a similar range of activities. This may be because the

⁹¹ The South African Country Report, drawing on data from Pouris (2012) reports that the single most important factor influencing a rapid upswing in research output in South African universities in the past ten years was the national policy to fund universities based on research output. This system-wide funding structure change has had a big impact on enhanced research-based university structures, and the valuing of research in these institutions. See South African mapping study Country Report, Volume 2, and Pouris, A. 2012. “Science in South Africa: The dawn of a renaissance?” *South African Journal of Science* 108(7/8). <http://dx.doi.org/10.4102/sajs.v108i7/8.1018> .

research methodologies and epistemologies at faculty level are easier to integrate than across faculties (i.e. social sciences and natural sciences collaborations).

There were, however, also some examples of CCD inter- and transdisciplinary research found in universities that crossed faculties (e.g. involving engineers, social scientists and biological scientists, as well as local government and community partners). In those cases stronger forms of inter- and transdisciplinarity were observed.

Two such examples of inter- and transdisciplinary research currently being undertaken are offered here in brief (below) for illustrative purposes only (Box 1 and 2). A wider range of examples are contained in the Country Reports (Volume 2)⁹².

Box 1: Malawi: Lake Chilwa Basin Climate Change Adaptation Programme (LCBCCAP)

(Implemented by LEAD SEA, Chancellor College Malawi, together with the World Fish Centre, and the Ministry of Environment and Climate Change Management with support of the Norwegian government) (2010-2014)

This transdisciplinary research and development project is a programme with the overall goal to secure the livelihoods of 1.5 million people in the Lake Chilwa Basin and enhance resilience of the natural resource base. The programme aims to achieve this goal through a social-ecological systems approach to the development and implementation of basin-wide climate change adaptations in support of the Malawi National Adaptation Programme of Action (NAPA), and to enhance the capacity of communities to adopt sustainable livelihood and natural resources management practices. The project is being implemented in ten selected Hot Spots in the Lake Chilwa Basin comprising villages from the three districts of Machinga, Phalombe and Zomba. A number of research activities support this larger programme, which include: ongoing monitoring and observation of climate patterns and trends; stakeholder analysis; data collection on fisheries and aquaculture; a fisheries frame survey; livelihoods analysis; income generating activities analyses; value creation and value chain research; practical action research to test and demonstrate alternatives; technical ecological and ecosystem service assessments; and participatory monitoring.

From this it is possible to see that CCD projects tend to be 'research rich' and that the research questions are situated in real issues, and data generated has potential for immediate application, and that the research also 'builds' over time from technical baseline type assessments to analysis of options and monitoring of new practices and benefits (although not necessarily in a linear manner). In the LCBCCAP, research results are drawn on to inform ongoing project activities and implementation plans, making knowledge useful in contexts of implementation. This forms part of a reflexive programme implementation process with annual reports that show the relationship between knowledge production and application, demonstrating also the knowledge co-production process that takes place between multiple stakeholders and multiple disciplinary researchers. The situated context of the research provides the platform for co-operative knowledge co-production and use.

The LCBCCAP research products are also well documented and available on the website, showing the blend of methodology development, actual studies, and how studies 'come together' in practical project activities, which are reported on regularly. Examples such as this can provide valuable case examples of transdisciplinary knowledge co-production processes that draw on multiple disciplines and multiple stakeholders.

Source: www.lakechilwaproject.mw

⁹² See section 5 of the various Country Reports (Volume 2).

Although it was not possible to undertake a detailed country-based analysis of all cases of inter- and transdisciplinary research, the mapping study was able to identify at least one or two cases of such types of CCD research in almost all of the countries participating in the mapping study, although it was not always possible to obtain detailed information on these cases. Where information was obtained, it was possible to see that these differed in 1) origination (often being originated by UNDP or external partners, but involving university-based researchers; or being originated by universities involving multi-institutional partners and multidisciplinary formations); 2) orientation (some had a strong community development and problem solving focus while others had a stronger focus on technological / scientific innovation); and 3) strength (quality and scope of outcomes differed). It was also noticeable that these forms of research were often closely embedded in, or related to projects or programmes of development; and/or were landscape / context defined in the first instance, from where research problems and practices were defined in consultative processes with multiple stakeholders and into which CCD research concepts, approaches and tools were introduced by researchers and/or development partners (e.g. vulnerability mapping etc.). An example of a 'landscape defined' transdisciplinary research programme was found at the University of Cape Town in South Africa, briefly summarised below in Box 2.

**Box 2: University of Cape Town's Bergrivier Transdisciplinary Research Programme
(an initiative of the African Climate and Development Initiative (ACDI))**

The "Bergrivier" action research project for climate responsive development: Emergence as a challenge and opportunity for transdisciplinary collaboration

The Bergrivier Project is an exploration of the UCT African Climate and Development Initiative (ACDI), seeking to develop innovative means to foster and support inter- and transdisciplinary interactions among researchers, and between researchers and practitioners. The overarching question is: "How do we create and sustain transdisciplinary action research processes that link knowledge co-generation and practice in pursuit of development that is responsive to climate variability and change?" To create a tangible platform for such a process, a geographic focus was identified in the Bergrivier municipal area, though other scales are included where appropriate, such as the Berg River catchment. Drawing on the work of Otto Scharmer and others, a 'U-process' was implemented. This was characterised by dedicated stages for collective 'sensing' of the 'system' and key issues in the region, a retreat to link these themes to personal proclivities and motivation, and smaller teams developing linked action research projects within the broader initiative. This has given rise to the tentative beginnings of a series of nested collaborative research projects involving UCT researchers and students that respond to the overarching question within the case study area.

These research projects include: (i) Support for Bergrivier Municipality in assessing climate change vulnerabilities and designing an adaptation strategy; (ii) Opportunities and barriers for making low cost housing climate resilient; (iii) Exploration of the primary organisational capabilities that are needed and missing in municipalities in support of climate responsive development; (iv) Water system governance in the Bergrivier Municipality and beyond; (v) Climate policy and behavioural change interventions at school and community level; (vi) Long-term land use/land cover change in the Groot Winterhoek Wilderness Area; (vii) Landscape and environmental education.

The project has clearly demonstrated the value of transdisciplinary approaches that engage participants from civil society, government and business in the definition of the research problem and in the actual research. However such processes have high transaction costs (time and funding), require administrative and financial support to maintain a collaborative network, and also raise tensions between research (depth and philosophy of enquiry) and practice (need for action).

Summary produced by the Pro-VC for Climate Change and the Director of the African Climate and Development Initiative (ACDI) at the University of Cape Town, Professor Mark New (see Appendix A for the combinations of departments that are working together under the banner of the UCT's ACDI).

Participants stated that this type of research required '*substantial patience*' and the '*development of a new research language*' and that '*researchers needed to understand each other better*', and that '*time should be invested in building methodological understanding across disciplines*'. Such concerns relate also partly to the fact that different disciplines tend to rely on historically established methodological practices, and shifting across faculties often required engagement with new forms of methodology i.e. a shift from quantitative methodology to qualitative methodology, or combining qualitative and quantitative methodologies and so on. Behind this, however, is also the need to re-conceptualise what a social-ecological focus for research means for methodology in practice, and for university education more broadly, involving multiple disciplines and research teams in interdisciplinary research formations. Few examples of theorising this new approach to research were found, although some South African researchers are beginning to do research on some of the methodological and epistemological challenges of inter- and transdisciplinary research. There is also an emerging body of international literature on inter- and transdisciplinary research which southern African researchers are beginning to draw on.⁹³ The work that needs to be done to methodologically and scientifically develop inter- and transdisciplinary sciences however, remains in its infancy across the SADC region as a whole. Research for CCD also requires more action-oriented research, and involvement of multiple stakeholders, with methodological implications for research that are as yet, also under-developed and under-theorised in a southern African context. There may, however, be lessons to be learned from the work of institutions and NGOs that have long implemented participatory action-oriented research; and other forms of engaged research. All the above have implications for *methodology development and research methodology capacity development*, which should be seen as an important facet of the SARUA five-year climate change and development programme.

⁹³ Some examples here are:

- Pickett, S.T.A., W.R. Burch, M. Grove. 1999. "Interdisciplinary Research: Maintaining the Constructive Impulse in a Culture of Criticism," *Ecosystems* 2: 302-307.
- Golde, D. and H.A. Gallagher. 1999. "The Challenges of Conducting Interdisciplinary Research in Traditional Doctoral Programs," *Ecosystems* 2: 281-285.
- Bridle, H., A. Vrieling, M. Cardillo, Y. Araya and L. Hinojosa. 2013. "Preparing for an interdisciplinary future: A perspective from early career researchers," *Futures* 53: 22-32.

3.2.6.2 ICT-enhanced research systems⁹⁴

One of the fundamental areas of climate change and CCD-related research is observation, monitoring and modelling. Such research requires sophisticated ICT-enhanced research systems, to which only a few countries have access at the university level. South African research-intensive universities like the University of Cape Town, University of Stellenbosch, University of Pretoria, and University of the Witwatersrand, were most well resourced with the kinds of computers and high technology research equipment required. As indicated by the findings of the Africa Adaptation Programme, providing for technology enhanced research capacity was one of the critically important aspects of facilitating climate change and CCD research in many countries. This is an area, however, which many international programmes have tended to support through capacity development and provision of equipment to the national meteorological systems. Donor-funded programmes such as the one proposed by UNDP for Angola also rely on high-end technology enhanced research systems, which involve training of researchers to use them successfully. In all countries, capacity for using modelling data and for producing downscaled models was noted as a critical capacity need. Yet there was not much said about how this will be developed and/or provided, which points to another important area of possible regional collaborative engagement, under the SARUA programme on climate change and development. The most efficient way to do this may be through making better linkages with existing and proposed international and regional climate services support programmes.

“The Tanzania Meteorological Agency has good capacity and is producing public goods, and if we have collaboration with the universities, that will be good. If the situation is going on like this, you are not going to have competitive students coming out of the university, because of the problems you are having, like with infrastructure.”

Tanzania government stakeholder

3.2.6.3 Knowledge sharing and participation platforms

One of the aspects that stood out in the mapping study was the increased dialogue and engagement with climate change and CCD issues, especially surrounding the development of new policy processes. More academics have been getting involved in climate change knowledge and policy processes, and there is a clear understanding that engagement across sectors and stakeholders is an important part of this process. The SARUA mapping study workshops themselves provided a forum for university professionals and stakeholders to meet and discuss CCD issues. There is also a need for platforms for sharing experience of CCD-related research, especially more innovative approaches to research such as situated,

⁹⁴ SARUA is also supporting other strategic programmes (in addition to climate change). Key amongst these is an ICT programme (www.sarua.org). In taking this CCD Knowledge Co-Production Framework forward, it is recommended that possible synergies between the SARUA ICT initiative and the SARUA Climate Change and Development work be investigated, something that was outside of the brief of this mapping study.

multidisciplinary and transdisciplinary studies. Currently few such platforms exist which significantly impacts on processes of knowledge co-production.

3.2.7 Current patterns related to universities as producers and co-producers of CCD knowledge

3.2.7.1 CCD is a 'new' area of research for many SADC researchers

A key finding of the mapping study is that CCD research is in general a 'new area' of research for many of the SADC researchers involved in it. As explained in section 3.2.4 concerning the science-policy-practice interface, it appears that policy and international reporting demands at a national level have stimulated the involvement of a number of academics in this area. Questionnaire data across countries showed that most researchers involved in climate change and CCD research had been involved in this area for an average of five years, especially those from within a range of different disciplines. There are some experienced researchers with ten years experience and longer in this field, but they are not in the majority amongst those involved in CCD research. There is an apparent ongoing process in which academics are 'self specialising' into climate change and CCD research, as it did not form part of their initial training or research, except for those that come from environmental science and/or climate science / geography and earth system science backgrounds. This is an interesting pattern that needs to be more carefully understood from a knowledge co-production perspective and from the perspective of the changing nature of knowledge and the changing nature of disciplines themselves, and how these are influenced by interdisciplinary trends and/or issues that demand stronger engagement with inter-disciplinarity. This also has implications for capacity building and for development of 'in-depth' climate science knowledge and research.

3.2.7.2 Disciplinary-based research and lack of interdisciplinary co-operation

The mapping study showed an enduring strong dominance of single discipline research, with multi-, inter- and transdisciplinary research approaches still in their infancy, and in some places not developed at all. The UNESCO Social Science Report of 2013 states that issues such as climate change "bring to the fore the need to draw on the social sciences to bring about the economic and behavioural changes required to achieve sustainability". The 2013 World Science Forum also emphasises this, stating in its 2013 declaration that "*intense research efforts involving inter- and transdisciplinary approaches are needed*". It is clear that this emphasis on multi-, inter- and transdisciplinary approaches to research is new at an international level too, especially in the context of dealing with complex issues such as global environmental change. This is a challenge for all scientists from all disciplines. For example, as noted in the 2013 UNESCO/ ISSC World Social Science Report:

"Social scientists need to collaborate more effectively with colleagues from the natural, human and engineering sciences to deliver knowledge that can help address the most pressing of today's environmental problems and sustainability challenges. And they need to do so in close collaboration with decision-makers, practitioners and the other users of their research."

The same call is made to the traditional natural, engineering and technological sciences.

As there is still a strong dominance of single discipline research in SADC, these new calls for changes in scientific practice must be accompanied by capacity building in which scientific communities can share experience of approaching and engaging with such approaches.

“The point of harmonisation among universities came out very clearly in our discussions. If you assume that climate change is part and parcel of environmental management, you could see a very big problem. Because the universities have very different backgrounds. For example, UDSM approaches this from the geography side while SUA is from the forestry perspective. So it is very possible that we may not teach environmental management as such, but we may more teach from our disciplines. I went to Makerere, when I did my Masters programme on NRM, I found most of the emphasis on agroforestry, rather than broader NRM.”

Tanzania university lecturer

3.2.7.3 Multi-, inter- and transdisciplinary approaches to CCD research: progress and challenges

The point above about capacity building for new approaches to research was also emphasised amongst those who were already engaged in multi-, inter- and transdisciplinary research and who had seen the benefits of such research approaches in relation to the problems being studied. As one questionnaire respondent said:

“Support integrated, cross-disciplinary climate change research and training within the university, invest in this research, set an example in terms of the way the university conducts its business (not business as usual), treat climate change as a priority area within the university and not something left only to those that ‘believe in it’.”

South African questionnaire respondent

There was, in particular, a strong call for university leadership to support these new approaches to research, as they also require structural change in universities at the highest level. Some of the most apparently intractable problems associated with transdisciplinary research were not at the level of research practice itself, but rather at the level of institutional management and incentives for undertaking research. These existed at university levels in promotion structures, as well as in the extra-university research context in research publication structures. It was said for example that there were ‘few’ journals that would accept multi- or interdisciplinary research papers, especially amongst those ‘high impact’ journals that counted most for promotional processes and peer recognition. A further problem identified was the sharing of income streams across departments where financial systems were oriented towards funding of single disciplinary teaching and research activities only.

“The way research has been pegged to incentives in universities compromises the ethical responsibility of academics/researchers to research.”

Botswana university staff member

3.2.7.4 Learning from similar knowledge initiatives on critical societal issues

A number of countries mentioned the need to learn lessons from the approach to addressing poverty and HIV/AIDS that countries had employed. These lessons were to be drawn from experiences of mainstreaming critical societal issues into the higher education system, as was the case in all SADC universities through government-university partnership programmes. Key here was the important role played by university leaders, and inter-university structures such as Higher Education South Africa (HESA) (a structure that allows all university Vice Chancellors to meet and agree on common priority issues to deal with collectively). It was noted that the support needed was not only technical and practical, but also societal, and all institutions in society concerned with the critical societal issues (e.g. HIV/AIDS) had been involved in supporting mainstreaming initiatives into Higher Education. Student organisations and internal university structures (e.g. Senates, Faculty Boards and Residence Boards, amongst others) were also important structures to engage with in building critical mass for mainstreaming.

3.2.7.5 Roles for universities in CCD knowledge production and co-production

In addition to the usual roles for university as expressed in the 'normal' mandates of universities i.e. to conduct research, teaching, and community outreach, the climate change and CCD research trajectory also expects universities to take up stronger innovation and leadership roles for universities, and to engage more actively in **solution-oriented** research, through research approaches that contribute to solutions and actual changes in practice.

A number of key mechanisms were mentioned for enhancing the innovation, leadership and solution-oriented contributions of university research, including:

- Introduce / re-activate public lectures and debates on topical issues such as climate change – as University of Swaziland (UNISWA) professionals mentioned, this has slackened in the past and should be reinvigorated. This relates to the problems of poor dissemination of information and new knowledge. It was said that more options for knowledge dissemination should be explored, other than the traditional route of journal publishing. However, these broader options for knowledge dissemination should also be recognised and rewarded as an important part of academic practice. Related to this were suggestions for HEIs to come together as much as possible, and to combine resources at their disposal for enhanced dissemination, public awareness raising, and policy influence – and in this way, strengthen their leadership on this critical societal issue.
- Another key strategy suggested in the mapping study workshops was for universities to develop on-campus demonstration projects e.g. reducing campus carbon footprint, testing out renewable energy options on campus and so on. This could be a way to facilitate practical demonstration sites that also strengthens student involvement (see discussion on student involvement below). The Africa Green Campus initiative could potentially be an important partner for the SARUA programme in this regard.
- Another significant mechanism for enhancing the innovation, leadership and solution-oriented contributions of university research is establishing collaborative research programmes across institutions, with wider stakeholders, and with international partnerships that have strong knowledge exchange and technology transfer frameworks.

3.2.8 General conditions for CCD knowledge co-production

3.2.8.1 *Institutional diversity, similarities and trends*

The SADC region has a range of different Higher Education Institutions, all with their particular niche areas and differentiated mandates. (For example there are universities of natural resources management that focus on agriculture and natural resources management degree programmes, while Universities of Technology often focus on issues such as renewable energy technology development, while others focus more on core disciplinary research and teaching). Identifying, recognising and acknowledging differences in institutional focus, specialisation areas, contextual challenges, disciplinary knowledge frameworks and contributions needs to be seen as a valuable and important feature of CCD research.

Existing experience, institutional diversity sectoral interest and level of operation in the system often determines how CCD is viewed and/or how CCD priorities are identified. The diversity of responses from diverse stakeholders and university professionals (in diverse disciplines and management positions) shows that different institutions / disciplines and levels of inter-disciplinary management are needed to develop an holistic view of climate compatible development 'needs'.

It is also important to identify and recognise these different perspectives in knowledge co-production processes and approaches, as personal and/or sector or institution-specific experience and context can shed light on specific priority areas. The diversity of responses from such a varied range of experts in their fields shows the interdisciplinary and multi-sectoral nature of climate change and CCD response.

How to harness such perspectives and the associated expertise that informs such perspectives is the ultimate challenge of a Knowledge Co-Production Framework and process.

3.2.8.2 *Addressing barriers to collaborative research*

It was also agreed in all of the countries engaged in the mapping study that there was a need to a) clearly identify and articulate, and b) address barriers to collaborative research, given that it would not be possible to address climate change and CCD-related issues within a 'business as usual' approach. Proposed strategies for addressing barriers included:

- Establish a clear coordination point for collaborative research in the university.
- Universities need to develop research policies and plans that can guide co-operative research and collaborative research approaches, however, if such plans and strategies are developed, they need to be implemented and revised regularly, and this requires engagement of university leaders – e.g. UNISWA Strategic Plan, which has clear statements on sustainable development, needs to be revised to incorporate climate change.
- There is also a need to establish systems for collaboration with partners that do research outside of the universities, and structures through which stakeholders who are interested in collaborating with universities can approach university researchers. For example, it was said in some countries that even though there is a Research Centre,

the way in which it facilitates co-operation is not effective and valuable opportunities for knowledge co-production are therefore lost.

- Strengthen systems for publishing and peer reviewing research outputs that are currently left largely in 'grey literature' form. As noted above, collaboration among researchers and government agencies is one of the most prominent 'outlets' for university research at present. Much research appears to be government-led, and few researchers are publishing research beyond 'grey literature' that informs the need for government information (for example for reporting to the UNFCCC) and/or for policy formulation, with the exception of the more experienced researchers in the region. To translate this research, often undertaken in teams, into published literature requires active support for collaborative publishing. It may also require higher level policy intervention, as shown in the case of South Africa where Higher Education policy interventions related to the funding of universities based on research output proved to be a key mechanism for stimulating a rapid increase in research-based publishing.

3.2.8.3 Internationalisation of research, international peer reviewed research publishing and research networks

Linked to the above point on the need to address barriers to collaborative research is the need to strengthen internationalisation of research and research networks, although in each country examples were found of researchers working in international research networks and partnerships, particularly with other SADC countries.⁹⁵ One of the most striking findings of the mapping study was that, although there is research on climate change and CCD taking place in SADC countries, this is often not being published by SADC researchers, but by international researchers. While definitive causes of this would need further in-depth analysis⁹⁶, some initial insights into why this might be the case are linked to 1) an inadequately developed scholarly publication system for southern Africa; 2) dominance of the publications arena by 'Northern' / international researchers (most high impact Anglophone journals are published in North America / Europe); 3) research funding patterns and global research-based power relations; southern African researchers are normally 'recipients' of funding rather than generators of funded partnerships; 4) publication production experience and confidence; 5) a lack of a substantive research culture in universities (teaching cultures tend to dominate as discussed in section 1); and 6) dominance of research by the 'older' guard, although the ICT context is

⁹⁵ Examples can be found in the Country Mapping Study Reports (Volume 2).

⁹⁶ Such in-depth analysis falls outside of the scope of this mapping study. However, there are programmes that SARUA may link with in addressing the issues raised here such as the Scholarly Communication and Access programme at the University of Cape Town; the initiatives of the Africa Journal Online (based in Grahamstown, South Africa); and lessons that can be learned from the HSRC Press (South Africa), all of which are looking at ways of strengthening scholarly publishing in Africa. Texts by Garry Rosenberg (former publishing manager of the HSRC Press and research co-ordinator of the UCT SCA project are also helpful here: Rosenberg, G. 2009. "Scholarly Books: Their production, use and evaluation in South Africa today," a report commissioned and published by the Academy of Science of South Africa, and a chapter by Rosenberg, G. 2009. 'The dynamics of Social Science scholarly publishing in Africa' in the UNESCO / ISSC World Social Science Report 2009, commissioned and published by UNESCO). African Journals OnLine (AJOL) is a non-profit organisation dedicated to improving the online visibility of and access to the published scholarly research of African-based academics. By using the Internet as a gateway, AJOL aims to enhance conditions for African learning to be translated into African development (<http://www.ajol.info>).

creating more access options for younger researchers and women researchers.⁹⁷ This is a pattern across southern Africa, with exceptions being South Africa on the whole, where more local scientists are publishing climate change research, and smaller sets of experienced and renowned researchers in other SADC countries, especially Zimbabwe, whose researchers were also publishing relatively strongly in international arenas on CCD related concerns. This mirrors the wider pattern that South Africa produces the most internationally published research in Africa, and particularly in southern Africa.

Another way to strengthen internationalisation of research is to develop strategies to engage with international agencies and international research systems. It was noted in the mapping study that in many cases SADC researchers find it difficult to access international research funding, as this often requires a complex set of partnerships, which increasingly are also multi-disciplinary and multi-institutional in nature. Capacity building for research fundraising and systems for facilitating research network formation are therefore also needed. This could potentially be a key output of the SARUA programme, as SARUA is well placed to facilitate this kind of capacity building within the networked structure that will be proposed in this Knowledge Co-Production Framework.

There is a need therefore to engage more proactively with international agencies and international research agencies and institutions that can play a role in research partnership building and also research capacity building. As found in the mapping study, international development agencies, while not research-led, do play a significant role in enabling climate change and CCD research within national government contexts, but also in partnership/s with university researchers, although the extent to which university researchers are drawn on in such knowledge partnerships is not clear. From the few large-scale studies that were scoped, it seemed that large-scale projects or programmes seek to work with 'centres of expertise' that already have capacity for certain aspects of knowledge production needed within the overall development programme's goals. If this capacity does not exist in-country, then it is imported from regional universities, such as the University of Cape Town, or from international universities such as the multi-institutional Tyndall Centre for Climate Change Research. They are therefore important 'knowledge brokers' for CCD in most SADC countries. This enhanced collaboration between regional and international agencies and regional university systems and professionals is likely to continue to be a significant aspect or condition influencing climate change and CCD knowledge co-production in the SADC region in future.

The mapping study also found that international and regional research networks such as the START programme, the Regional Agricultural and Environmental Initiatives Network – Africa (RAEIN-Africa), the Benguela Current Commission, the Southern African Science Service Centre on Climate Change and Adaptive Land Use (SASSCAL), Africa Monitoring of the Environment for Sustainable Development (AMESD); Africa Environmental Observation Network (AEON),

⁹⁷ Here it was found that research-based initiatives that explicitly focused on gender and climate change (such as the Heinrich Boll Foundation programme documenting case studies of gender and climate change in southern African countries) were supporting younger women researchers to access the international publications arena.

WATERNET and the Famine Early Warning System (FEWSNET) were playing an important role in both research capacity building and research networking (see Appendix A), and were operating at a level that allowed for SADC researchers to interact, learn from each other and produce new knowledge at a regional scale.

START (global change System for Analysis, Research and Training)⁹⁸ may be a particularly important model to consider, as it promotes research-driven capacity building to advance knowledge on global environmental change through research grants and fellowships, knowledge assessments and syntheses, curricula development, advanced training institutes, multi-stakeholder dialogues, and place-based strategic planning.⁹⁹ This programme scope could provide some valuable lessons in the further design and implementation of the SARUA capacity building programme.

3.2.8.4 Research funding systems

As indicated above, few of the countries had dedicated national research and development funds that were 'set aside' for climate change and CCD research, except South Africa, which has a National Grand Challenge on Global Change and another National Grand Challenge on Energy, both being relatively well funded by the Department of Science and Technology. Most national governments have Science and Technology Innovation Strategies, but these are not (as yet) strongly oriented towards CCD research, leaving a 'big funding gap' for the kind and scope of research required. The South African case of a national government working with its scientists to define national research plans focussing on CCD priorities within a ten-year Innovation Framework is a good example as the national government commitment to these research thematic areas is also attracting international research funding, which can then be channelled through national research structures. For example, the South African National Research Foundation recently gained Belmont Forum Funding under the Global Change Grand Challenge National Research Plan and the Future Earth Global Sustainability Research Plan, and was able to put out a call to its national researchers to conduct research at the water-energy-food security nexus. SARUA could potentially also play a facilitating role in enabling the flow of global research funding in partnerships with national university systems and Ministries of Science and Technology / Higher Education, making links across SADC universities with for example the ICSU Regional Office for Africa, which is getting involved in facilitating the Future Earth Global Sustainability Research Plan at regional level. It is clear from the findings of the mapping study that a key priority for institution building for climate change and CCD research is the development of enabling funding systems for research in SADC countries.

⁹⁸ <http://start.org/about>

⁹⁹ The work focuses on climate variability and change, disaster risk reduction, land-use/land-cover change, biodiversity conservation, urban development, human health, water resources management, agriculture and food security, and regional climate modelling and climate services. The actions of the programme target science, as well as the interface of science, policy and practice, and inform actions toward fostering more resilient and adaptable development.

“Funding in Botswana cannot improve as long as Botswana does not have a National Research Foundation of some sort.”

Botswana university staff member

3.2.8.5 Building staff capacity and PhDs

Another key finding of the mapping study relates to the profile of the researchers engaged in CCD research. In all countries some women researchers were identified, although they remained in the minority. Most of those responding to the questionnaire had five or more years experience in their disciplines. However, a minority of the total number of mapping study respondents identified with specific expertise in CCD-related sciences had PhDs. This shows a need for not only encouraging more women to become involved in CCD research in SADC universities, but also to support those that are involved in CCD research in SADC universities to obtain PhDs. This points to the need for improved institutional and academic support for developing more PhD scholars, particularly in climate change and CCD related fields, another area that the SARUA climate change programme is well positioned to respond to. Examples of Academic Capacity Development Programmes exist, which can provide guidance for this dimension of the SARUA programme. The emphasis needs to be on supporting women researchers and those who are yet to obtain PhDs. One such example is the Higher Education South Africa (HESA) programme¹⁰⁰ entitled *‘Building the Next Generation of Academics’* which is a multi-institutional programme that has clearly developed approaches and strategies for attracting and supporting the growth and development of a ‘next generation’ of academics in South African Higher Education Institutions. This programme states clearly that the ‘PhD pipeline’ is particularly critical for such an intervention. There are also various programmes offering PhD scholarships for CCD related study fields, but these differ from the HESA example, which is *dedicated to development of academic staff in universities* (in addition to their academic specialist fields), and therefore also addresses institutional issues associated with Higher Education practices and contexts (e.g. marginalisation of women academics, publishing capacity and so on). Besides giving attention to the development of academics, the SARUA programme can potentially also ‘broker’ funding partnerships for PhD study in relevant CCD areas (see sections 4 and 5), and make knowledge of new programmes that offer CCD related opportunities available to southern African universities.

The point made above is particularly significant in relation to building the wider human capacity base for climate change and CCD research and practice, as questionnaire data revealed that there is a clear link between those lecturers involved in climate change-related research and curriculum innovations in this area. This shows that the relationship between CCD research and curriculum innovation should be more clearly understood, implying a need

¹⁰⁰ <http://www.hesa.org.za>

to examine *how research drives curriculum innovation* in new knowledge areas such as CCD in universities.

Additionally, it was found that those researchers with PhDs and with more experience in the field of climate change and CCD were also those that were most widely ‘networked’ into the national policy and international development expertise networks, showing that their research expertise was valued at both a national and international level. More PhDs, and more opportunities to generate experience and participate in such networks, have a positive effect on curriculum innovation, and on national research competence and policy outcomes (judging by the effect and influence of those researchers that did have climate change-related PhDs, and that did have extensive experience in CCD-related research). The South African Global Change Grand Challenge National Research Plan’s Human Capital Development Strategy made the important point that is necessary to build a ‘critical mass’ around key areas of necessary expertise, as reliance on one or two experts is inadequate for the demand, and also is high risk for the knowledge community. In some of the SADC countries this was noticed where a strong individual in CCD research had left the country, leaving a ‘critical gap’ in his/her wake for national level CCD knowledge generation, impacting downstream on policy contributions, education and training.

3.2.9 Curriculum development and innovation

3.2.9.1 Integration and infusion of CCD into curricula

The mapping study also pointed to some interesting institutional patterns related to climate change curriculum development. In most countries and in almost all faculties that were involved in climate change it was found that climate change and CCD-related concerns were slowly being integrated into existing disciplines and that, where it existed, CCD knowledge was *infused into, integrated with* and generally seen to be ‘part of’ other aspects of training; although where this was the case, it was also noted that existing efforts in this direction were currently inadequate and much more needed to be done. Some examples here include:

- The Environmental Science, Geography and Earth Sciences Department at the University of Malawi reports that “*Climate change is integrated in most of our courses at graduate level. Courses include environmental studies and natural resources management, rural development, agricultural geography, climatology etc. However, we are currently reviewing our curriculum and climate change is one of the suggested courses to be introduced at second year and fourth year*”.
- The Department of Fisheries and Aquatic Sciences in the Faculty of Agriculture and Natural Resources at the University of Namibia report that “*CCD infused into three undergraduate modules which have a biodiversity focus (some CCD infusion). A more significant component of CCD is needed in the courses*”.¹⁰¹

¹⁰¹ Further examples can be found in the Volume 2 Country Mapping Study Reports.

A typical response to the question of infusion and/or inclusion of CCD into courses is captured below:

“We have no specific CCD courses, but some of our courses include elements of CCD, usually ‘in passing’.”

Namibian Professor

3.2.9.2 Interdisciplinary curriculum development

There were very few examples identified of interdisciplinary curriculum development and teaching, and where this occurred it was more based on ‘voluntary interest’ than on institutional policy or frameworks. One example here is the Department of Sociology at the University of Namibia, who were co-operating with the Department of Geography, History and Environmental Studies to offer interdisciplinary CCD courses to **Department of Sociology** students in the following courses:

- CCD included in second year Social Demography course;
- CCD included in fourth year Sociology of Health course;
- CCD included in fourth year Rural Sociology course;
- Special course on ‘Sociology of Environment’ is offered; and
- Urban Sociology is a new course being introduced in 2014.

However, the relationship was not one-sided, and courses being offered to **Department of Geography, History and Environmental Studies** students were:

- CCD integrated into Honours degree in Environmental Management and Governance (fourth year); and
- CCD integrated into Environmental Studies, GIS and Remote Sensing courses (third year).

In this case, one of the lecturers concerned was serving on the National Climate Change Committee, and all lecturers concerned involved in the co-operation were also part of the Multidisciplinary Research Centre (participating in the research theme on climate change risk and vulnerability in Namibia), *showing the importance of engagement with specialist and contextual knowledge of CCD issues amongst lecturers as being a key stimulant for interdisciplinary curriculum innovations.*

3.2.9.3 Undergraduate CCD curriculum development

While it was not possible to survey all courses offered in southern African universities, there were a few dedicated courses / modules focussing on CCD-related concerns only found at undergraduate levels. These were found at a wide range of universities across the region, showing that there is a definite ‘*bottom up*’ curriculum change movement occurring in response to CCD concerns, although this was not institutionally mandated or structured in any way. Some examples are briefly mentioned below to show that this is occurring *regionally, and in different faculties*. Detailed information on undergraduate and postgraduate course offerings are listed in tables in the Volume 2 Country Reports. Only a few cases are shared here by way of example:

- An undergraduate BSc course in Environmental Science at the University of Seychelles offers a specialisation in climate change.
- The College of Education at the University of Malawi offers undergraduate courses on 'People and their environment'; 'Ecological systems'; 'Climate change and environment'; 'Bio-geographical sciences'.
- The Environmental Science Department at the University of Botswana offer a Tourism and Climate change course, and courses on 'Remote Sensing and Geo-Spatial Information Systems'.
- The Bachelor of Environmental Studies (BES) at Mulungushi University in Zambia focuses on current environmental issues facing the world today, including climate change mitigation and adaptation, disaster risk reduction, waste management, pollution, land degradation, energy use and sustainable resource use.
- Also in Zambia, the Energy and Environment Research Group (EERG) at the Physics Department, University of Zambia (UNZA) has been at the forefront in integrating climate change studies into the Physics Department curriculum over the past two decades, both at the undergraduate and postgraduate levels;
- The Copperbelt University of Science and Technology has been integrating climate change into the environmental engineering and biological studies curricula.
- From October 2013, the University of Zambia has been offering a new course on climate change and education, which will be offered for a full year, and will allow for going into greater detail on climate change issues.

3.2.9.4 Curriculum innovation at Masters degree level

A key area for CCD curriculum innovation was at the Masters degree level. A number of universities had plans to develop a climate change-related Masters degree. This is particularly important for the SARUA climate change programme, which seeks to support integration of CCD modules into Masters degrees as one of its key outputs (section 1). Masters degree curriculum innovation took different forms, and was found to be at different levels of completion:

- *New Masters degrees*: Examples of universities that would like to develop new climate change / CCD Masters degrees included the University of Namibia and Eduardo Mondlane University in Mozambique. Sokoine University of Agriculture in Tanzania is considering developing another programme on Climate Change and Natural Resources, although it seems that this will only be at an undergraduate level initially.
- *Focussed integration of CC /CCD into existing Masters degrees*: Examples here are the UNISWA stand-alone graduate course on climate change titled 'Climate change and environment' within its multidisciplinary MSc on Environment and Resources Management (ERM). In Tanzania, the Muhimbili University of Health and Allied Sciences' Masters degree in Environmental and Occupational Health (MSc EOH) includes a module on the 'Impact of Climate Change on Health', which is a further positive innovation for the under-researched area of climate change impacts on health. Some courses include climate change issues to a very high degree, such as the Masters programme on Ecosystem Sciences and Management at Tanzania's Sokoine University of Agriculture, in which almost half of the courses are related to climate change, including a focus on gender and climate change.

- *Already existing specialist degrees in CC/CCD:* Examples of these were found at the University of Eduardo Mondlane (in the Faculty of Agronomy and Forestry Engineering, with a focus on disaster risk reduction); at the Lilongwe University of Agriculture and Natural Resources (with a focus on environment and climate change); at the University of Cape Town where a Masters degree in Climate Change and Sustainable Development exists; the recently launched Master's Programme in Climate Change and Sustainable Development (Regular and Executive Programmes) at the University of Dar es Salaam's Centre for Climate Change Studies; and at the Universities of Stellenbosch, Wits, Fort Hare and North West (in South Africa) where Masters degree programmes in renewable energy are on offer; the University of the North West (SA) where an LLM course in Climate Law exists; and the University of the Free State (SA) where a Masters degree in Disaster Management exists. This shows that these Masters degrees all focus specifically on CC / CCD, but are also oriented towards specialist disciplinary areas, with some levels of inter-disciplinarity. Interesting is that all these Masters degrees are 'relatively new offerings' and have been in existence for between three to five years only. This shows that this is a potentially important new area of curriculum innovation that should be more widely supported.
- *Multi-institutional Masters degrees in CCD across countries:* While no specific CCD Masters degree in this category was identified, the mapping study found that Masters degrees closely related to CCD in this category were emerging. An example here is the University of Stellenbosch, which is developing a joint Masters degree programme in sustainable development with universities in Europe, India and Japan.

The Masters degree therefore seems to be a key 'curriculum innovation point' for further development, especially via partnerships with universities that already have such Masters degrees, and those that are ready to, or in the process of developing Masters degrees. E-learning approaches and shared courseware are further important strategies for curriculum innovation. The ACCESS Centre of Excellence in South Africa potentially has capacity to lead a regional curriculum innovation programme at Masters degree level via a shared expertise model (such an initiative is already listed in their workplan). Universities with already existing capacity for such a process include the University of Cape Town (already linked to ACCESS), the University of Dar es Salaam, the University of Stellenbosch (also linked to ACCESS), LUANAR and the LEAD SEA linked programme at Chancellor College at the University of Malawi and others. However, such a process needs to be carefully planned and costed, and care should be taken to ensure that the programmes can be sustained after initial interventions. The proposed new SADC Centre of Excellence in Energy Research may also be able to broker such a multi-institutional Masters degree programme across SADC countries, as significant expertise exists for renewable energy research in various centres around the region (see Appendix A).

3.2.9.5 CCD and PhD programmes and supervision

The mapping study did not probe issues of PhD supervision in great depth, but it was noticeable that those professors with more experience and strong track records in climate change-related study fields were also those that were more likely to be supervising and teaching PhDs in this area. The University of Stellenbosch has an innovative Transdisciplinary PhD programme that works with cohorts of PhDs, all of whom undertake transdisciplinary research in an area of sustainability. A number of the South African universities have

substantive PhD programmes in various areas of CCD specialisation (as can be seen in Volume 2, and in Appendix B), and the Universities of Botswana, Malawi LUANAR, UEM in Mozambique, Dar es Salaam, Mauritius, University of Zimbabwe, Zambia and others were also supervising some PhD studies in the area of CCD. These programmes and supervisors involved in PhD supervision in this area could all potentially contribute valuable insights into PhD learning and supervision within the SARUA Climate Change Capacity Development programme, as can programmes or individual academics that are supervising smaller cohorts of PhDs attached to individual supervisors or smaller scale research 'nodes' with specialist expertise. It may also be possible to establish a regional *PhD cohort programme/s* across institutions, via the SARUA programme drawing in high level PhD supervision capacity from across the region.

However, it was noted across the mapping study, and is also documented more broadly, that one of the key issues associated with PhD production in South Africa and also in other SADC countries is supervision capacity, due also to increases in undergraduate teaching loads for all university staff. More enabling conditions therefore need to be created for the best and most experienced CCD academics to supervise PhD teaching and research. There are also a few innovative programmes in the SADC region that are seeking to address the supervision capacity gap, which could be considered or adapted for the SARUA programme, such as direct and explicit supervisor training, twinning and co-supervision programmes, and supervisor mentorship programmes.

3.2.9.6 *Teaching methods and service learning approaches*

Knowledge co-production approaches also require new forms of pedagogy and more innovative teaching methods. The mapping study found that there were a range of preferred teaching methods used by academics for CCD-related issues, many of which pointed towards more innovative teaching and learning approaches. Questionnaire data shows that in most cases, academics involved in sustainable development / CCD teaching were seeking to use more innovative teaching methods such as problem based learning, case studies, practical assessments, games and scenario-based analyses, film and new media and so on.

The questionnaire data probed the extent to which universities were using service learning approaches as these potentially provide a mechanism for curriculum innovation that allows for stronger links between universities and communities, which is one of the features of knowledge co-production approaches to teaching and learning. The study revealed that there were examples of service learning in different SADC universities, but it was not a widely spread practice across institutions. The development of service learning approaches for CCD knowledge co-production through teaching and learning could therefore also potentially be an area of ongoing curriculum innovation in the SADC region. The University of Swaziland, University of Malawi, University of Zambia and some of the South African universities had some good examples of using such approaches. Such approaches are also, however, constrained by issues of budget and time.

3.2.9.7 *Curriculum innovation using Web2.0 platforms*

Little was said, however, about the new forms of pedagogy that are emerging via the Web2.0 platforms, and how these can best be used to strengthen and support curriculum and

pedagogical innovation, despite the fact that these approaches hold much potential, especially also for regional knowledge exchange. One innovative CCD programme that was identified in the mapping study is the Development Reality Institute in Zimbabwe, which runs a 'virtual school' offering online courses on climate change. This institute has been established as an independent training institute by youth organisations, and is currently not affiliated to any university, but has, however, won several regional awards for its innovative teaching, e-learning and curriculum practices and its proactive use of online learning for CCD. Other initiatives in this direction were visible within the mapping study, although it was not a widely reported area of curriculum innovation. An example is the Habitable Planet initiative of ACCESS that has had some success with linking its programmes to social media platforms. This seems therefore to be a potentially important arena for curriculum innovation for CCD in a regional context.

While Massive Open Online Courses (MOOCs) (see Box 3 below) are not uncontested in terms of their pedagogical value as formal learning programmes, and there are various accreditation complexities associated with them for use in formal teaching programmes, and they are of uneven quality and currently have a low completion rate (10 percent), they nevertheless are also setting a trend towards Web2.0 forms of learning, interaction and knowledge sharing that may be worth researching in more depth for CCD learning platforms. One of the issues that may, for example, need to be debated is the relationship between 'global' MOOC knowledge, and local level CCD concerns; ideological perspectives and interests embedded in the course materials; and if and how MOOC can be integrated into other curriculum development innovations, at what levels and so on.

Box 3: MOOCs on climate change / CCD

There are currently six different Massive Open Online Courses (MOOCs) on climate change available on Coursera (www.coursera.org). These are offered by the World Bank (new course starting January 2014, see below); the University of Chicago; the University of British Columbia; the University of Pennsylvania; the University of Melbourne; and the University of California, San Diego. Other related MOOCs are available on 'The Age of Sustainable Development' offered by the Earth Institute at Columbia University, USA (Jeffery Sachs); and LifeCycle Assessment (Northwestern University, USA). No MOOCs on CC/ CCD developed by southern African / African universities or institutions were identified.

One example of a MOOC and how it works:

*The World Bank MOOC on climate has four modules and is being offered in two tracks: (1) Climate Champion / Generalist; and (2) Policy and Leadership. The course runs for four weeks (involving three hours of study per week; and broadband Internet access), and is free of charge. Participants on the course have access to the material for approximately six months after the course ends. The course format involves use of climate films and video material (17 interactive video talks by renowned climate scientists and practitioners); interactive activities; **quizzes** that check the learners' knowledge, reinforce the lesson's material and provide immediate feedback; **assignments** that sharpen skills of analysis, reflection and communication; **discussion forums and social media** that enable collaboration with others from around the world; two live interactive **Google Hangouts on Air** with international experts, who will engage in a Q&A session on climate change. As a final project, participants create a **digital artifact**. Successful completion leads to a Coursera Statement of Accomplishment. Course requirements include gaining a cumulative score of 50 percent in the following required activities: three quizzes, two peer review assignments and a final project. Distinctions are awarded for scores of 80 percent or over. The core resources and assignments take around three to five hours per week to complete.*
(<https://www.coursera.org/#course/warmerworld>)

Note: Coursera overall currently has a community of five million students from around the world. The World Bank MOOC attracted 15 000 learners in its first round. This therefore potentially offers a more informal learning avenue for expanding internationalisation experiences of SADC learners in CCD. MOOC statistics currently show a high level of use by undergraduate and postgraduate scholars for 'additional study' / enrichment study purposes.

3.2.9.8 Competence development for CCD

Another area that was not raised in great detail in the mapping study, but which is nevertheless a key issue of concern for curriculum innovation, as discussed briefly with the Pro-Vice Chancellor for Climate Change at the University of Cape Town in South Africa, is the question of 'core competences' for CCD graduates. The mapping study revealed that in broad terms that there is agreement that CCD graduates should have at least some of the following competences:

- Knowledge of social-ecological systems as these relate to CCD (e.g. risk and vulnerability etc.);
- Policy knowledge;
- Specialist knowledge of climate change and local climate change conditions and impacts at various levels and scales (e.g. landscape level, wider national level, regional and global levels);

- Specialist knowledge relevant to CCD; adaptation and mitigation in various sectors and/or focus areas (e.g. agricultural adaptation; fisheries; renewable energy; clean technology; CC and health; water security and CC etc.);
- Integrative competence and the ability to work in multi- and interdisciplinary teams;
- Knowledge of global and contextual dimensions of CCD;
- Ability to deal with and navigate complexity and change;
- Capacity to engage with communities (including ability to work with IK in CCD contexts) and multiple stakeholders;
- Motivation to learn and be part of change processes; and
- Ethical decision making.

The mapping study also clearly pointed to the need for wider enabling competences e.g. new financial management competences, new policy formation and networking competence, leadership and ethical competences, as well as knowledge dissemination competences. These are besides those competences related to the priority thematic areas for CCD such as agricultural adaptation knowledge, or water management knowledge, amongst others as mentioned above.

However, there was no clear ‘definition’ of how such competences are aligned, or how they are linked together or in what ‘measure’ they are required in the curriculum, or how they relate to values and knowledge. Thus, it seems further care is needed in defining competences to guide curriculum innovation.

It is instructive though to note that a key finding of the mapping study is that CCD capacity **must be systems based, and must be developed cross-sectorially**, and that much wider **enabling competencies** and support are needed, over and above specific knowledge and competences as outlined above, to engender CCD action. This has implications for curriculum development and innovation, as there is a need to conceptualise what ‘much wider enabling competences’ mean, and what the relationship is between knowledge and these ‘wider enabling competences’. A more considered analysis of the data in the mapping study (across data sources; policy expectations; capacity gaps, and with wider analytical tools provided by Wiek et al., 2011¹⁰²) reveals the following types of competences that are necessary for CCD:

- Competences to understand complex problems from an integrated social-ecological systems perspective, and to understand such problem constellations in the current situation, and their history and relations to other contexts or situations. This requires **systems thinking competence**.
- Competences to assess and understand risk and vulnerability, and to anticipate possible scenarios and consequences. This requires **anticipatory competence**.
- Competences to engage with future planning and strategy development to conceptualise appropriate alternatives and responses that are sustainable and viable i.e. to engage with transitioning processes. This requires **strategic planning**

¹⁰² Wiek, A., L. Withycombe and C. Redman. 2011. “Key competences in sustainability: A reference framework for academic program development,” *Sustainability Science*. Published online 19 May 2011. doi 10.1007/s11625-011-0132-6.

competence. This also requires knowledge of certain planning tools (multi criterion analysis etc). Here modelling competence is also important (energy modelling, climate modelling, economic modelling, combining different types of models etc) and is a good aid for **systems thinking competence**¹⁰³ as well.

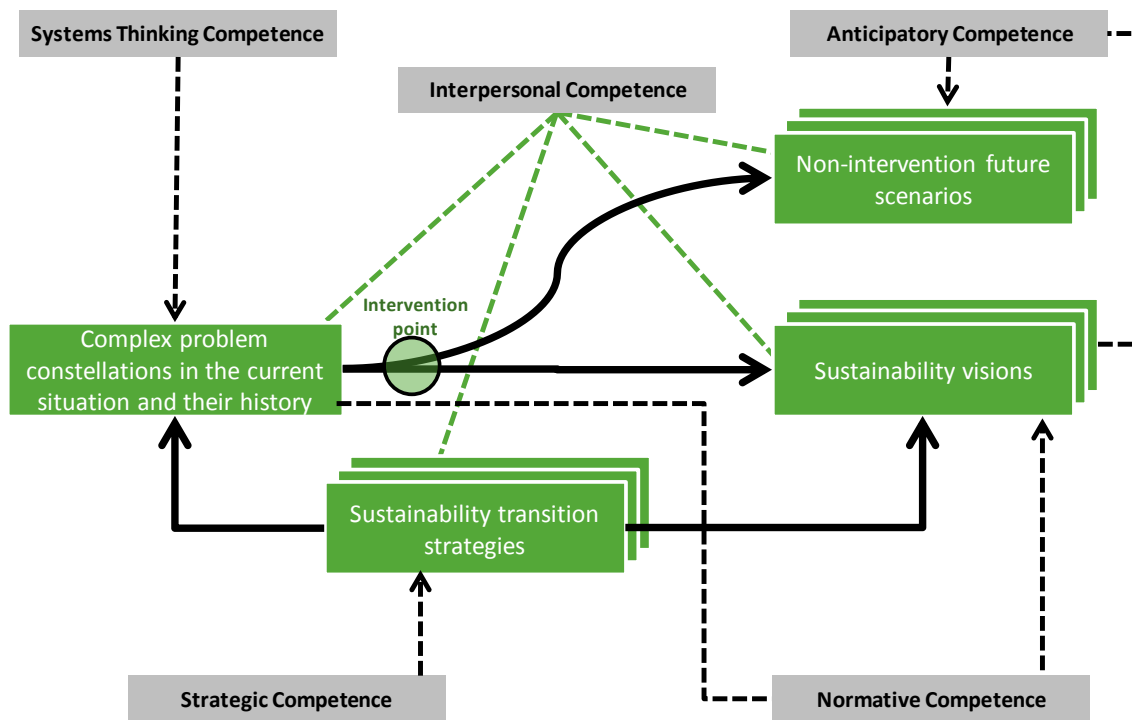
- Competences to consider the implications of decisions and how they affect current and future well-being, of people and planet. This requires **normative competence.**
- Competences to engage in adaptive management and to participate in social innovations that generate new practices. This requires **socially engaged practical competence.**

Much has been said about such competences in the international literature. A substantive literature review of sustainability competency thinking in academic development, and its influence on curriculum development was recently undertaken by Wiek et al. (2011).¹⁰⁴ Their analysis shows similar competences to those identified above, and suggests that there is a relationship that exists *between such competences*, and that foundational to the other forms of competences is knowledge and understanding of complex social-ecological systems i.e. systems thinking competence. It is important to note that the way in which ‘competence’ is used here does not exclude knowledge (see below). They also argue that anticipatory and normative competences need to be carefully informed by knowledge, *knowledge of risk and vulnerability, and possible consequences*. Normative competence needs to be informed by knowledge of ethics, and the consequences of ethical choices. Such knowledge is also aesthetic and existentially related, and hence there is a strong need for humanities disciplines to become involved in CCD related teaching and research. Strategic planning competence and socially engaged practical competence are technically and sociologically informed, and knowledge is needed to inform planning and practice (e.g. knowledge of renewable energy technologies is necessary to plan for renewable energy technological installation and use), hence there is need for engineering and economics in CCD competence development.

Wiek et al. (2011) provide a diagram, showing the inter-related nature of these competences as they play out in sustainability research and problem solving contexts (such as those often engaged in CCD research and teaching) shown below.

¹⁰³ Competence framings in bold help to synthesise the findings of the SARUA mapping study on competences and align these with international analysis of sustainability competences as outlined by Wiek et al. (2011) in previous footnote. Wiek et al. note that there is little strong empirical evidence that these competences are in fact the ones required for sustainability. Data in the SARUA mapping study appears to confirm that Wiek et al. do provide a useful way of thinking about sustainability competences in and for education. The SARUA mapping study, however, also emphasised practical competence (as read via community-based adaptation responses that add value to the lives of community members) as being important. This was therefore added to Wiek et al.’s interpretation of social competence.

¹⁰⁴ Wiek, A. et al. 2011. “Key competences in sustainability”.



Note: The five key competencies in sustainability (shaded in grey) as they are linked to a sustainability research and problem-solving framework. The dashed arrows indicate the relevance of individual competencies for one or more components of the research and problem-solving framework (e.g. normative competence is relevant for the sustainability assessment of the current situation as well as for crafting of sustainability visions)

Figure 10: Conceptual framework for competence development (Wiek et al. 2011)

The mapping study also showed that while there is a need for integrated competence development, and diverse forms of knowledge to inform such integrated competence development, there are also very specific knowledge and capacity development needs that will need to be addressed sectorally and from within specific university disciplines, for example:

- *Town and regional planning:* Design and invest in improvements in the drainage capacities of flood prone cities / settlements – this research will need to be a core focus of Engineering Faculties.
- *Food Security:* Conduct research to develop crop varieties that are climate resistant and resilient (e.g. maize, wheat, pearl millet (Mahangu) etc. – this research will need to be a core focus of Agricultural Science Faculties. [There are many other such examples.]

3.2.9.9 CCD knowledge, values, ethics and calls for ‘new paradigm’ thinking

As noted above, competence development cannot emerge without a strong focus on knowledge. But CCD raises a number of questions as to what kind of knowledge is to be taught. There was a strong feeling across the mapping study workshops that a greater focus on integrated, holistic, interdisciplinary, and solution-centred forms of knowledge is needed.

Again, no clear typology for such forms of knowledge emerged, but a publication on Curriculum Innovation for Sustainable Development being produced by UNEP's Global Universities Partnership for Environment and Sustainability¹⁰⁵ is instructive here, and can potentially be useful for further deliberations on what exactly curriculum innovation in a CCD context means in practice. UNEP suggests that, for purposes of understanding SD / CCD knowledge issues from a curriculum innovations perspective, it is possible to differentiate the landscape of scientific and social knowledge production into the following categories:

- **Knowledge of 'what is'**, or what can be observed and analysed (i.e. knowledge of the current situation; inclusive of IK perspectives);
- **Knowledge of 'what is not yet known'** but can be predicted or 'staged' (i.e. knowledge of risk and vulnerability);
- **Knowledge of 'why things are the way they are'**, and how they can be changed (i.e. historical and explanatory accounts);
- **Knowledge of 'what can be different'** and how this could be achieved (i.e. possible solutions); and
- **Knowledge of 'what can and must be done'** (solutions) and 'new ways of being, doing and becoming' (i.e. practical options and change processes).

All these forms of knowledge emerged in the mapping study discussions on what needs to be taught under CCD. Interestingly, UNEP's perspective suggests that these forms of knowledge are applicable to almost any discipline under a CCD / SD framework. Lawyers in an environmental law course need to discuss the problem as it currently manifests, what the risks and vulnerabilities are, how the risks and problems came into being, and what can and must be done differently. Similarly, a sociologist dealing with gender and climate change could also work with this same set of forms of knowledge – i.e. what is the current situation regarding gender and climate change, what are the risks and vulnerabilities, how did the issues come into being, and what can and must be done differently. This meta-knowledge framework therefore potentially provides a useful approach for establishing inter- and transdisciplinary curriculum innovation platforms¹⁰⁶ in the SARUA programme, and should be considered in the curriculum innovations aspects of the programme (see section 4), in combination with discussions on competences, values and ethics, and 'new paradigm' ways of thinking about curriculum (see below).

It was also repeatedly mentioned across the mapping study that curriculum innovation should also include **values and ethics**, and that these should be made explicit. Following the general discourse as revealed in the SARUA mapping study interactions, these values need to be:

- Inclusive and democratic (inclusive also of IK, culture and history);
- Take into account people and planet and all life forms;
- Consider the relationships that exist between people and their environments;

¹⁰⁵ Lotz-Sisitka, H.B. in press. Education and Sustainable Development Curriculum Innovations Guidelines for Universities. UNEP/GUPES (in production).

¹⁰⁶ This section is adapted from Lotz-Sisitka, H.B. in press.

- Be aesthetic and respectful;
- Be critical when the need arises;
- Be inclusive of principles of equity and social justice;
- Help to develop a futures vision and systems perspective; and
- Be oriented towards improved quality of life for all.

There were also a few participants in the mapping study workshops that argued for **new paradigm thinking** when it comes to CCD. This concept may hold different meanings for different people and what is new and radical for some may be ‘old school’ to others. Some of the features of this ‘new paradigm’ are captured in the discussions above on competence, knowledge and values and ethics. Broadly, the sentiments associated with calls for ‘new paradigm thinking’ require a different way of thinking about curriculum, more integrated, creative, critical and integral (integrating cultural, social, psychological and normative aspects amongst others) and relying more on the dialectic of tradition and innovation, imagination, relationships and ‘thinking out of the box’. Such curriculum interests need to be probed in more depth in the SARUA programme as they may offer important transformative learning opportunities. More examples of such curriculum innovation need to be brought to the fore, as almost no such curriculum examples were identified in the mapping study. This may also be because this form of curriculum development is heavily dependent on the style of interaction and relation that is established between lecturer and student, more so than on documented course designs or course outlines.

3.2.9.10 Curriculum innovation support

In general, and as outlined in the needs analysis, there was a strong need expressed for curriculum innovation in all countries, and for curriculum development support to strengthen new programmes. This implies staff professional development, which was also cited as a strong need; and capacity building to integrate research-based new knowledge into curriculum development activities. An exemplary programme identified in the mapping study was found at LUANAR, supported by CC-DARE where researchers worked in interdisciplinary teams at community level to generate CCD knowledge in climate change ‘hotspots’ and then used this to inform curriculum development at LUANAR (see Box 4 below).

Box 4: CC-DARE Research and Curriculum Development Project, LUANAR Faculty of Natural Resources

A UN supported Climate Change Adaptation and Development Initiative (CC-DARE) research and curriculum development project was implemented by the LUANAR Faculty of Natural Resources, then the Department of Forestry and Horticulture in the Bunda College of Agriculture of the University of Malawi. The purpose was to use a research-led approach to integrate climate change adaptation into the Agriculture and Natural Resource Curriculum in Malawi. The project involved a range of stakeholders including the Environmental Affairs Department, district assemblies in the two districts of Chikhwawa and Nsanje, district agricultural officers, district irrigation officers, and district forestry officers. Additionally, NGOs including Action Aid Malawi, the Catholic Development Commission of Malawi and the Evangelical Lutheran Development organisations were involved in the project, showing a multi-stakeholder approach. Community organisations and chiefs, and local media were also involved. A baseline study was undertaken to establish best practices in adapting to climate change, and from this knowledge (combined with other sources), a curriculum module was developed for building capacity of institutions and communities in adapting to climate change. The study was located in two NAPA priority areas (Chikhwawa and Nsanje), and involved three research scientists from the Bunda College of Agriculture who worked with students, colleagues and the multi-stakeholder set-up to undertake the research, and to translate it into curriculum. Key practices that were identified were rainwater harvesting, irrigation agriculture, winter cropping, crop diversification, and growing of drought tolerant crops, as well as improved tillage practices. The research based information was used to inform a curriculum stakeholder workshop, where additional inputs were offered from multidisciplinary perspectives. Besides the university based curriculum modules for the MSc programme, additional modules for training of teachers and community members were developed and teachers in six villages in two districts were trained. This approach to research and curriculum development resulted in a number of multidisciplinary stakeholder partnerships: climate change and agriculture, climate change and health, climate change and forestry, and climate change and policy development amongst others. Community education was also part of the programme, and through local community radio, knowledge that had been developed was shared more widely at community level, and was also shared with extension officers working at district level.

Interestingly, this integrated, transdisciplinary research and practice project contributed direction to curriculum innovation, and five modules were developed for the new MSc in Environment and Climate Change.

Importantly it should be noted here that these modules also draw on universal and formalised scientific forms of knowledge relevant to climate change, but were *contextually enriched* through this approach to curriculum development.

It has also provided an opening for further research for scholars who undertake the degree, and at the time that the project was completed, there were plans to expand the approach to other NAPA districts.

This project has given rise to a further expanded project at LUANAR which continues to strengthen curriculum development and research for CCD in Malawi.

(Source: Malawi Bunda CC-DARE Project Final Report, August 2010, www.ccdare.org.)

Another current initiative that may offer valuable lessons and links for the SARUA programme is the curriculum innovation work that is currently taking place via the START programme (www.start.org) at the University of Dar Es Salaam (Box 5).

**Box 5: Climate Change Research, Education and Outreach Centre,
University of Dar es Salaam, Tanzania**

START (global change SysTEM for Analysis, Research and Training) is partnering with the University of Dar es Salaam on a university-wide programme to integrate teaching and learning on climate change into the classroom experience, and to promote communication on critical climate change issues between the university and the public. The work, carried out through the University of Dar es Salaam's Centre for Climate Change Research, Education and Outreach in collaboration with START, involves developing new curricula to enhance learning about climate change, providing training that develops instructional approaches for teaching on climate change issues, promoting interdisciplinary research on climate change, and facilitating opportunities for discourse between university-based researchers, civil society organisations, the private sector, governmental institutions and policy makers around issues of climate change. The programme started in 2012 and this work is supported by the Open Society Institute.

As indicated above, while they do exist, there appear to be few institutions focussed on providing professional development for academic staff. The SADC Regional Environmental Education Programme and the Mainstreaming Environment and Sustainability in African (MESA) Universities Programme supported by UNEP and the African Association of Universities (AAU) is an example of a programme that has offered professional development support to academics *across SADC countries*; but they have not had adequate capacity to respond to the scope of the demand for staff professional development in southern African universities. The mapping study found, however, that where these programmes had been operating or where university staff had participated in the MESA and/or SADC REEP professional development programmes, there was clear evidence of curriculum change and renewal occurring, showing the value of such programme that gives attention to staff capacity building for curriculum innovation.

“Why are universities not taking leadership, and in innovation? Limkokwing University is predicated on technological innovation, universities did very little in this area before. Existing universities must re-orient their curriculum now.”

Senior academic, UNISWA

3.2.10 Changes involving students

The mapping study found relatively low levels of student engagement with CCD-related issues, although in most countries at least one student organisation was found that deals with environmental issues, and it was noted that there was an increased interest in these issues amongst the student body. Zambia may be an exception, as there appeared to be greater involvement and more dynamism amongst student organisations on climate change related matters in all three of the public universities. The University of Swaziland also had a Green Team, supported by the MESA Chair. South Africa too also revealed an emerging dynamism amongst student organisations, facilitated by the Africa Green Campus initiative that hosts student conferences (these have been facilitated by the University of Cape Town (initially) and most recently by the Nelson Mandela Metropolitan University in South Africa to date). An inter-university student organisation network called the 'Blue Buck' Network also exists which

links green student organisations across different campuses. Student leaders from Zambia and Swaziland were supported by the MESA Chairs to join the first South African ‘Blue Buck Network’ activity, an event that was initiated by student organisations, and hosted at Rhodes University in South Africa in 2011. This regional interaction appears to have strengthened student engagement in these countries.

In general, however, there appeared to be few proactive programmes in the region that were focused on enhancing student participation in issues such as CCD, and yet it was recognised as a very important area for future action. There was general agreement that students should be involved more in decision making on campus, and have more opportunities for more engagement with the public and private sector on CCD related issues. SARUA could explore a stronger link with the Africa Green Campus Initiative to expand its currently emerging influence in South Africa to other southern African universities.

3.2.11 Community engagement and policy outreach

As noted above, academics engaged in CCD related matters tended to service the policy sector with their capacity. Community engagement was generally seen to be poorly constituted and not really executed. This was also due to heavy demands placed on academic staff due to large student numbers and heavy teaching loads. However, there were some outstanding examples of community outreach identified across the SADC region, although few such examples were institutionally framed e.g. through service learning courses or modules. In general there was a high level of concern for community well-being and a strong sense that knowledge should be made more relevant and communicated more successfully to communities, but it appeared that the strategies and enabling conditions for doing this were not in place. Community engagement, as noted above, is an important mechanism for knowledge co-production and stronger institutional frameworks and support for community engagement are clearly needed. Some approaches that could be followed include placing stronger emphasis on community level at Higher Education policy level (as in the case of South Africa); developing service learning approaches that integrate teaching and student community engagement; establishing student volunteer programmes in the universities (these were some examples of how good practice in this area was being supported in SADC universities). Among the stronger forms of community engagement for CCD observed in the mapping study, however, was when CCD projects required student involvement in transdisciplinary approaches to research (as in the Lake Chilwa case study at Chancellor College at the University of Malawi – see Box 1 above) as these approaches integrate research and community engagement, since the research tends to be ‘community engaged’ in its purpose and constitution from inception. There was also mention of funding and incentives for community engagement, which in most institutions was virtually non-existent.

“Universities should help communities and should be drivers of change. The responsibility of universities should be to take technology into villages and translate it to local understanding.”

Zambia university professional

Policy outreach, as mentioned above, appeared to be one of the strongest forms of outreach currently being practised by SADC academics in relation to CCD. This can be explained by the recent demands for international reporting via the First and Second National Communications to the UNFCC, by the NAPA process, and by the associated and very recent emergence of national Climate Change Policies in almost all countries (during the study in most countries National Climate Change Policy was still in draft). Some countries are still currently developing such policies. There has therefore been ‘intense’ policy engagement on CC / CCD issues over the past five years in the SADC region, and countries have drawn on their academic communities to assist, as can also be seen by the relatively shorter periods of time that academics have been involved in CCD concerns, compared to their longer disciplinary histories. As indicated in many of the workshops, these processes were ‘seeding’ CCD research communities, which in turn were providing governments with the necessary research-based support for policy development. There was, as mentioned above, concern across the region with policy *efficacy and implementation*, and this may well be where the next phase of policy outreach would need to be concentrated. This will, however, have to be taken up within the ongoing SARUA programme.

3.2.12 Campus management and ‘demonstrations’ of CCD

There were some cases of proactive CCD-oriented campus management actions, but these were not the norm. In some countries, universities were trying out ‘green buildings’ (e.g. in Namibia) but it was said that this practice was not widespread and most often university management followed the ‘business as usual’ path when undertaking new developments on campus. This was, however, seen to be a valuable opportunity for *demonstrating* new CCD relevant technologies (e.g. renewable energy), but there was also a realisation that this required new forms of technical competence that did not always exist on the university campus. The Nelson Mandela Metropolitan University George Campus in South Africa is perhaps a ‘model’ in this regard, as students are actively engaged in researching and pilot testing more sustainable campus management practice *as part of their* research and/or education. In Mauritius, the Université des Mascareignes is working on a Green Campus project that will promote the use of climate compatible technologies, and provide specific, experience based guidance for maximising cost effectiveness of high performance building designs. There are also exemplary cases of Green Campus development, as shown by the University of the Western Cape’s Africa recent Green Campus award. Again a partnership between the SARUA programme and the Africa Green Campus programme could strengthen this aspect of university education.

UNEP has recently released a ‘Green Campus Toolkit’, which could be used for this purpose. Many campus sustainability assessment tools also exist to support such initiatives. One such a sustainability assessment tool (called the Unit-Based Sustainability Assessment Tool)¹⁰⁷ was developed and tested at Rhodes University in a PhD study, and this has been adopted by the

¹⁰⁷ Togo, M. and H. Lotz-Sisitka. 2009. “Unit-Based Sustainability Assessment Tool (USAT)” www.unep.org/training.

UNEP MESA programme, and has been used by more than 40 universities in Africa, including the Nelson Mandela Metropolitan University who used it to mobilise and strengthen university activities; and UNISWA who used it to strengthen mainstreaming of environment and sustainability courses and activities at UNISWA. UNEP have also established a 'sustainability portal' where the full range of globally available sustainability assessment tools for universities are located. Within these initiatives universities are also doing carbon emissions monitoring, energy efficiency management and green technology installation, retrofitting and use; all of which 'model' CCD to students on campuses.

3.2.13 Implications for the Knowledge Co-Production Framework

As can be seen from the institutional assessment throughout section 3, there are many dimensions to the institutional context that require changes for CCD to become an integral and important facet of university life, teaching, research and community and policy engagement. Specifically the institutional changes that require most attention, and which have implications for a CCD knowledge co-production framework include, **but are not limited to:**

- *Conceptualising the university's role within the changing post-2015 frameworks for human development.* These are clearly integrating environment, society and economy within a sustainable development framework, within which transitioning to a low carbon future will be a priority, given the challenges of climate change which are now clear, and which have significant development related implications for Africa, and SADC in particular. In particular, this requires strong leadership engagement with CCD related issues which see CCD as a societal concern, significant to development, not as a 'side issue' that belongs to environmental scientists.
- *Addressing research system constraints and engaging in research system development* as a response to climate change, as shown in all national policies, is heavily dependent on knowledge (co) production and research. National research systems need to 'align' with national climate change response policies, and CCD research needs to be integrated into national research plans and priorities, with associated funding and incentive mechanisms for researchers put in place. There is therefore a need to give attention to institution building at a high level, not only in universities, but also in research systems development (national and international research development platforms, policies and processes). This will require *high level* engagement with research systems across the SADC region, as well as with international institutions. SARUA is well placed to facilitate such interaction supported by Vice Chancellors and the university system and Ministries of Higher Education, Environment, and Science and Technology in SADC more broadly. UN organisations such as UNDP, UNFCC, UNEP and UNESCO and other international scientific organisations (e.g. ICSU, ISSC) are also actively involved in CCD related issues, and could potentially be drawn into research institution building for CCD in SADC, as could the AU, the AAU and other regional institutions, since sustainable development research and research system development is also being emphasised Africa-wide.
- *Creating and supporting enabling mechanisms and funded research programmes that can facilitate stronger interactions, networking and knowledge co-production at a*

regional level, via partnership building and collaborative research amongst the Nodes of Expertise, Centres of Expertise and Centres of Excellence (existing and emerging) that are currently or are beginning to focus on CCD research. Within these research clusters attention should be given to research capacity building, methodology, research publishing as well as policy and community outreach.

- *Supporting and expanding existing and new initiatives that engage multi-, inter- and transdisciplinary research and teaching for CCD.* This requires capacity building, methodology development, leadership support, and changes to internal structuring of programmes in universities. This also requires reform of academic performance management systems so that they reward collaborative research. The conflict between knowledge production and performance could usefully be addressed by SARUA and other university networks that encourage collaboration and collaborative publishing.
- *Supporting and expand mainstreaming of CCD through curriculum development and innovation for CCD* at undergraduate and postgraduate levels. Innovation at Masters degree level is an important innovation point for CCD curriculum development. Curriculum development concepts and approaches also need renewal, and a clear framework for CCD curriculum development is needed that encompasses the knowledge forms and types of knowledge that characterise CCD concerns (especially social-ecological system knowledge, knowledge of risk and vulnerability; response knowledge etc); competences for CCD and values and ethics that are congruent with the aims of CCD. New paradigm thinking (including critical and creative thinking, and 'new solutions' and futures orientations) are also needed for real curriculum innovation to occur. Curriculum innovation is not only about 'putting CCD content' into old courses. Research-led curriculum innovation is also important for CCD curriculum development as knowledge of the issues is both rapidly evolving, and both global and highly contextual at the same time.
- *Supporting and expanding policy and community outreach programmes, student engagement and campus management*, all of which can complement and enhance CCD research and teaching and help to facilitate knowledge co-production with a range of diverse stakeholders. Such approaches have potential to ensure that university education has societally oriented and practice-centred links and outcomes. In particular, concerted efforts are needed to strengthen more proactive and evidence-informed policy processes, as well as policy implementation efficacy. There is also a need to strengthen university policies on SD and CC issues, so that this work in universities is not relegated or left to individual initiatives, but that it forms an integral part of university policy, vision and direction setting. This requires that CCD and SD are mainstreamed into Strategic Plans of universities, and into the research plans of universities.
- *Reforming academic performance management systems so that they reward collaborative research.* The conflict between knowledge production and performance is one that universities across the SADC region face, and is something that could fruitfully be addressed by SARUA and other university networks that encourage collaboration and collaborative publishing, through for example instituting a regional

high-level dialogue on necessary changes to university policy to incentivise knowledge co-production.

“Institutional constraints that inhibit collaboration e.g. collaboration may mean less credit going to participants and thus it is not meaningful for publishing and promotion purposes. Thus the way performance is assessed needs to be re-assessed. The issue of transdisciplinary research and the lack of it relates to the question of why we do research. Most of the time we do it for PMS (performance management system), not for knowledge production. So if you engage in research with people who would not take it seriously, then one would rather do it alone to provide evidence because we want promotion. The incentives attached to research also face some institutional constraints.”

Botswana university staff member

These and other insights gained from sections 2 and 3 of this Knowledge Co-Production Framework, will be integrated into the definition of strategically oriented thematic research thematic areas for CCD, and into strategic direction setting for CCD curriculum innovation, policy and community outreach, and higher education policy interventions (in section 4). These will then be taken further into the roadmap with practical recommendations for system development (section 5).

4 STRATEGIC DIRECTIONS FOR CCD KNOWLEDGE CO-PRODUCTION

4.1 Introduction

Section 4 sets out strategic directions for CCD knowledge co-production in the southern African region, based on the findings of the mapping study. It thus constitutes the strategic section of this Knowledge Co-Production Framework (Volume 1), together with the 'road map' in section 5.

In its definition of climate-resilient pathways, the IPCC highlights the need for development to combine adaptation and mitigation to realise the goal of sustainable development, and emphasises that these are iterative, continually evolving processes for managing change within complex systems. The proposed framework for knowledge co-production in southern Africa aims to contribute to the development and realisation of climate-resilient pathways through a multi-pronged approach that addresses identified regional needs for enhanced research and other capacities for HEIs in the region, as set out above, and including through the following intervention areas:

- Initiating research clusters for CCD;
- Curriculum innovation and development on CCD;
- Capacity development of researchers and the providers of education and training;
- Community and policy outreach; and
- Institutional development, including higher education policy and strategy.

In elaboration of this, section 4 sets out the context for urgent action on enhancing climate change research and implementation in southern Africa, which builds on section 2.1 (the regional climate projections), highlights opportunities for the SARUA climate change programme to add value to the way in which the region engages with forthcoming international climate change negotiations and developments, and provides examples of programmes that could play a supporting role in the proposed SARUA regional climate change knowledge co-production programme. This is followed by suggestions for design of the SARUA programme, and proposals for seven research themes, arising from the mapping study findings and developed to promote strengthening of single, multi-, inter- and transdisciplinary research. Both the design considerations and the proposed research themes are presented to be considered and refined by the SARUA executive and universities, as one of the key next steps after receiving the final mapping study report.

After this focus on research, the KCPF then focuses on the remaining key areas investigated in the mapping study, and for which recommendations are made: curriculum development and innovation, community and policy outreach, and higher education policy and strategy. Section 4 then concludes with a summary of the key recommendations of this mapping study, to enable knowledge co-production on climate change and CCD in the SADC region. Section 5 of this report provides an outline roadmap for the key next steps for SARUA, in terms of acting upon the findings and recommendations of the mapping study.

The mapping study has occurred within a year in which the urgency for action on climate change has been further emphasised. A number of recent analyses have highlighted that the current window of opportunity for action to keep the global temperature increase to 2°C, or preferably lower (1.5°C), below pre-industrial levels, and to build resilience to current climate variability and projected changes, is rapidly closing. The Africa Adaptation Gap Report, launched on 17 October 2013, confirms that Africa faces huge financial challenges in adapting to climate change, and spells out the costs faced by the continent if governments fail to close the “emissions gap” between current 2020 emissions reduction pledges and what is needed to keep warming below 2°C. The study assigns a 40 percent chance that we will inhabit a “4°C World” by 2100, if mitigation efforts are not stepped up from current levels, which is confirmed by the recently completed IPCC Fifth Assessment Working Group I Report. Due to present and committed climate change caused by past emissions, Africa is already committed to adaptation costs in the range of USD 7-15bn per year by 2020. These costs will rise rapidly after 2020, since higher levels of warming result in higher costs and damages.¹⁰⁸

Global climate negotiations, while unfortunately moving at an extremely slow pace, are still heading towards agreement of a new climate deal by 2015, under the Durban Platform for Enhanced Action agreed at COP-17 in South Africa. The southern African region needs to position itself now for optimising opportunities inherent in this process, and developing and delivering on contributions towards the needed global emissions reductions. While the African region rightly emphasises that we must talk of commitments on the part of developed countries, and contributions on the part of developing countries, there is little doubt that the latter is needed as well, and can certainly catapult countries’ moves towards resilient and low-carbon development.

In addition to making development more resilient according to national (and regional) needs and priorities – which is the major task for the southern African region, all countries will need to develop ‘national offers’ or contributions for emissions reduction proposals, as well as set out actions for adaptation.¹⁰⁹ These will provide a way to link the 2015 international agreement more closely to domestic debates and national circumstances. The better the region is prepared in this regard, which includes being able to clearly detail country priorities and what is required to achieve these, the more likely that southern Africa can take advantage of opportunities inherent in the international funding regime that is being put in place. There is a strong role for evidence-based research to fast-track national and regional efforts to strengthen resilience at the livelihoods level and to climate-proof economies; it will also be key in helping to mobilise the necessary adaptation funding. The proposed regional Knowledge Co-Production Framework and SARUA regional capacity building programme can contribute considerably to this process.

¹⁰⁸ http://www.unep.org/roa/Portals/137/Gaborone_declaration.pdf, accessed 27 November 2013.

¹⁰⁹ See, for example, Olsen, K.H., J. Fenhann and S. Lutken. 2013. “Elements of a new climate agreement by 2015,” UNEP Risoe Centre Perspectives Series, 2013.

As the mapping study has found, developing capacity for the research to assist in unlocking all this will require strengthening individual disciplines, as well as building research capabilities and removing barriers (which includes institutional reform) for multi-, inter- and transdisciplinary knowledge production. It will also require concerted effort to enhance the climate change-related competences, knowledge and expertise of those who will develop and deliver many of the capacity development initiatives – the researchers, educators, trainers and their partners. This is a very clear finding from the mapping study.

The mapping study has identified a wide range of knowledge, research and capacity needs for the region, and indicated how many of the broad priorities for developing a better response to climate change are shared across countries. This does not deny the need for contextualised and localised responses, but highlights that there are broad knowledge and research issues that can be clustered, and that are highly relevant across the region, within the context of national and local development specificities. The study has also identified existing areas and centres of expertise for climate change and CCD within each of the countries, active researchers, and potential knowledge production partners. It is clear that while climate-related capacity and research development needs are many, there are existing nodes and centres of expertise that can play a strong role in further developing research and teaching capacities to address the identified priorities and gaps.

Given the far-ranging nature of climate change needs, and the need for a wide systemic response across all sectors, an almost endless set of clustered research issues could validly be proposed for further support. This is not, however, likely to be the most helpful approach in terms of either implementability or fundability. What is required, rather, is a strategic approach, that builds upon existing expertise, addresses the most pressing shared priorities while allowing for local specificities, and assists the countries and the region to do so in a way that also positions themselves better for the potential opportunities inherent in the unfolding international architecture of climate agreements and funding institutions. Section 4.4 contains a proposed set of priority research thematic areas, distilled from the mapping study data, for addressing through research clusters.

While the new Sustainable Development Goals (SDGs) are still being developed, these proposed research clusters have also been designed for potential linkage with the SDGs, to the extent that this is possible. A conference was held in Accra, Ghana, from 20–22 November 2013, with support from the International Development Research Centre (IDRC), on the theme “Beyond Rio+20: Emerging Challenges and Opportunities”, which may provide additional information on Africa’s priorities for the SDGs.¹¹⁰ The proposed research clusters also link to wider research agendas that are being put forward under, for example, the Future Earth Global Sustainability Research Plan, and address some of the findings of the World Social Science Report, as these relate to the southern African context, and the findings of this mapping study.

¹¹⁰ The conference statement was not available at the time of finalisation of this report.

In addition to the 2015 global climate agreement, the Adaptation Fund and the Green Climate Fund, some new elements of the international architecture that provide a broader context and could play a supporting role in the proposed SARUA regional climate change knowledge co-production programme include¹¹¹:

- The Climate Technology Centre and Network (CTCN)¹¹², which is the operational arm of the UNFCCC Technology Mechanism. The CTCN will respond to requests from developing countries to create low-carbon pathways and serve as a broader network for sharing domestic innovations to generate partnerships. It will launch a Knowledge Management System in 2014, to enable access to and exchange of climate technology data, resources and expertise.
- Various programmes of UNDP, which has taken leadership in supporting countries to develop low-carbon, climate resilient development strategies, through its Low Emission Capacity Building (LECB) Programme.¹¹³
- PROVIA – the Programme of Research on Climate Change Vulnerability, Impacts and Adaptation¹¹⁴ – has developed a summary of 33 global research priorities related to climate change vulnerabilities, impacts and adaptation.
- Future Earth, a new ten-year international research initiative that will develop the knowledge for responding effectively to the risks and opportunities of global environmental change and for supporting transformation towards global sustainability in the coming decades. Future Earth will mobilise thousands of scientists while strengthening partnerships with policy-makers and other stakeholders to provide sustainability options and solutions in the wake of Rio+20¹¹⁵, and will be an international hub to coordinate new, interdisciplinary approaches to research on three themes: Dynamic Planet, Global Development and Transformation towards Sustainability.¹¹⁶ With its drive for a regional presence, the Future Earth research programme is likely to benefit southern African researchers, and a number of high level representatives are already engaged with steering this programme regionally. It will be directly linked to the Belmont Forum funding framework, which southern African researchers are already beginning to access.¹¹⁷

In the process of considering and further elaborating the proposals set out in this report, SARUA could additionally consider the partnership and other opportunities inherent in the above programmes and initiatives.

¹¹¹ Note that this list is merely indicative, and is not intended to be comprehensive, as this would have required additional research beyond the scope of this study.

¹¹² <http://www.unep.org/climatechange/ctcn/>

¹¹³ UNDP, UNEP and the UNFCCC have recently developed guidelines entitled 'Guidance for Nationally Appropriate Mitigation Actions (NAMA) Design: Building on country experiences', which aim to support developing countries in developing and implementing NAMAs.

¹¹⁴ See <http://www.unep.org/provia/>

¹¹⁵ <http://www.icsu.org/future-earth>, accessed 9 December 2013.

¹¹⁶ <http://www.futureearth.info/about-us>, accessed 9 December 2013.

¹¹⁷ The Nelson Mandela Metropolitan University has recently been granted a ZAR 13 million grant for coastal zone adaptation research under this framework.

4.2 Design considerations for the SARUA climate change programme

Most climate related research programmes are framed within the wider concept of global change, which incorporates global environmental change, as well as global social and economic changes. All these research programmes promote larger scale research clusters, that are networked across institutions, and that also draw in policy makers and community partners within a Knowledge Co-Production Framework. The SARUA mapping study, being a regional initiative set to profile and support regional interaction amongst southern African universities and their partners, is framed both within the broader global change research trajectory, but has a strong focus on regional priorities and regional partnerships, through which researchers in the southern African region can position themselves in active research clusters and networks to contribute to wider knowledge production processes. As shown in the mapping study, there *is* research being done in SADC countries, but little of this is being published in the international arena *by southern African researchers*.

The SARUA mapping study therefore puts forward a research and Knowledge Co-Production Framework that allows for the development of sufficient climate change research capacity at a regional level to hopefully initiate and develop research clusters with more capacity to produce and publish knowledge for sustainable development and climate resilient pathways for southern Africa and her people. Overall, the vision of the SARUA programme is to create a system of knowledge co-production that provides southern African researchers opportunities for capacity building and relevant, high quality knowledge production. The initial concept put forward by SARUA for such a system of knowledge co-production is illustrated in Figure 11.

Diagram showing a possible knowledge platform hub

The network comprises a coordinating hub (shown in blue), potential growth hubs (shown in red) and 5-6 other nodes (shown in green). Along with the policy and community outreach, institutional learning and development, research and teaching networks (also shown), the coordinating hubs meet through a coordinating committee (blue oval).

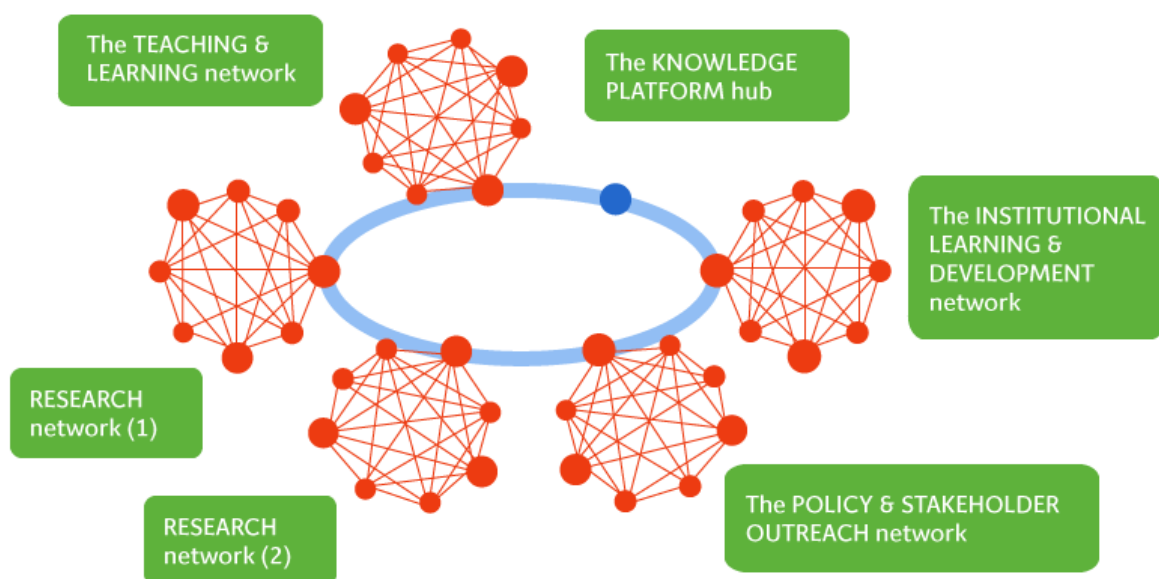


Figure 11: Initial conceptual model showing the vision of SARUA to create a regional system of knowledge co-production with capacity building and outreach components

This model or system of knowledge co-production requires further clarification, and also refinement based on the mapping study needs analysis and institutional assessment, as will be discussed in section 4.3 below, and then revisited in section 5, which will describe proposed processes to initiate the networks and determine hub location, amongst other details .

This mapping study has identified research networks, nodes of expertise, centres of expertise and centres of excellence for climate change and CCD where these exist, country-by-country.¹¹⁸ Details of these are captured in Volume 2 of the mapping study, with a summary presented in the Institutional Analysis Summary in Appendix B. For a regional Knowledge Co-Production Framework however, there is a need to *establish research programme clusters*, that have potential to bring together Centres of Excellence, and Centres and Nodes of Expertise, and research networks from across countries, in new formations that can collaborate at a regional level, on regionally defined research priorities. We therefore use the concept of ‘research clusters’ to signal potential new research formations, organised around broad research themes. Researchers involved in the clusters can define research sub-themes, and through this expand the scope of their knowledge co-production.

We also include an institutional development, curriculum innovation, and a capacity building network (see Figure 12 below). These three networks are critical institution and system building components that are required for longer term institutional change, necessary for the research clusters to flourish and grow. All the research clusters can be linked together via the SARUA CCD support networks for curriculum innovation, institution building and capacity development; and or to wider research networks such as the various global change research networks that exist internationally (e.g. the Resilience Alliance, Global Change / Future Earth research network etc.).

4.3 Priority thematic research areas

"Global sustainable development, implying the environmental, economic and social dimensions of sustainability, as well as the need to face the challenges of growing complexity, requires intense research efforts, interdisciplinary and transdisciplinary approaches. Population growth, climate change, food, energy and water shortages, growing urban concentrations, natural and technological catastrophes, epidemics, social inequality and poverty all require that the world's scientific establishments assume new roles necessitating the integration of all knowledge systems."

Opening statement from the 2013 World Science Forum Declaration¹¹⁹

As noted in section 4.1, the climate change and CCD needs in the region are so far-ranging that an extremely comprehensive set of clustered research issues could validly be proposed for

¹¹⁸ See Glossary of Terms for definitions of these terms.

¹¹⁹ <http://www.sciforum.hu/declaration/index.html>

further support. However, this would present challenges for funding and implementation of the proposed SARUA regional climate change capacity development programme, and would not provide optimal entry points for effective and efficient use of scarce resources. Therefore, this section contains a set of priority thematic research areas, based on the articulated needs and the findings of the institutional assessment, and developed to provide a direction for supporting research and capacity development in the southern African region that is both strategic and integrative. The research areas have been distilled from the mapping study data and are based on articulated needs and the current institutional context for CCD research in SADC. This provides for building upon existing expertise, addressing the most pressing shared CCD research and capacity development priorities while allowing for local specificities, and assisting the countries and the region to do so in a way that also positions themselves better for the potential opportunities inherent in the unfolding international architecture of climate agreements and funding institutions.

The proposed research themes have been developed through a combined analysis of workshop data, questionnaire data and policy and document analysis from each of the countries engaged in the mapping study. The themes have further been framed to allow for proposed changes and emerging issues in the international and regional climate change policy and development landscape. While the research themes have thus been defined through a careful triangulation process, we present these as a starting point for the SARUA community to undertake further discussion and internal consultation, in order to refine and/or re-work the selected research themes upon which the ensuing SARUA climate change programme will focus, as further recommended below.

The process to develop the proposed research themes has moved from the country-level workshop discussions, summarised into the workshop reports, and to the Country Reports that bring together all of the data sources – workshops, questionnaires and initial desktop reviews, further supplemented by Internet research, to the regional syntheses of needs analysis and institutional assessment, as set out in sections 2 and 3 of this report.

The following criteria have been used to develop the research themes:

- The extent to which the particular thematic areas have been highlighted in the national-level needs analyses (especially also where articulated needs were repeatedly identified across countries);
- Addresses findings from the regional synthesis of needs analysis and institutional assessment;
- Policy relevance of the proposed research theme;
- Scope for simultaneously enhancing single discipline research and multi-, inter- and transdisciplinary research and engagement on the thematic area, thus furthering the possibilities for knowledge co-production (see below);
- Allows for innovative research approach and the development of innovative solutions;
- Availability of existing nodes and centres of expertise and excellence that could begin to drive the thematic research area – across different countries to ensure that there is sufficient critical mass for a regional ‘start up’ to further engage with clarification, refinement and re-definition of the research areas; and

- Provides for an integration of the social dimensions of climate change into the more technological and infrastructural dimensions – given that the social dimensions of CCD are the least well researched, as identified extensively in the mapping study.

The proposed research themes have been developed at a broad level¹²⁰, only articulating broad *potential* research areas. This is to allow for discussion and re-framing amongst the SARUA community across the SADC countries. Once this has been done, then specific objectives, research questions, time frames, partners and anticipated changes can be identified. To proceed to this level of detail in this KCPF would not only be beyond the scope of this mapping study, but would also undermine regional and institutional ownership of the programme.

The research themes need to be considered within the overall landscape of the proposed SARUA climate change capacity development programme, as set out in section 5 (see Figure 12 below). A critical point is the interaction with the following three proposed supportive networks (explained in more detail in section 5):

- Policy and institutional development network;
- Curriculum innovation network; and
- Capacity development for CCD researchers and teachers.

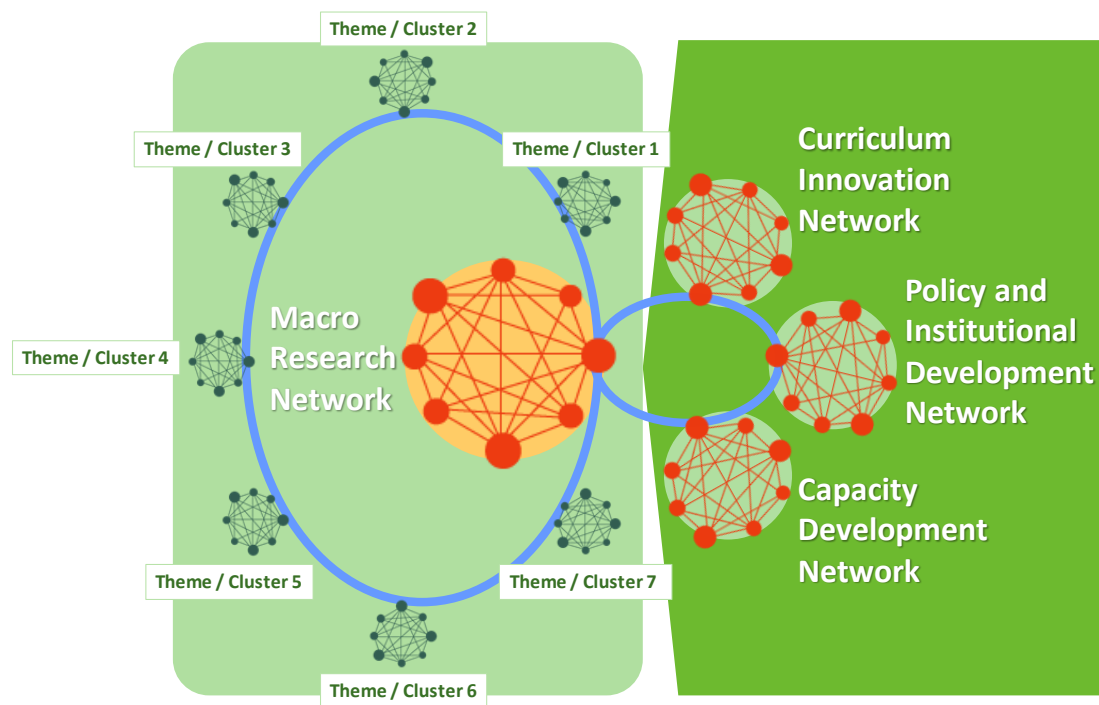


Figure 12: Revised conceptual framework for the SARUA programme (based on Figure 2, and adapted according to the results of the mapping study)

¹²⁰ This follows similar processes used to design multi-stakeholder research programmes. An example here is the Global Change National Grand Challenge Research Programme in South Africa, and the Future Earth research plan being defined at global level. These, by necessity, must be broadly framed to allow for further contextualisation and more detailed framing at the actualised research partnership and programme level.

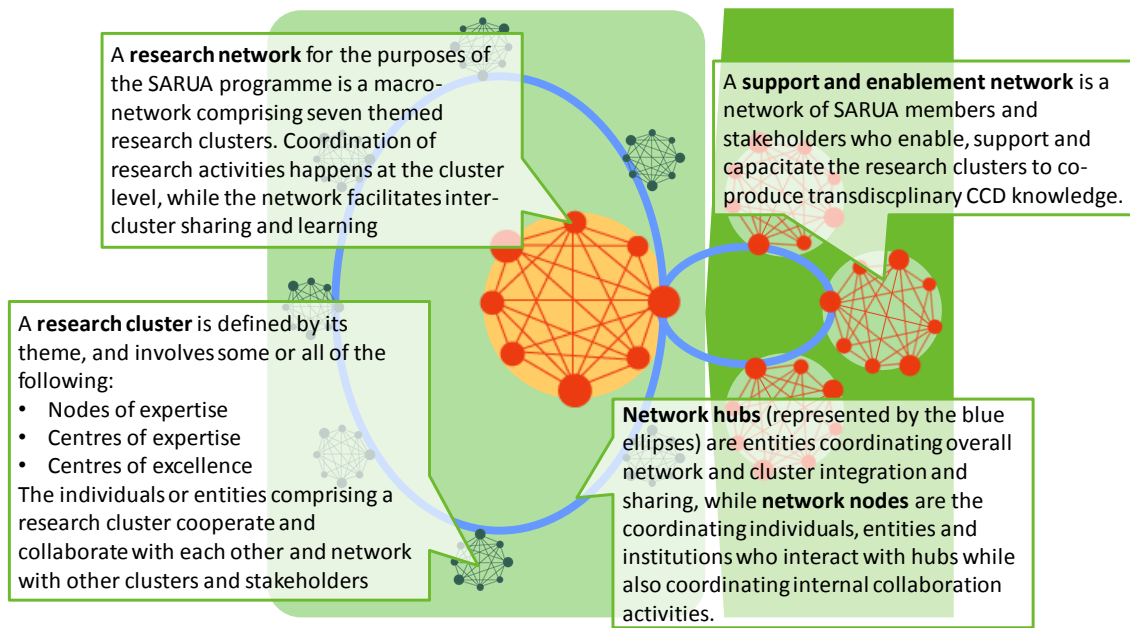


Figure 13: Definitions of key concepts in the revised network model

It is proposed that each of these research clusters will provide a thematic area for solution-oriented regional inter- and transdisciplinary knowledge co-production, while also necessitating further expertise development in single discipline priorities. This is in line with the mapping study findings that both specialised single discipline research and more collaborative and holistic research are required for addressing identified knowledge and research gaps. As noted in section 3.2.8, the mapping study has found that stakeholders and university staff observe a wide range of priority needs that require attention for CCD, constituted as a mix of adaptation, mitigation and cross-cutting issues. Cross-cutting issues tend to include two types of needs: knowledge needs that cut across other priorities such as improved observation and vulnerability assessment data; and research oriented towards social system change, most often focussing on the efficacy of systems and/or the need for education, training, communication and engagement with communities.¹²¹

As was shown in the mapping study, there are cases of multi-, inter- and transdisciplinary research in almost every SADC country, but the mapping study also showed that these kinds of research practices are a) in their infancy, and b) not easy to implement given that they require different forms of institutional collaboration and output to the traditional set up in universities. Despite this, the mapping study participants in all countries agreed that there was

¹²¹ Furthermore, existing experience, sectoral interest and level of operation in the system often determines how CCD is viewed and/or how CCD priorities are identified. The diversity of responses from diverse stakeholders and university professionals (in diverse disciplines and management positions) shows that different institutions / disciplines and levels of inter-disciplinary management are needed to develop an holistic view of climate compatible development 'needs'.

value in these approaches, especially since they had the potential to benefit communities more directly than was currently the case with discipline-centred research that tended to be more 'silo' based and removed from contexts of practice. Participants also agreed that these approaches would assist with bridging the commonly identified research-policy gap. There was further agreement that for such approaches to work in the longer term, institutional development, change in mindset, stronger university leadership, and changes in incentive structures are needed. Thus, while the mapping study puts forward research themes that encourage multi-, inter and transdisciplinary approaches to knowledge co-production, it recognises that there is a need for enabling transitions from more mainstream research to these new forms of research. Experience in the SADC region shows that this requires researchers to:

1. Adopt a social-ecological systems / landscape-based / situated contextual (e.g. a common site such as Lake Chilwa in Malawi, or climate 'hotspots') as a starting point for defining research questions in multidisciplinary teams, with stakeholder involvement in the research question definition being a key contributor to the possibility for transdisciplinary knowledge co-production (good contextual and historical analysis often provides a strong starting point for such engagement);
2. Conceptualise the contributions of each discipline to the common research context / question / social-ecological system being studied;
3. Agree on similar / different methodological approaches to the problem, and adopt a 'methodologically open' view allowing for different ways of approaching a problem ;
4. Begin to work in multidisciplinary / interdisciplinary research teams, with a willingness to engage in reflexive dialogue and regular synthesis throughout (it may also involve developing an understanding of different research discourses and ways of knowing);
5. Add a strong focus on community and policy engagement into their research programming from the start of the programme, regularly sharing insights with communities and policy makers / implementers and obtaining feedback on the research-in-progress, as well as providing for community members and policy makers to articulate research questions and needs, through a two-way process.

These seem to be the five strongest strategies to work towards a transdisciplinary knowledge co-production trajectory, and present a practical pathway for making transitioning from single discipline research to more transdisciplinary approaches, without losing the strength of individual disciplinary contributions.

Given that each of these research clusters would be conducted within a transdisciplinary research approach, they would of necessity have a focus on both community and policy engagement. In the initial stages, research proposals would be designed and developed by groups of interested researchers from several universities / HEIs in the region, in collaboration with other knowledge co-production partners, including from the policy community and from grassroots users of the research. In many cases, but not all, the primary research users, who

would be involved in co-designing the research, would be poor and marginalised communities, thus providing a mechanism for a commonly repeated refrain in the mapping study – that research should be more clearly oriented to specifically benefit such communities. The Consultative Group on International Agricultural Research (CGIAR) have recently expressed this shift in research as a ‘paradigm shift’ from Research for Development (R4D) to Research *in* Development.¹²²

“We see more research on climate change, vulnerability and adaptation. But there are other issues that need to be focused on, such as power balance issues. Are we as researchers focusing on the right issues that will really help the poor people?”

Tanzania university staff member

The road map in section 5 provides greater detail on how the research clusters and networks would be interlinked within the SARUA research and capacity development programme.

4.3.1 Research theme / cluster 1: Resilient landscapes for people, food and ecosystems

This research theme focuses on developing pro-poor, sustainable and resilient production landscapes. It engages the climate change, energy, agriculture and food security nexus, within the context of sustaining and enhancing ecosystem services and agro-biodiversity. Production landscapes here are conceptualised as integrated ecological-agricultural systems – i.e. the form of agriculture required would be ecological and sustainable agriculture, within a broader landscape focus on enhancing ecosystem services and biodiversity. The research theme thus would build on existing work in the region on ecosystem-based adaptation (EbA), which is the use of biodiversity and ecosystem services to help people to adapt to the adverse effects of climate change, with a focus on the goal of food security.

The theme responds directly to an overwhelming regional priority, expressed as highly significant in all of the country data. There are serious concerns that as climate risks increase in the region, even in the near future, southern Africa may experience reduced food security and an increase in hunger.¹²³ By 2050, under what now may in fact be optimistic scenarios, the number of people at risk of hunger as a result of climate change is expected to increase by 10 to 20 percent more than would be expected without climate change, with particularly severe impacts on children, and the worst impacts expected in sub-Saharan Africa.¹²⁴ This relates to the correspondence between rapidly increasing population densities in areas of high

¹²² <http://blog.worldagroforestry.org/index.php/2013/11/29/one-small-change-of-words-a-giant-leap-in-effectiveness/>

¹²³ Ericksen P., P. Thornton, A. Notenbaert, L. Cramer, P. Jones and M. Herrero. 2011. “Mapping hotspots of climate change and food insecurity in the global tropics,” CCAFS Report no. 5 (Advance Copy). CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online www.ccafs.cgiar.org.

¹²⁴ Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, eds. 2007. *IPCC, Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.

agricultural productivity and areas of high vulnerability to current and future climatic factors¹²⁵, as well as to changes in other elements of food security.

In southern Africa there are numerous social and political dimensions of food insecurity, which include diminished social capital linked to poverty, conflict and HIV/AIDS. These are also fundamental constraints to food production.¹²⁶ The interaction between food security and volatile food prices, which affect urban and rural poor people, and climate change is not well understood but may be significant, as are the impacts of trade agreements. As the Head of the World Food Programme recently stated, “Climate change is the game changer that increases exposure to high and volatile food prices, and increases vulnerability of the hungry poor.”

Given emerging climate change risks for food security, and the need to feed growing populations better, it is no longer possible to focus on the exploitative approach of the ‘production maximisation curve’; the status quo now necessitates managing agro-ecosystems for resilience and sustainability, to feed the region’s growing population within ecological boundaries. The literature has emphasised the role of sustainable agriculture approaches such as conservation agriculture and agroforestry for enhancing food production in an ecologically sustainable fashion, and for providing mechanisms to expand and diversify livelihood options. Conservation agriculture would appear to have good potential for implementing low-regrets adaptation with development and mitigation synergies, in the face of future climate and socio-economic uncertainties; however, as indicated in the mapping study, the critical issue in southern Africa is to upscale these approaches so that they become mainstream.

Moreover, these approaches also constitute integrated adaptation-mitigation approaches. There is high potential for emission reductions via better cropland management, grazing land management and the restoration of cultivated soils. A key focus would be on the importance of farmer decision making procedures, which in turn has implications for effective extension services. Challenges identified include providing an enabling legal and political environment; improving market accessibility; involving farmers in project-planning; improving knowledge, extension services and training; improving tenure security; and overcoming high land costs. A side event organised by ICRAF at the UNFCCC COP-19 climate conference in Warsaw emphasised the need, and the potential, for agriculture to generate multiple benefits, including food security, livelihood support, economic growth and climate adaptation.¹²⁷

A key focus for this research cluster would therefore be on how to optimise conservation agriculture practices, including agroforestry and farmer-managed natural tree regeneration, conservation tillage, contouring and terracing, and mulching, which are being increasingly

¹²⁵ Midgley, S.J.E., R.A.G. Davies and S. Chesterman. 2011. *Climate Risk and Vulnerability Mapping in Southern Africa: Status quo (2008) and future (2050)*. For the Regional Climate Change Programme for Southern Africa (RCCP), UK Department for International Development (DFID). OneWorld Sustainable Investments, Cape Town; and Osbahr, H., C. Twyman, W. N. Adger and D. S. G. Thomas. 2010. “Evaluating successful livelihood adaptation to climate variability and change in southern Africa,” *Ecology and Society* 15(2): 27. <http://www.ecologyandsociety.org/vol15/iss2/art27/>

¹²⁶ Misselhorn, A. 2005. “What drives food insecurity in southern Africa? a meta-analysis of household economy studies,” *Global Environmental Change* 15 (1): 33-43.

¹²⁷ <http://www.cop19.gov.pl/latest-news/items/global-landscapes-forum-concluded-yesterday-in-warsaw>

adopted in Africa, for strengthening ecological and social resilience. A further issue would be integrated crop-livestock systems. Investigations of this research cluster would result in regional knowledge and best practice in conservation agriculture and related approaches that could be upscaled to enhance direct adaptation-mitigation co-benefits, in a pro-poor manner. In this case, findings could be of value for the development of positions for the region in terms of its contributions to the post-2015 international climate agreement, as discussed above. This sub-focus of the research cluster would include soil and water resources management practices, including improved methods for rainwater harvesting and irrigation. It would also include crop diversification and livestock resilience research, but within a systems-based social-ecological resilience perspective.

This research cluster would additionally need to explore the growing trend for biofuel production, which, despite potentially positive effects on growth and energy security, includes significant sustainability risks such as competition for land and water between fuel and food crops, negative impacts of biofuels on biodiversity and ecosystem services, high exposure of farmers to risk from contractual and regulatory obligations, loss of land tenure security, and reduced livelihood opportunities for women, pastoralists and migrant farmers who depend on access to the land resource base. A further relevant research area would be to build on work of the Centre for International Forestry Research (CIFOR) and others on challenges and opportunities for getting REDD+ off the ground – i.e. Reducing Emissions from Deforestation and Forest Degradation, and the Role of Conservation, Sustainable Management of Forests and Enhancement of Forest Carbon Stocks in Developing Countries (REDD+).

“Everyone is talking about REDD, planting trees etc., but most of these areas are pastoral areas, most of them are poor land with marginal farmers, what happens to them when we turn all of these areas into REDD forests?”

Tanzania university staff member

The theme also includes a focus on how rural livelihoods can be sustained in a changing environment, and thus may also encompass aspects of livelihood diversification. Although this was not often raised specifically in workshop and questionnaire data, and hardly at all in policy documents, livelihood diversification is already being implemented of necessity in autonomous adaptation, and will become more crucial as climatic changes intensify, particularly in the drylands of the region. This also necessitates research on value addition and value chain analysis, and creating new markets chains for diversification of livelihoods, and may also include examining the role of micro-credit and its efficacy in such livelihood diversification systems.

A research theme / cluster on these aspects of CCD could therefore potentially include a focus on the following types of research areas:

- Impact on food security across different hotspots in the region by climate change, taking into account an integrated perspective on food security (production, access, availability, including transport, processing, storage, marketing and consumption) – *this would entail inter alia assessments of risks, impacts and vulnerability and would necessitate developing methods in vulnerability analysis for capturing the complex interactions in systems across scales;*

- Potential interactions between climate change and other key drivers of food prices that act at national, regional, and global scales, and how can these be moderated;
- Socio-economic and environmental tradeoffs associated with biofuel production in southern Africa, including the effect of large-scale schemes on land use change and subsequent food and livelihood security;
- Optimising conservation agriculture practices for strengthening ecological and social resilience, and upscaling them for pro-poor integrated adaptation-mitigation benefits;
- Climate change impacts on food security in the region – including on livestock, fisheries and aquaculture, and how these foci could be made more resilient;
- Given that forests are mainly used for reactive coping and not anticipatory adaptation, and that governments favour mitigation while local communities prioritise adaptation, explore how equitable decision-making processes and flexible REDD+ models that include agriculture and adaptation could be developed to ensure broad developmental outcomes;
- Enhancing the implementation of the international REDD+ programme to ensure that it results in developmental, ecologically sustainable and climate resilient outcomes for poor and marginalised people;
- Taking into account the above, transdisciplinary research to explore what pro-poor low carbon development would look like within this thematic area, and what the necessary enablers would be;
- Policy incentives to enable sustainable and resilient productive landscapes, with enhanced ecosystem services and agrobiodiversity.

Engagement across disciplines: This research theme would draw on a range of disciplines, through multi-, inter- and transdisciplinary research approaches, to explore these or other related research areas. These disciplines include, **but are not limited to**, the following:

- Agriculture – crop, animal, and soil science, fisheries, aquaculture, agricultural extension, amongst others;
- Biology – botany, zoology, biochemistry, genetics, molecular biology etc.;
- Climatology;
- Ecology and natural resources management;
- Environmental management;
- Energy and biofuels;
- Physical sciences: hydrology, geology, water management, etc.;
- Economics;
- Development studies;
- Sociology;
- Planning;
- Political science and international relations;
- Law;
- Environmental education; and
- ICT and computer science.

Key nodes and centres of expertise for this include, **but are not limited to**, the following¹²⁸:

- Botswana College of Agriculture (BCA), Department of Animal Science and Production and the Forestry Unit: manipulation of feeding systems of ruminant livestock to reduce methane production, agroforestry research, livestock waste production of biogas;
- Natural Resources and Environment Centre (NAREC) in the Faculty of Science, Chancellor College Malawi: involved in climate change adaptation research in the Shire River basin, soil carbon mapping, agro-ecosystem services research and water resources research;
- Centre for Agricultural Research and the Natural Resources Faculty at the Lilongwe University of Agriculture and Natural Resources in Malawi: involved in climate smart agriculture research, livelihoods analysis and diversification, and natural resources management (including CC impacts on aquaculture and fisheries);
- University of Eduardo Mondlane in Mozambique: agronomy-oriented disaster and risk reduction research expertise (at UEM's Faculties of Agronomy and Forest Engineering and Veterinary Sciences) and linked to CIGAR, IIAM and other regional and international agricultural research CCD partners;
- University of Namibia and Polytechnic (Agriculture and NRM: Crop Science Department and Biological Sciences Departments): Agricultural Science and NRM Adaptation (crop diversification and livelihoods, commercialisation of indigenous crops) and Community-based Natural Resource Management and Land Use (CBA and sustainable land management), soil information for adaptation;
- Sokoine University of Agriculture, Tanzania (Department of Forest Biology, other departments): group of active and experienced researchers working on ecosystems and CC, IK on CC, vulnerability assessments, management of natural resources for sustainable agriculture, developmental and pro-poor approach to REDD+; home for a number of relevant large research programmes e.g. Climate Change Impacts Adaptation and Mitigation programme (CCIAM);
- Zimbabwe universities: Midlands State University in Zimbabwe is conducting CCD agricultural adaptation trials in three agro-ecological zones in Zimbabwe. Zimbabwe has a programme mainstreaming CCA into Zimbabwe's extension system, which was noted as a critical need in all countries. The University of Zimbabwe and the Soil Fertility Consortium for Southern Africa have also been working on resilience of smallholder farmers in response to CC. They Chinhoyi University of Technology in Zimbabwe is also involved in developing conservation agriculture, crop science and post harvest technologies for CCA to build adaptive capacity amongst smallholder farmers. The Lupane State University Zimbabwe Agricultural Sciences programme is improving the quality of drought tolerant sorghum varieties, and has agroclimatology expertise. Zimbabwe Open University is also involved in agro-based CCA research;
- The National Plant Genetic Resources Centre (CNRF) at Augustino Neto University in Angola which is a national centre of expertise for germplasm research and which has

¹²⁸ Contact details for project stakeholders are provided in the project database (available as a separate document). Please also see the individual Country Reports – Volume 2 – for contact details for many of the individual researchers and nodes, as well as centres of expertise and excellence.

- links to MINAGRI (national institute for Agricultural Research in Angola), and links to the SADC network of genetic resources centres;
- South African universities: University of Pretoria, North West, Stellenbosch, Fort Hare (Faculty of Agriculture and Agriculture; Rural Development Research Institute, and Risk and Vulnerability Science Centre); UKZN, Limpopo, Venda (Institute for Rural Development); Free State (Centre for Sustainable Agriculture), in South Africa, together with the Agricultural Research Council (ARC) which together have a range of CCD related research capacities ranging from CC adaptation in Agriculture research, food security, soil, plant and animal sciences, including veterinary sciences dealing with increases in zoonotic diseases due to CC, agricultural modelling, irrigation and crop water use research, agroforestry, ethnobotany, IKS, agro-hydrology and other specialist areas (see Appendix A and Volume 2).
 - Regional Agricultural Environmental Initiatives Network – Africa (RAEIN-AFRICA).

This research theme will have direct relevance for the programme on Climate Change Adaptation and Mitigation in COMESA-EAC-SADC Region, which aims to address the impacts of climate change through successful adaptation and mitigation actions aimed at building socio-economic resilience of communities through Climate-Smart Agriculture (CSA). Important existing partners for this research cluster could be regional offices of the World Agroforestry Centre (ICRAF), the Climate Change, Agriculture and Food Security Programme (CCAFS) of the Consultative Group on International Agricultural Research (CGIAR), and the African Risk Capacity Programme.

A potentially important new partnership for this knowledge network will be the UNDP project which is under preparation, in partnership with Japan, based on lessons learned from the Africa Adaptation Programme. This new programme will be known as the Africa Adaptation and Food Security Initiative. It will seek to strengthen climate information systems developed under AAP and scale up climate risk management measures, including weather index insurance and community based adaptation. It will also work to build participating countries' capacities to access and manage climate finance.¹²⁹

As shown in the institutional analysis large scale programmes and projects such as the UNDP AAP programmes have provided much needed research support to countries. *What has not yet emerged from these processes is a clear strategy on how to transfer knowledge from such research and development programmes to inform curriculum innovation and research capacity building in universities and HEIs.* SARUA, together with the SADC Education Sector can potentially mediate such a process to ensure that research tools and approaches are shared into universities, and that shared data and analysis becomes more possible to enhance capacity in university research centres and programmes. This 'new knowledge' needs to feed into curriculum innovation in especially Agricultural Sciences and Natural Resources management teaching programmes, but also into Sociology, Agricultural Education and other

¹²⁹ Helen Clark. June 2013. Speech on Adaptation to Climate Change, Fifth Summit of the Tokyo Conference on Africa Development. www.undp.org/content/undp/en/home/presscentre/speeches.

related disciplines. The African Development Bank is a further potential partner, with respect to its engagement in the rural energy nexus.

4.3.2 Research theme / cluster 2: Monitoring and mapping biodiversity and complex social-ecological systems changes for CCD

This research theme focuses on biodiversity, ecosystems and water within a social-ecological systems perspective, placing emphasis on enhanced observation and monitoring. Many of the knowledge gaps identified in the mapping study needs analysis related to the lack of systematic and reliable long-term data in different sectors to serve as baselines for research, modelling and monitoring. In many cases, this referred to monitoring of the environment and better understanding changes in biodiversity and ecosystems services that underpin important economic sectors in the region, and also have significant livelihoods implications. For example, in Namibia, emphasis was placed, in both policy and workshop data, on coastal and marine biodiversity management, and on the need to better understand the impacts of sea-level rise, coastal erosion and increased storm activity at sea on these ecosystem components.

As for research theme 1, this research cluster would include assessments of risks, impacts and vulnerability, and would necessitate developing methods in vulnerability analysis for capturing the complex interactions in systems across scales. It could also include a focus on the role of indigenous and local knowledge in monitoring the environment, and could explore systems for participatory ecosystem monitoring involving multiple stakeholders (universities, schools, officials in line ministries, extension workers and communities). This could include a critical assessment of past experiences, towards optimising these systems for social-ecological climate resilience. Research could also be targeted to explore the implications for ecosystem-based adaptation, as well as integrated adaptation-mitigation approaches.

A research theme / cluster focussing on these aspects of CCD could therefore potentially include a focus on the following types of research areas:

- Regional climate projections and impact on inland, coastal and marine ecosystems, developing collaborative monitoring systems to allow for adaptive management for resilience;
- Developing systems for monitoring non-timber forest products to allow for an optimal livelihoods contribution while still maintaining sustainable harvesting regimes under changing climatic and other conditions;
- Impacts of climate change on sensitive natural environments such as wetlands, and better management of these to enhance natural and social resilience;
- Enhanced application of environmental monitoring data into climate change models at regional, national and local levels;
- Developing and optimising participatory ecosystem monitoring systems for social-ecological climate resilience – this would include monitoring for payments for ecosystems services projects and mitigation initiatives; and
- Systems for reporting and assessing the implications of changes in ecosystems and biodiversity, including for livelihoods of local people and appropriate adaptation measures.

Engagement across disciplines: This research theme would draw on a range of disciplines, through multi-, inter- and transdisciplinary research approaches, to explore these or other related research areas. These disciplines include, **but are not limited to**, the following:

- Climatology;
- Biology – botany, zoology, etc.;
- Ecology and natural resources management;
- Environmental management;
- Physical sciences: hydrology, geology, water management, etc.;
- Economics;
- Development studies;
- Anthropology;
- Sociology;
- Planning;
- Environmental education;
- Statistics;
- ICT and computer science; and
- Law.

This wide-ranging ecosystem monitoring research theme has many potential partner institutions in the region, and would in all likelihood need to be further developed into more focused research sub-themes. Therefore, the following is only a very provisional list of key nodes and centres of expertise for this research theme:

- University of Namibia, Faculty of Science: Conservation Biology;
- University of Cape Town: Marine Research Institute and Freshwater Research Institute;
- Regional universities and other partners involved in the Benguela Current Large Marine Ecosystem Programme;
- University of Dar es Salaam Institute of Resource Assessment;
- The Centre of Excellence for Sciences Applied to Sustainability at Augustinho Neto University in Angola;
- NEPAD Regional Fish Node at LUANAR in Malawi;
- Okavango Research Group at the University of Botswana;
- The Centre of Excellence in Invasion Biology and global change at the University of Stellenbosch (extensive capacity for ecological modelling, and other studies needed for this research theme);
- Centre for African Conservation Ecology, the Coastal and Marine Ecology research unit and the Sustainability Research Unit at Nelson Mandela Metropolitan University in South Africa;
- University of Johannesburg Centre for Aquatic Research;
- University of KwaZulu-Natal's water, environment and biodiversity research groups; and
- Rhodes University's biodiversity scientists and environmental scientists (plant biodiversity, entomology, aquatic biodiversity, wetland ecology, forests and SARCHI Chair in interdisciplinary environmental sciences and rural livelihoods).

There are many potential programme partners for this research cluster, including programmes of the Southern African Science Service Centre for Climate Change and Adaptive Land

Management (SASSCAL). Other partners could include relevant initiatives of the Inter-governmental Science-Policy Platform on Biodiversity and Ecosystem Services, the Biodiversity Programme at the UNEP Regional Office for Africa, and various existing UNEP programmes on adaptation, which focus primarily on highly vulnerable ecosystems (drylands and low lying coastal lands), Small Island Developing States (SIDS) and mega deltas, to reduce vulnerability and increase resilience to climate change. This research cluster could also possibly link at some stage with various ongoing Transfrontier Conservation Area initiatives in the region, such as the efforts by the governments of Angola, Botswana, Namibia, Zambia and Zimbabwe on establishing the Kavango-Zambezi, a 300 000km² Transfrontier Conservation Area (KAZA TFCA).

4.3.3 Research theme / cluster 3: Indigenous knowledge, resilience and cultural, social and technological innovation

As noted above in sections 2 and 3, the potential role of indigenous knowledge in CCD pathways was repeatedly raised in the mapping study. Participants across all SADC countries felt that to date, the potential role of indigenous knowledge in building resilience through the cultural, social and technological innovations necessary for transformation to a low carbon, more equitable and sustainable society has been under-valued, and under-developed.

Mobilising indigenous knowledge into scientific and social processes of cultural, social and technological innovation is not without its complexities, as indigenous knowledge is often context bound, reliant on local languages and embedded in particular social practices. The challenge for researchers is to mobilise and surface the foundational assumptions, practices and aspirations embedded in indigenous knowledge, and to make this more available for dialogical engagement within a wider range of knowledges / forms of knowledge.

This involves more than 'capturing' indigenous knowledge. As pointed out by participants in the mapping study, it also involves reviewing and evaluating indigenous knowledge for its contextual and socio-cultural value, but also for its potential value to provide more universal or widely used wisdoms or approaches that can support adaptation, resilience and cultural, social and technological innovation. It requires a view of indigenous knowledge that is dynamic and that engages the dialectic that exists between tradition and innovation. There is, however widespread recognition that modern forms of western science, as practised by modern institutions, constitute an important form of knowledge for CCD, but that other sources of knowledge and experience are also essential for policy making and action.

Added to this is the increased understanding that there are 'embedded' scientific processes (if tacitly framed) in much indigenous knowledge, which challenge ways of seeing indigenous knowledge as 'non-scientific'. Thus, research focussing on indigenous knowledge should be able to not only mobilise and surface the tacit or socio-cultural dynamics of indigenous knowledge and make it more visible and/or explicit, but such research should also be able to avoid simplistic oppositions which see western scientific knowledge as 'scientific' and other forms of knowledge as 'non-scientific'.

More sophisticated analyses of knowledge and its formation and construction are needed in such contexts, if the dialectic between tradition and innovation is to be fully engaged within such research. A relational view and methodologies are needed in which different forms of

knowledge are *related to each other*, rather than simplistically oppositionalised and discarded, which is the core reason for the existing marginalisation of indigenous knowledge in modern education institutions today.

Studies have indicated the positive role of local and traditional knowledge in building resilience to climate change in the African region, and the recent IPCC (2012) report on extreme events and disasters supports this view, finding *high agreement* and *robust evidence* of the positive impacts of integrating indigenous and scientific knowledge for adaptation. However, there are also growing concerns about the future adequacy of local knowledge to respond to climate impacts within the kind of multiple-stressor context of the southern African region. These concerns include the perceived decline in the reliability of local indicators due to socio-cultural, environmental, and climate changes; and, worryingly, the apparent exceeding of farmers' indigenous knowledge and coping mechanisms by the emerging climatic changes; in addition to the decline in intergenerational transmission.¹³⁰

These are important points which caution researchers not to simplistically or idealistically rely only on the resurgence of indigenous knowledge in and for climate change adaptation, but which rather foreground the role of indigenous knowledge in the context of a need for ongoing cultural, social and technological innovation and change. The climate change context therefore provides an interesting and challenging environment for indigenous knowledge research, especially as it relates to futures perspectives, and projected impacts and the associated need for adaptation and mitigation.

Some research has already been carried out in the region on blending scientific, local and indigenous knowledge when developing adaptation strategies. An important focus of this research cluster would be to build on this by researching, reviewing and critically interrogating the potential role of local and indigenous knowledge and systems in adaptation and mitigation, with a focus on its potential for pro-poor integrated adaptation-mitigation approaches. This would entail exploring how different forms of knowledge – like indigenous/local and scientific knowledge can be brought together, through a transdisciplinary research approach, for these purposes.

The 2013 World Social Science Report makes a case for working with a wider range of knowledges in CCD responses, and suggests that it is important to bring indigenous knowledge and the knowledge of local communities into the co-design of research and policy. There are a number of cases in the SADC region that also show how such research is being done. From a curriculum innovation perspective, such research can also provide interesting new content and ways of thinking about curriculum in a southern African context, which can enable a

¹³⁰ See, for example, Hitchcock, R.K. 2009. "From local to global: perceptions and realities of environmental change among Kalahari San." In *Anthropology and climate change: from encounters to actions*, edited by Crate, S.A. and M. Nuttall, 250-264. Walnut Creek, CA, USA: Left Coast Press; and Ifejika Speranza, C., B. Kiteme, P. Ambenje, U. Wiesmann, and S. Makali. 2010. "Indigenous knowledge related to climate variability and change: Insights from droughts in semi-arid areas of former Makeni District, Kenya," *Climatic Change* 100(2): 295-315.

curriculum that can be more strongly socio-culturally engaged, without losing the universality of knowledge that is taught in universities.

A research theme / cluster focussing on these aspects of CCD could therefore potentially include a focus on the following types of research areas:

- Mobilising and ‘surfacing’ indigenous knowledge for wider analysis and application within cultural, social and technological innovation processes – this theme would need to give due attention to ethical and beneficiation concerns associated with Intellectual Property;
- Integrating local and indigenous knowledge systems into approaches for adaptation and mitigation, with a focus on potential for pro-poor integrated adaptation-mitigation approaches; and
- Enhanced methodologies for bringing together indigenous/local and scientific knowledge, and linking this with bottom-up planning, including development of National Adaptation Plans.

Engagement across disciplines: This research theme would draw on a range of disciplines, through multi-, inter- and transdisciplinary research approaches, to explore these or other related research areas. These disciplines include, **but are not limited to**, the following:

- Agriculture – crop, animal, and soil science, fisheries, aquaculture, agricultural extension, amongst others;
- Biology – botany, zoology, biochemistry, genetics, molecular biology etc.;
- Ecology and natural resources management;
- Environmental science and management;
- Energy and biofuels;
- Economics;
- Development studies;
- Anthropology;
- Sociology;
- Politics;
- Planning; and
- Environmental education.

Some key nodes and centres of expertise for this include, **but are not limited to**, the following:

- University of Namibia Multi-Disciplinary Research Centre;
- University of Zimbabwe (Institute of Environmental Studies and Centre for Applied Social Sciences Research), Midlands State University, Chinoyi University of Technology, and Zimbabwe Open University;
- Universities of KwaZulu-Natal, Limpopo, Walter Sisulu University, Pretoria, and UNISA in South Africa. The UKZN has a key research theme on Indigenous African Knowledge Systems and a Centre of Expertise in this area, while Walter Sisulu University has a SARCHI Chair focussing on this theme.
- LUANAR University in Malawi, CARD, and LEAD SEA Malawi;
- University of Botswana Environmental Science department and Okavango Research Institute; and

- In Tanzania, Mkwawa University College of Education, Humanities and Social Sciences Faculty, Geography department – research on traditional environmental knowledge system in climate change coping and adaptation; Sokoine University of Agriculture, Department of Forest Biology and other departments – various relevant research projects, including Local Knowledge Climate Change Adaptation Programme (LKCCAP).

4.3.4 Research Theme / cluster 4: Social dynamics of adapting to environmental change: sense making, social learning and social transformation

This research theme on ‘Social dynamics of adapting to environmental change: sense making, social learning and social transformation’ includes education system change, gender and climate change aspects.

Climate change is intimately linked to and also exacerbates other social and economic concerns, especially poverty and inequality. It has been widely reported that southern Africa is more vulnerable to the impacts of climate change than many other regions in the world, because the impacts of climate change interact with, and impact on other stressors that affect people’s quality of life such as poverty, HIV/AIDS, unemployment, and poor quality education, issues which affect many southern Africans today. CCD must therefore also be seen as a social justice concern, and an issue that directly addresses problems of poverty, social justice, poor quality education and ill health.

Climate compatible development also requires changes in social practice and habits, and changes in practice often require new values and ethics, learning, social innovation and social learning. As the 2013 World Social Science Report states, and as is also underpinned by the findings of this SARUA mapping study, urgent action is needed “to protect the planet and to ensure human equity, dignity and well-being”. The World Social Science report argues strongly that the social sciences need to research “the **human** causes, vulnerabilities and impacts of environmental change more effectively and inform responses to the challenges society faces”. While this research theme *foregrounds* the social sciences, it does not do so by reducing the potential for multi-, inter and transdisciplinary forms of research. Rather it seeks to strengthen the social foundations of such forms of research.

The mapping study has shown that across universities in southern Africa, even in those that are most strongly engaged with CCD, social science participation in climate change and CCD issues is barely in existence. Only in a few instances were strong social science research programmes found that are addressing the social change and social vulnerability aspects of climate change, even though risk and vulnerability assessments are on the rise, and some analysis is taking place of climate and gender relations. Generally other social dynamics aspects of climate change are quite neglected, for example, few good sociologies of climate change adaptation exist, and little is understood of how people experience climate risk and how this shapes their identities, social practices and societal relations.

We also lack understanding of how climate change knowledge and uncertainty is to be adequately accommodated in education and training systems, or of what it means for pedagogy and social learning. Similarly there is inadequate knowledge of public science

communication approaches and their efficacy, or full understanding of the role and potential of the media, and various communication systems and approaches. Often too, the implications or more technical forms of risk and vulnerability analysis require deeper analysis from psychological and sociological vantage points. A further gap is in-depth analysis and understanding of multi-level, whole system change or how to best mediate and facilitate transitions that are required to a low carbon, sustainable and more equitable world, especially in contexts that are already stressed by poverty and other ills.

The mapping study has also shown that there are multiple dynamics that require in-depth investigation when it comes to climate compatible development. Broadly, these involve an exploration of the following types of research areas, which would require refinement and further development under this research theme:

- Processes of social and cultural change associated with CCD, and how these can be better understood and mobilised for wider social change, greater resilience to climate impacts, and improved quality of life for all;
- Perceptions¹³¹, understandings and meaning making associated with climate change knowledge and media messages and how these shape action and change;
- Role for public media, social media, arts, literature, ecocriticism, and philosophy (for example) in mediating and enabling social change in a changing global environment;
- Gender and climate change: how gender influences and impacts on experiences of, and vulnerabilities to climate change in southern African contexts, and what this means for action and social change;
- Relationships between poverty, vulnerability and other stressors that are impacted further by climate change;
- Social, cultural, economic and political dynamics of CCD, and how an understanding of these influences action and change in social practices and society more broadly;
- Role of education, training and communication in enabling transitions to CCD and how these can be systematically and creatively engaged across the SADC region in and through national systems of education, training and communication;
- How social learning and meaning making processes can be enhanced and strengthened for CDD-related transitions; and
- Role of climate ethics in decision making and how such ethics are to be conceptualised, and engaged within social practices and social systems.

Engagement across disciplines: This research theme would draw on a range of disciplines, through multi-, inter- and transdisciplinary research approaches, to explore these or other related research areas. These disciplines include, **but are not limited to**, the following:

- Philosophy;
- Development studies;

¹³¹ Here it should be noted that while much research is taking place into perceptions of climate change, it appears to lack strong theoretical grounding, and tends to lack adequate attention to earlier critiques.

- Psychology;
- Sociology;
- Journalism and communications;
- Drama, film and media studies;
- Planning;
- Business studies;
- Education;
- Politics;
- Environmental education; and
- Law.

As indicated above, the mapping study generally showed a weak engagement with the social dynamics of climate change. There is, however, a growing network of researchers engaged in these dynamics across the SADC region; these researchers broadly fall into different groupings, including, but not limited to:

- Social systems, humanities, and social innovation researchers at the following universities:
 - University of Stellenbosch Faculty of Humanities and School of Public Management / Tsama Hub researchers working with the Sustainability Institute;
 - University of Namibia Multidisciplinary research centre (gender and climate change research);
 - Research Chairs in Social Change at the University of Johannesburg and the University of Fort Hare;
 - Wits University programmes in social systems innovation for global change, human ecology resilience;
 - UCT's African Centre for Cities, Centre for Film and Media Studies, Department of Social Anthropology, Gordon Institute for the Performing Arts (linked to ACDI), SARCHI Chair of Security and Justice (environmental security);
 - University of Fort Hare's Centre for Transdisciplinary Studies;
 - University of Johannesburg's Centre for Social Development in Africa, and SARCHI Chair for Social Change;
 - University of KZN's programmes on African ethics, environmental history and gender economics; and
 - University of Zimbabwe's Centre for Applied Social Sciences linked to the sociology department.
- Community development and rural development researchers at the following universities:
 - Risk and vulnerability science centres at the University of Fort Hare, Limpopo and Venda;
 - University of Malawi, LUANAR in Malawi and the Catholic University of Malawi's rural sociology, education and extension researchers are engaged in CCD and social development oriented research;
 - Environmental Evaluation Unit at UCT;
 - University of Limpopo Centre for Rural Community Empowerment;
 - Wits Rural Facility, including the AWARD programme; and

- University of Zimbabwe Centre for Applied Social Sciences and Development research institute.
- Environmental Education / Education for Sustainable Development (ESD) / Science Communication / Social learning researchers based at the following universities / Centres:
 - University of Botswana (Education Faculty);
 - University of Swaziland (Swaziland UNU linked RCE);
 - University of Malawi (LEAD SEA; and Malawi UNU linked RCE);
 - University of Zambia (School of Education, Department of Language and Social Sciences Education (LSSE), UNU linked RCE for Zambia;
 - University of Namibia (Education Faculty, and UNU linked RCE for Namibia, also EE at the Gobabeb Centre of Excellence);
 - Mauritius Institute of Education (with a UNU linked RCE for Mauritius);
 - University of Eduardo Mondlane (Education Faculty) and the Pedagogical University in Mozambique;
 - ACCESS Habitable Planet initiative; and
 - Rhodes University’s Environmental Learning Research Centre (which houses a research Chair and a UNU Regional Centre of Expertise (RCE) in ESD); Stellenbosch University’s Environmental Education Programme; UNISA Environmental Education Programme (in SA); UCT’s Schools Development Unit.

These institutions could work with regional and international institutions such as the SADC Regional Environmental Education Programme, the SADC sector’s human resources programme, the International Social Science Council (who published the World Social Science Report); UNESCO who are supporting Climate Change Education and Education for Sustainable Development, the United Nations University and the United Nations Environment Programme (all of whom are supporting ESD and environmental education); the Development Bank of Southern Africa, the UNDP and other organisations that have a commitment to strengthening social change aspects of CCD. Here it is also worth noting that the African Ministers Conference on the Environment has called for an African Environmental Education Action Plan which is being developed for 2015-2025 by UNEP. This foregrounds teacher education, e-learning innovations, and community and social learning processes that respond to CC and associated issues.

4.3.5 Research theme / cluster 5: Green economy and sustainable energy and infrastructure technology innovations

This research theme focuses on important aspects of the Green Economy thrust and the move towards sustainable and renewable energy in the region, and includes energy efficiency and infrastructure development. As such, it has a strong focus on industrial processes, infrastructure and technology development, and in particular aims to strengthen engineering, infrastructure and technology capabilities development, with implications for establishing low carbon energy and development pathways and more sustainable human settlements.

Clean technology and renewable/sustainable energy technologies and infrastructure (including transport infrastructure) were frequently mentioned in the mapping study country data as constituting important knowledge and research needs, for which additional individual and institutional capacities would need to be built. African leaders agreed in 2011 to develop an African Green Growth Strategy¹³², to build a shared vision for promoting sustainable low-carbon growth through a linked adaptation–mitigation approach, with adaptation seen as an urgent priority. A national example is the launch of Ethiopia’s Climate Resilient Green Economy Facility in 2012.¹³³ This research theme could contribute strongly to the realisation of aspects of the draft SADC Climate Change Programme, particularly, under the ‘Research, Technology Development and Transfer’ component, the programme’s aims to generate evidence-based information, develop appropriate technologies for sustainable development and poverty reduction and disseminate the technologies.

There is an immediate mitigation potential in developing and implementing energy efficiency and renewable energy, and energy efficient and sustainability-oriented infrastructure. Given the energy access issues in many countries in the region, this also has strong developmental benefits. The research theme would bring in issues of technology development, innovation, transfer, and localisation, and would further explore a frequently cited need in the region – to identify and benefit from opportunities that may be inherent in the process of responding to climate change. In countries that are highly reliant on external sources of energy, such as Swaziland and Seychelles, the research cluster would also assist with developing energy security, an emerging area of enquiry.

“CCD is the business of the future, so it’s not a bad thing to prepare our future professionals, like it or not, this is coming. It will happen when the world business community decides it should come online. We are still busy making money out of the other technology, but it’s going to come. So if we prepare our professionals today, I don’t see harm. But it is the approach we take, you have to make it exciting. So the environment can become exciting, because there is a lot of money to make out of it.”

Senior manager, business and industry, Seychelles

While this theme is strongly engineering, technology, design-oriented, it should be noted that in the South African workshop a strong call was made for these kinds of studies. They need to be complemented by innovation uptake studies, which often require market based, value chain and business development research programmes, as well as cultural and social beneficiation studies. Thus, business / private sector partnerships would be a key feature of research in this cluster. This research cluster could also give attention to the request from

¹³² Agreed at the Third TICAD Ministerial Follow-up Meeting in Dakar, Republic of Senegal, on 1-2 May 2011, to commence the work to prepare a "Low-Carbon Growth and Sustainable Development Strategy in Africa" – see http://www.mofa.go.jp/policy/environment/warm/cop/cop17/a_strategy_1206.html for more details.

¹³³ Corsi, M., S. Hagemann and C. Salgado Silva. 2012. "Africa Adaptation Programme third quarterly report 2012." Prepared by the AAP Inter-Regional Technical Support Component. UNDP Africa Adaptation Programme.

students for more ‘demonstrations’ of green economy, green technologies and green system development innovations, and the potential for university campuses to be ‘living laboratories’ for such technological innovations.

This research theme in particular, deals with issues such as Green Transport Design, clean technology research, renewable energy pathways, energy efficiency and urban / rural resilience and adaptation to climate risk. Most of these research areas are complex within a CCD context, and all are engaged in developing and testing technological solutions that assist societies in making the transition to a low carbon, climate resilient future. Solutions are not technological only, but are also technological and economic at the same time, hence the need for this combination of disciplinary expertise. Additionally the solutions also have social and cultural elements (for example uptake and popularisation of new technologies, knowledge of how to use them, skills development for installation and maintenance and so on).

An example which shows the complexity of the transitioning process is provided in the case of South Africa which relies heavily on coal-based fossil fuels for energy, and hence for driving its economy. Currently advanced fossil fuels research focussing on clean energy production is focussed on the transition to a low(er) carbon future. The use of fossil fuels remains a challenge for transitioning to a low carbon future. As noted by the South African Energy Development Institute (SANEDI) (who are engaged in such research with university partners):

“Notwithstanding national efforts to increase the use of renewable energies and energy efficiency measures, coal will continue to be the mainstay of South Africa’s development for decades to come. Therefore it is essential that the continued use of coal be undertaken in a clean approach while taking necessary steps to minimise greenhouse gas emissions.”

Clean coal research programmes, by way of one example of clean technology research, requires, but is not limited to: research that focuses on direct extraction of liquid fuels from coal; the absorption of carbon dioxide into coal as a carbon sequestration mechanism, the speciation of heavy metals in coal; and testing of new technologies such as the ‘high pressure spray’ that tests the characteristics of new liquid fuels. Universities have a role to play, as shown by the participation of the University of Witwatersrand and the North West University in South Africa in the studies mentioned here (conducted in partnership with SANEDI). The mapping study identified that Mozambique also had an interest in clean coal technology development since new coal resources have recently been identified there. Potential therefore exists for regional collaboration on such research thematic areas.

Renewable energy research programmes (to illustrate aspects of this in this thematic research area) focuses on a range of different aspects, including for example solar radiation measurement, photovoltaics, energy system engineering and design, wind mapping and modelling, heat storage and high temperature applications, new materials testing, algal biotechnology research, and ocean energy resource testing, amongst others. Such research necessarily needs to be accompanied by renewable energy business development research, which includes but is not limited to: studies on mutual beneficiation; development and management of renewable energy technology standards; value chain promotion and so on.

Energy efficiency is another area of research that has many different dimensions such as energy performance auditing systems, planning, incentives design and testing and so on. Another important related area of research, also emphasised many times across the mapping study, is the need for applied rural energy provisioning research and practice which includes a focus on alternative cooking fuels, cooking technologies, alternative forms of bio-mass use, and social and social learning studies that focus on cultural changes required for uptake of new technologically supported practices.

Infrastructure and sustainable human settlements research is already a strongly integrated social-ecological science, also with many different areas for research such as use of green open spaces for urban resilience, spatial planning and infrastructure design, decision making support systems, urban networks and social learning, governance and climate services for adaptation and mitigation, urban agriculture and local food systems, green transport systems, fresh water supply, resilient housing (especially in areas that are at risk from flooding), carbon emissions mitigation and many more inter-related elements.

Green Economy research, which to some extent underpins and can enhance the outputs and impacts of these other forms of research mentioned above, relies on strong economic and policy analysis. It also requires research into Green Economy Trade opportunities, potential for green investments, research and development of green growth indicators, potential for biotrade, and beneficiation models that support pro-poor growth and development. Such approaches also require critical political economy studies, as 'Green Economy' is not an uncontested concept, and it requires strong contextualisation. Here research on business sustainability and carbon disclosure is also relevant and important.

A research theme / cluster focussing on these aspects of CCD could therefore potentially include a focus on the following types of research questions. Since this research thematic area is wide in its application and also requires high levels of specialisation, smaller sub-groups centring on some or all of the following areas can be identified. The delineation of these will need to take place amongst the research groups themselves:

- Technologies for clean production and renewable energy, and their localisation (including value chain research) to enhance developmental benefits;
- Design, testing and upscaling and commercialisation of new green technologies (i.e. full life cycle and value chain system research pathway);
- The renewable energy technology development, uptake and beneficiation 'chain';
- Energy efficiency;
- Life cycle analysis and green design;
- Water infrastructure resilience, water governance and adaptive management;
- Sustainability indicators and carbon disclosure analysis and uptake;
- Policy and economic incentives for driving the Green Economy and their application and beneficiation;
- Transitioning research (urban – rural, techno-social / socio-material, political ecology aspects etc.); and
- Infrastructure, social-ecological and governance system development for more sustainable and climate resilient and adaptive human settlements (including cities, rural areas, transport networks etc.).

Engagement across disciplines: This research theme would draw on a range of disciplines, through multi-, inter- and transdisciplinary research approaches, to explore these or other related research areas. These disciplines include, **but are not limited to**, the following:

- Engineering;
- Technology development and innovation;
- Environmental management;
- Energy and biofuels;
- Biotechnology;
- Physics and nanotechnology;
- Economics;
- Business studies;
- Public management;
- Development studies;
- Media, journalism and marketing studies;
- Sociology;
- Planning;
- Political science and international relations;
- Environmental education;
- Law;
- Politics;
- Architecture and design; and
- Landscape planning.

Key nodes and centres of expertise for this include, but are not limited to, the following:

- Université des Mascareignes Faculty of Engineering and Sustainable Development, which conducts research and training in the field of renewable energy sources (wind resource assessment, photovoltaic, rain water harvesting), online daily traffic fluidity monitoring, use of natural refrigerants in air conditioning and refrigeration, and environmental engineering courses, and has an ongoing project for setting up a green campus;
- University of Mauritius, Faculty of Engineering, which conducts research on sustainable forms of energy, including the use of coconut oil for electricity production;
- South African universities involved in renewable energy research, clean technology and infrastructure development research include: University of Stellenbosch which hosts the national hub for renewable energy research; the Centre for Renewable and Sustainable Energy Studies; the Cape Peninsula University of Technology; Nelson Mandela Metropolitan University (Centre for Energy Research); University of Fort Hare Institute of Technology (establishing a CoE in renewable energy research); University of Johannesburg (has the Sustainability Energy Technology and Research Centre); University of KwaZulu-Natal (has research groups working on this topic); University of Pretoria: Human Settlements and Energy Studies; University of the Western Cape; University of the Witwatersrand (School of Electrical and Information Engineering); Tshwane University of Technology; Rhodes University Biotechnology Research Unit; Wits University School of Architecture and Planning; University of Cape Town's Energy Research Centre and Engineering Faculty;
- University of Botswana Centre of Study in Renewable and Sustainable Energy (CSRSE);

- Energy and Environment and Climate Change Research Centre (EECG)¹³⁴ – consultancy in Botswana headed by Peter Zhou;
- SADC / Gobabeb Centre of Excellence, a joint initiative of the SADC, the MET and the Desert Research Foundation of Namibia (DRFN, a research-led NGO) – in addition to CCD related research in areas of biodiversity, geology, anthropology, climate science, it models and tests new energy technologies and works with a range of national and international research partners;
- University of Namibia and Polytechnic: Faculty of Engineering – Renewable Energy Technology and Green Facility Design;
- South African Energy Development Institute, that is linked to the energy research centre network above, as well as major international partners;
- Centres that focus on human settlements and infrastructure resilience and transitioning, include for example the University of Stellenbosch's Sustainability Institute, the UCT Africa Centre for Cities, Cape University of Technology, the Central University of Technology, and the Vaal University of Technology in South Africa (Department of Built Environment focuses on sustainable building); various institutes involved in water services and supply research, the University of Pretoria (linked to NEPAD Centres of Excellence in Water – co-ordinated by the University of Stellenbosch's Water Institute), the University of Fort Hare Institute of Technology, Wits University's School of Architecture and Planning; Chinhoyi University of Technology in Zimbabwe, the Malawi Polytechnic (part of the University of Malawi) and others; and
- Business research centres such as the Centre for Corporate Governance in Africa at the Stellenbosch Business School, or UNISA's Exxaro Chair in climate change and business.

This research cluster could have an important partnership with the African Development Bank's recently approved US\$25 million equity investment in the Bank's Africa Renewable Energy Fund (AREF), which has been supplemented by further partner investments of US\$39.5 million. The fund aims to demonstrate and catalyse the viability of Africa's renewable energy potential to investors, and to begin overcoming the lack of pan-African funding options for such investments. By focusing on inclusive green growth and energy security, it is in line with the AfDB's Ten-Year Strategy for 2013-2022. SADC recently announced that it would be setting up a Centre of Excellence in Renewable Energy. There are also key international organisations working on some of these research thematic areas. Examples are the International Energy Agency for Greenhouse Gas, and the Carbon Sequestration leadership forum, UNEP's industry and cleaner production programmes, UN Habitat, the German Government (via GIZ), the Royal Danish Embassy and others.

¹³⁴ <http://www.eecg.co.bw/about.html>

4.3.6 Research theme / cluster 6: Climate change resilience: A focus on health and well-being

Better understanding of the effects on health and well-being of climate change was mentioned in all of the countries as a priority area in the national response, yet this area has received very little research attention to date. This is an important knowledge and research gap to fill, given that the health sector is considered to be particularly vulnerable to climate change, as are the agriculture and water sectors. For the African region as a whole, climate change is seen as a multiplier of existing health vulnerabilities, including inadequate access to safe water and improved sanitation, food insecurity, and limited access to health care and education.

The health impacts of reduced food security do not relate solely to access to food, but also concern the nutritional status of the food that people eat. Thus, in addition to a likely increased disease burden of a range of climate-relevant health outcomes, climate change is projected to increase the burden of malnutrition, already high in southern Africa, with the highest toll expected in children. Despite progress since the 1990s, approximately 95 million people in southern Africa, or 40 percent of the population, are undernourished.¹³⁵ There has been even less consideration of the effects of heat stress on people and economies, but this could be severe, given the already high average annual temperatures in the region, and the climate projections.

A research theme / cluster focussing on these aspects of CCD could therefore potentially include a focus on the following research areas:

- Impacts of climate change on water quality, and how this links to food and health security;
- Research and improved methodologies (including longitudinal studies) to assess and quantify the impact of climate change on vector-borne, food-borne, waterborne, nutrition, heat stress and indirect impacts on HIV;
- Quantifying the direct and indirect health impacts of extreme weather events in Africa: injuries, mental illness, health infrastructure;
- Frameworks and research platforms developed with other sectors to determine how underlying risks (for example food security) will be addressed to improve health outcomes; and
- Understanding compound impacts from associated temperature and precipitation stress, such as the effect on a particular threshold of a heat wave occurring during a period of below normal precipitation.

Engagement across disciplines: This research theme would draw on a range of disciplines, through multi-, inter- and transdisciplinary research approaches, to explore these or other related research areas. These disciplines include, **but are not limited to**, the following:

¹³⁵ Figures from 2004-2006. De Wit, M.P. and S.J.E. Midgley. 2012. *Hunger and climate change: an analysis of key variables in southern Africa*. For the Regional Climate Change Programme for Southern Africa (RCCP), UK Department for International Development (DFID). Cape Town: OneWorld Sustainable Investments.

- Medicine;
- Epidemiology;
- Public health;
- Biology;
- Ecology;
- Environmental management;
- Sociology;
- Planning;
- Environmental education;
- Health education;
- Media and public communications departments (health journalism); and
- Political sciences / Policy studies.

The mapping study identified very little information on potential key nodes and centres of expertise for this thematic area. However, this is likely to lie within departments of public, epidemiological and environmental health, and related institutes, as well as national medical research centres. Some possibilities are:

- Zimbabwe Open University of Science and Technology (Nursing Science);
- University of Namibia;
- University of Botswana;
- University of Malawi, College of Health Sciences;
- Mzuzu University in Malawi, CoE on WASH (Water, Sanitation and Health);
- University of Zimbabwe;
- University of the North West (Africa Unit for Trans-disciplinary Health research);
- University of Cape Town School of public health and family medicine (SA);
- University of Pretoria health sciences (SA);
- University of the Western Cape (SA); and
- Medical Research Council (SA and others).

Relevant supportive programmes or institutions are the World Health Organisation's (WHO) Department of Public Health and Environment, and IDRC's Ecohealth programme, which has been providing funding in this area. The WHO AFRO (Africa Regional Office) is working on early warning systems for climate-sensitive health outcomes. The Wellcome Trust recently held a call for proposals on climate change and health; reportedly, some of the proposals invited to the third round include research in Africa, but it is not clear whether this involves any researchers in southern Africa.

A further relevant partner could be the new African Plant Breeding Academy, based at the ICRAF Headquarters in Nairobi. This is an initiative of the African Orphan Crops Consortium (AOCC). It will train 250 African plant breeders in high-technology and time-saving techniques for plant improvement. The breeders will apply this knowledge to boost the nutritional quality and yield of about 100 little-researched yet nutritionally dense indigenous African food crops and trees, work that will help tackle malnutrition on the continent.

4.3.7 Research theme / cluster 7: African futures are resilient (AFAR): Governance, participation and social-ecological system change

An institutional issue repeatedly noted in all mapping study countries was a lack of policy coherence, and the necessity of developing institutions for adaptation and for systemic integration of climate change. These aspects were often linked with the need for greater participation and ethical leadership in decision making on climate change responses and CCD, and greater political will to consider environmental change issues as priorities in policy contexts.

The World Social Science Report reflects on the pace and scope of governance in relation to the pace of environmental change, stating “Many social organisations, including governments, favour incremental change. But many of the greatest challenges now call for a more fundamental and far-reaching transformation of social systems. The prospect of global environmental change – and the major, long-term risks and vulnerabilities associated with it [as shown also in this mapping study] – has generated a new debate about how to stimulate and govern radical social and economic transformations of the longer term”. It suggests that there is a need to “match the speed of governance with the pace of environmental change”. This issue is reflected in the southern African concerns for systems of governance that are inadequate for the rate, scope and interconnectedness of environmental change. How to institute such new forms of politics and governance at multiple levels of the system, and how such processes and issues can further principles of participation, democracy and accountability, are important research topics.

Studies in Africa, including southern Africa, show that given uncertain climate futures, adaptive capacity can be enhanced by replacing hierarchical and fragmented governance systems with more adaptive, integrated, multi-level and flexible governance approaches, which institutionalise inclusive decision making and result in more effective adaptation responses. Such adaptive and integrated governance systems can operate successfully across multiple scales – thus constituting adaptive governance and co-management.¹³⁶

Co-management and transboundary management arrangements for collective management of natural resources, and the efficacy of such programmes and policies in a rapidly changing environmental context, also emerge as important to such a research theme, as do others such as the capacity of institutional structures to make use of emerging funding instruments in the international climate arena, engage in adequate financial planning within a long term framework, mainstream climate change and so on.

Citizenship and public participation is also potentially an important sub-theme of this cluster. The mapping study clearly indicated, across all countries, a strong concern that communities

¹³⁶ See, for example, Pahl-Wostl, C. 2009. “A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes,” *Global Environmental Change* 19(3): 354-365.

should be involved in CCD issues. This necessitates considering the processes in and through which communities 'get involved'. Environmental citizenship and public participation provide a potential mechanism, and also encourage links to be made with NGOs and CBOs in the research enterprises. The role of social movements is a further important sub-theme, given their frequent strong role in public monitoring, accountability and local level governance, as well as in climate negotiations and activism. The role and potential of student organisations and youth movements within this process are as yet poorly understood, but the mapping study showed an increase in student engagement with such concerns across southern African universities, with emerging student-initiated networks amongst their various 'green societies / groups'.

Taken together, the above aspects begin to constitute an interesting research cluster on governance for CCD. If this governance nexus is combined with the emerging cutting edge debates on climate change that are happening nationally and in the global arena, such as limits to adaptation, loss and damage, and the need for transformational adaptation, it could provide great value in terms of positioning the region for leadership in this regard, and greater leverage in the international arena. Key related emerging issues being debated are the following:

- Limits to adaptation, and need for transformational adaptation, and possibilities to link mitigation to this;
- Loss and damages, and the need for monitoring, reporting and verification of this, as well as of adaptation funding;
- Future environments – i.e. what will the southern African region look like in 50 years? 100 years? Further into the future?; and
- Near-term adaptation responses (focus on the next 20 years) versus medium and far-term responses.

This research theme could include a focus on some or all of these emerging issues, which could also assist the region's preparations and positioning in the international climate negotiations process, and understanding and leveraging of the political economy of climate change decision making.

To consider one of these, the crucial topic of loss and damage in the international negotiations process has profound resonations for how countries in the SADC region may be affected through irretrievable loss of environments, livelihoods and cultural identity and values, through severe climate impacts. The 2013 AMCEN Gaborone Declaration on Climate Change and Africa's Development stressed the need for international action on loss and damage – see section 2.1.3; this will require further research on understanding, and quantifying where applicable, loss and damage in the region.

Moreover, a report¹³⁷ by the UN University Institute for Environment and Human Security (UNU-EHS) highlights how people are being pushed further into poverty by climate change. The study presents case studies from Burkina Faso, Ethiopia, Mozambique and Nepal that analyse the impacts of droughts and floods on households, primarily small-scale farmers. It shows that despite applying adaptation and coping measures, 96 percent of surveyed households in Ethiopia, 78 percent in Nepal, 72 percent in Burkina Faso and 69 percent in Mozambique experienced negative impacts on their food security or livelihoods following climate-induced damage.¹³⁸ The report suggests people in vulnerable countries may be approaching adaptation boundaries, “beyond which climate change compromises sustainable development”. The report also illustrates non-economic loss and damage, such as loss of way of life and cultural identity of pastoralists who had to move to urban areas or take up crop cultivation. These discussions relate to both limits to adaptation, as well as to the need for more transformational approaches to adaptation, which again will often necessitate deep-reaching social and behavioural change.

Sub-themes/focus areas for this research cluster could include developing transboundary water management for climate resilience, a strong priority at the SADC-level priorities, as well as modes for enhancing participation and negotiation capacity in multi-lateral agreements. Decision support tools for enhanced climate governance could also be developed through this research theme, for example to explore the following research area:

- Developing an iterative process for decision making using scenario development on complex questions that need to be answered, such as longer-term cropping areas and future hydropower potential.

Additional proposed research questions for this theme would need to be further developed.

Engagement across disciplines: This research theme would draw on a range of disciplines, through multi-, inter- and transdisciplinary research approaches, to explore these or other related research areas. These disciplines include, **but are not limited to**, the following:

- Environmental management;
- Economics;
- Development studies;
- Sociology;
- Planning;
- Law;
- Political science and international relations; and
- Environmental education.

Key nodes and centres of expertise for this include, but are not limited to, the following:

¹³⁷ Warner, K., K. van der Geest and S. Kreft. 2013. “Pushed to the Limit: Evidence of climate change-related loss and damage when people face constraints and limits to adaptation,” United Nations University Institute for Environment and Human Security (UNU-EHS).

¹³⁸ <http://africasd.iisd.org/news/unu-ehs-report-illustrates-loss-and-damage-in-four-countries/>

- University of Cape Town, African Climate and Development Initiative (ACDI) and Environmental Evaluation Unit;
- Okavango Research Institute: multidisciplinary research on natural resource management in the Okavango River Basin, specific research programmes focused on climate change;
- LEAD Southern and Eastern Africa (Chancellor College, Malawi): Centre for research and development, focus on leadership training and development for environment and SD, includes three large CCD research and development programmes. Linked to LEAD Africa and LEAD international; UNEP MESA Programme, and UNU Centres of Expertise in ESD; local community radio station;
- University of Dar es Salaam: Mwalimu Julius Nyerere Professorial Chair: Environment and Climate Change, held by Prof. Pius Yanda;
- Stellenbosch University's Sustainability Institute and Tsama Hub and School of Public Management (extensive expertise in areas of environmental governance, public policy and sustainable development);
- University of the North West Faculty of Law (are setting up a CoE in Climate Change and Law);
- University of the Western Cape (SA);
- University of Pretoria (SA) also has expertise on technology innovation and technology policy;
- University of Stellenbosch (Faculty of Humanities – has internationally recognised expertise in climate change ethics);
- Business Schools: UNISA Exxaro Chair in Climate Change and Business; linking with Rhodes University, Stellenbosch and UCT Business Schools who also have programmes on climate change and business / sustainable development;
- Wits University Global Change and Sustainability Research Institute (hosts a climate leadership programme) and the Wits University Centre for Applied Legal Studies;
- Departments of Politics at various universities; and
- Student organisations .

A note on regional strengthening of climate information and climate services

As noted in section 2, climate information and climate services were enduring knowledge and research gaps, including modelling, downscaling and scenario development. This is a fundamental and cross-cutting gap that is well recognised in most analyses, and is being addressed through numerous international and regional programmes, such as those of the World Meteorological Organisation, the World Climate Research Programme (WCRP), UNDP-coordinated activities, including the new AAP food security programme that research theme 1 can partner with, and the SADC Climate Services Centre, located within the Botswana Department of Meteorological Services, which provides training in climate prediction for personnel in the National Meteorological/Hydrological Services (NMHSs), and with an end-user focus. The SADC centre includes programme activities such as attachment of SADC Visiting Scientists to the Centre and running workshops, including the Southern Africa Regional Climate Outlook Forum (SARCOF), and further includes the SADC Climate Data Processing and Production System (CLIDAP), which comprises two parts: the Data Centre and the Task Centre. A particularly relevant initiative for SADC's knowledge needs for downscaled projections is the WCRP's CORDEX (Coordinated Regional Climate Downscaling Experiment).

This is an international coordinated framework to produce an improved generation of regional climate change projections worldwide for input into impact and adaptation studies within the AR5 timeline and beyond, and involves a 50 km grid spacing. However, one of the fundamental constraints to improved climate projections and modelling is the sparse digitised meteorological datasets for the SADC region. Addressing these is a long-term and capital-intensive approach that involves building the observational network and the capacities of the national meteorological agencies, which is beyond the scope of the SARUA programme.

Considering the above, a dedicated research theme on climate information has not been developed for this programme. However, enhanced methods of working with and integrating climate information do form part of a number of the proposed research themes, such as the assessments of risks, impacts and vulnerability envisaged under research theme 1, and the research clusters would need to partner with other programmes and institutions to obtain the best available climate information for their needs.

The SARUA programme would also contribute to the development of climate modelling and scenario development, for example through support to filling the gaps in systematic and reliable long-term ecosystem data to serve as baselines for research, modelling and monitoring, as envisaged for research theme 2, which would aim inter alia to answer the following kind of research question: How could the collection of such environmental monitoring data be better applied into climate change models at regional, national and local levels? A further contribution would be under research theme 7, which could explore enhanced processes for decision making on complex questions, for example by developing an iterative process for decision making using scenario development on complex questions that need to be answered, such as longer-term cropping areas and future hydropower potential.

Such research questions would need to be developed through further discussion with existing programmes, the national meteorological services, and with leading climate information and analysis centres such as UCT's Climate Systems Analysis Group (CSAG) and the Council for Scientific and Industrial Research (CSIR) in South Africa.

4.4 Curriculum development and innovation

4.4.1 A proposed framework to guide CCD curriculum development and innovation across all disciplines¹³⁹

The analysis of capacity needs and the existing status quo related to CCD curriculum innovation outlined in the mapping study (see section 3.2.9) shows clearly that across all 12 countries involved in the mapping study there is a strongly expressed need to engage in curriculum innovation. For this reason, a proposed framework to guide CCD curriculum development and innovation is proposed here to start deliberations on this aspect in the SARUA programme (see section 5). The framework is *necessarily broad*, and can be applied to diverse contexts (as shown in Figure 14 below).

¹³⁹ Note: this section is adapted from a UNEP publication that is 'in progress' (Lotz-Sisitka, in press).

It responds to a challenge that emerged across the mapping study that CCD curriculum innovation is needed across all disciplines, *and* that such curriculum innovation also requires engagement with inter- and transdisciplinary approaches to teaching, involving new teaching methods and new forms of learning. This is besides more specific course innovations, discussed in more detail below.

The mapping study noted that academics require support to engage in curriculum innovations, especially in new areas such as CCD, as CCD has different implications for different disciplines and has new challenges for Higher Education curriculum development. The suggested **framework for CCD curriculum innovation** outlined in Figure 14 below recommends dedicated programmes for staff capacity development that engage staff in curriculum innovation practices.

“We do not feel confident in what we are teaching in CCD yet.”

Zimbabwe workshop participant

A proposed **framework for CCD curriculum innovation** to guide curriculum development at a broad level, and to guide staff capacity development is captured in Figure 14 below, with further explanations following, for consideration by the curriculum innovations network.

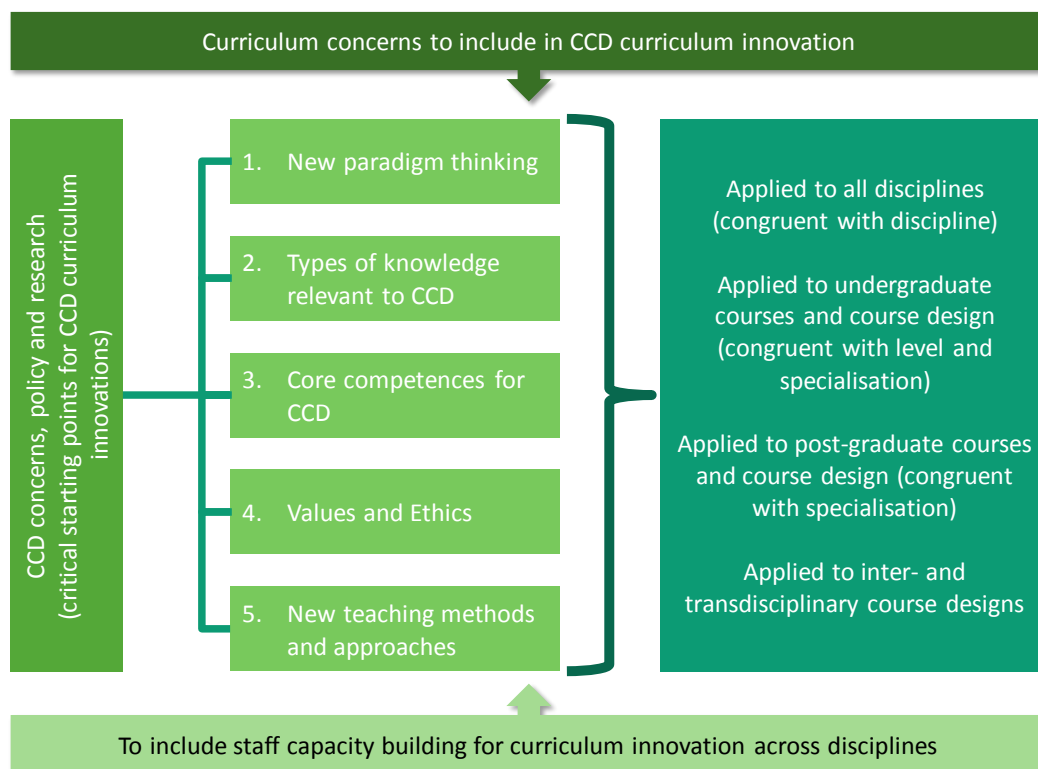


Figure 14: Proposed framework for CCD curriculum innovation¹⁴⁰

¹⁴⁰ Note: this proposed framework can be re-defined by the curriculum network should it be established. This figure and discussion below seeks to establish the principle of such a broad guiding framework for CCD curriculum innovation

All CCD curriculum needs to be guided by **CCD concerns, policy and research**. Research-informed curriculum development is therefore recommended.

Curriculum concerns to include in CCD curriculum innovations across disciplines and levels include new paradigm thinking i.e. systems thinking, integrative thinking, critical and creative thinking; integration of different types and forms of knowledge relevant to CCD (see section 3.2.9), including giving attention to indigenous knowledge where relevant; core competences for CCD (see section 3.2.9.8); values and ethics, including for example inclusivity and democracy; respect for people and all life forms; relational understanding; aesthetic appreciation; equity and social justice; futures oriented; quality of life; care and concern; sustainability. New teaching methods and approaches also need to be considered, as reported in the mapping study, including service learning and Web2.0 approaches.

Application of the core curriculum concerns outlined above is possible in relation to different disciplines (here lecturers would need to consider the framework in relation to the specific disciplinary requirements e.g. the framework applied to Law may be different to the framework being applied to Biological or Biodiversity Sciences); different programme levels (e.g. under- and postgraduate programmes); and different specialisations (at under and/or at postgraduate level). The framework will also have to be contextualised according to disciplinary structure and specialisation. It can further be used to guide aspects of **inter- and transdisciplinary teaching**. This could help to provide a 'shared language' that many say is difficult to develop in inter- and transdisciplinary curriculum development processes.

This proposed 'broader framework' could be applied to the design of a range of new programmes.

4.4.2 New courses needed across the region

The mapping study revealed that a number of new courses were being developed and/or were in development in the SADC region, focussing on climate change-related concerns. As mentioned above in section 2, the primary curriculum innovation practice was to integrate aspects of CC into existing courses but this was not systematically done, nor was there a clear 'vision' for how these curriculum innovations were to contribute towards CCD. There was a strong feeling that new courses needed to be developed, but there was little clarity on what they should contain, or how they should be focussed. It was also said that new courses needed to be carefully thought through, and should be developed within the curriculum revision cycles of universities. The proposed **framework for CCD curriculum innovation** outlined above could help to address such problems.

There are four types of courses that were identified in the mapping study that need to be developed:

- **Undergraduate courses** / modules for integrating into undergraduate teaching programmes in a range of disciplines (examples here are the CCD modules developed for the undergraduate BA degree at UNAM, and the Agro-meteorological courses developed for the undergraduate degrees at Midlands State University in Zimbabwe; other examples can be found in Volume 2). This involved a process of mainstreaming of CCD into existing programmes and degrees, which clearly requires more discussion

at a regional level as to how this is to be facilitated, supported and how high quality outcomes can be achieved through regional interaction and co-operation. Quality outcomes could potentially be significantly enhanced through engagement with the **framework for CCD curriculum innovation** outlined above.

- **Postgraduate Masters degrees**, focussing on CCD, either as:
 - A specific MSc/MPhil degree in Climate Change and Sustainable Development (as at the University of Cape Town; or
 - A Masters degree that has a disciplinary focus, but which incorporates a strong CCD focus (as in the Masters degree in Environment and Climate Change recently developed at LUANAR in Malawi); or
 - ‘Core’ or ‘shared’ modules that can be applied within a range of other specialist Masters degrees (for example, it would be possible to develop a ‘core module’ on CCD which could be integrated into the University of the Free State’s Masters degree in arid zone integrated water resources management; such a process has been discussed in the ACCESS masters degree initiative in South Africa but is yet to be implemented).

All three of these options need to be considered by participating universities, and a decision needs to be made that would work most appropriately in the diverse university, university system and country contexts. Again, curriculum development work here could be supported through collaborative curriculum development activities guided in broad terms by the proposed framework for CCD curriculum innovation outlined above.

However, for the Masters Course Curriculum Innovations sub-programme sub-groups focusing on particular specialisation areas (e.g. renewable energy; or climate modelling; or agro-biodiversity and food security etc.) would need to be formed as sub-groups within the curriculum innovations cluster. The sub-group formation will be determined by ongoing participation in the SARUA five-year climate change and development programme. While it is too early to determine this, the possibility exists that Masters degree programmes associated with some or all of the key research thematic areas could emerge. This will, however, depend on participating universities and their core interests, expertise areas and so forth.

While not necessarily more important than the undergraduate mainstreaming course development work, this focus on **Masters degree curriculum innovation should be seen to be a key priority**, particularly if research capacity for CCD is to be enhanced.

- **Interdisciplinary courses:** This form of course development typically involves more than one discipline, and focuses on an area or CCD focus that is essentially interdisciplinary such as ‘Urban climate change vulnerability and resilience’. Critical issues to address in such course design are not only the curriculum framework issues as outlined above (section 4.5.1), but also institutional issues associated with accreditation of the programmes, and funding of teaching across different departments. Such curriculum development because it does not easily ‘fit’ into existing institutional structures (which follow the mainstream discipline framework) often

requires leadership at a high level in the university (as in the case of UCT who has appointed a DVC to drive this kind of innovation in the university). While this kind of curriculum development is 'not easy', it is nevertheless an important form of curriculum innovation that should also be prioritised and developed further in the SARUA programme where interest and capacity exists for taking such work forward. Participation in this form of curriculum development may also be linked to the research clusters outlined above in section 4.4.

- **Research methodology development and training:** This form of course development is focussed on research methodology course design, and a clear request was for training in how to conduct multi-, inter- and transdisciplinary types of research, as well as for mainstream forms of climate change research (e.g. risk and vulnerability assessments). Some practical suggestions for new methodologies include using more mixed methods approaches; action oriented approaches; systems modelling and so on. The Water Research Commission in South Africa calls this a 'transdisciplinary research toolbox', and there may be an interest across various research councils to support development of such a methodological support programme.

There is a need for research methodology training and development processes in which the best inter- and transdisciplinary methodological practices of participating universities can be documented and shared with others at a regional level. A research science council (e.g. ICSU / ISSC / Future Earth regional programme) could support such a process to develop a research methodology textbook and course for southern African researchers to strengthen capacity for undertaking CCD and / or global change research. There are also internationally published inter- and transdisciplinary research handbooks that have recently been published and various published works on inter- and transdisciplinary research that can be used within this training programme. These would need to be adequately scoped, and regional examples of such methodology will need to be collected from participating universities to be used as case study material in the methodology training. As indicated in the mapping study, such work is in its infancy in the SADC region. The SARUA programme could potentially boost this kind of methodological work at a regional level. Added to this should be capacity building for research fundraising, and research publishing.

In all of these course development initiatives, efforts should be made to focus on possible use of ICTs and Web2.0 tools and shared courseware and materials where such approaches are appropriate.

4.4.3 Regional 'start up' partners for the Curriculum Innovation network

The mapping study has identified a number of potential regional partners or groups that could begin to form the curriculum and / or the capacity building networks who have capacity for taking the proposed capacity building network activities forward at a high level; and who could in turn support various curriculum sub-clusters in the curriculum network where needed (as mentioned above, and as discussed in more detail in section 5). These include, **but are not limited to:**

- START programme and University of Dar Es Salaam's and its curriculum innovation work for CCD in universities.

- SADC Regional Environmental Education Programme (which has substantial experience of supporting curriculum innovations for sustainability oriented areas including climate change).
- MESA Chairs at the University of Botswana, the University of Zambia, and the University of Swaziland; the MESA/Sida International Training Programme Alumni Network; and the MESA southern African network as they also have experience and expertise of supporting CCD related curriculum innovation practices.
- Rhodes University Environmental Learning Research Centre in South Africa, which has been leading curriculum innovations work for the United Nations Environment Programme, UNESCO, the SADC Regional Environmental Education Programme and the MESA network. Rhodes University's ELRC has also been co-ordinating the Africa-Asia International Training Programme for Higher Education for Sustainable Development.
- Higher Education Academic, Teaching and Learning Support Centres and Units (as these support curriculum development and teaching and learning in universities).
- University Centres, Institutes, Chairs and senior researchers and academics with 'model programmes' that can model and support curriculum innovations for CCD. Examples mentioned during the mapping study include the University of Cape Town's ACDI Masters degree in Climate Change and Development, which others would like to link to, and the University of Stellenbosch TSAMA hub transdisciplinary curriculum innovations at MEd and PhD levels (amongst others). Included here are also the ACCESS Centre of Excellence who have a mandate to engage in Masters degree curriculum innovation across a number of institutions.
- Other support may also be obtained for further innovations (especially the use of Web2.0 approaches) from institutions such as the Open University in the UK, and regional Open and Distance Learning (ODL) institutions; the University of South Africa being the largest on the continent. However, others also stand out such as the Zimbabwe Open University (whose Vice Chancellor is also Chair of the SARUA board). SADC also has a programme that focuses on ODL, and they have shown interest in training ODL staff in how to integrate sustainability and CCD related concerns into ODL programmes.
- UNEP also has training programmes for academic staff to develop curriculum innovation competence and a range of resource materials for use by universities as resources that can be used for teaching and curriculum design and teaching.
- The Council for Science (ICSU) and its Future Earth Programme, together with UNESCO and the International Social Science Council (ISSC), and southern African research councils / institutions / departments should be approached for support for SARUA programme linked research methodology training in inter- and transdisciplinary research approaches that are oriented to the social-ecological sciences and that help to address CCD related research issues. Various universities across SADC where such expertise could be mobilised within such a partnership to develop a framework and a toolkit / materials for such training which could then be offered annually or bi-annually to students in CCD related areas.

4.5 Community and policy outreach interventions

4.5.1 CCD research and policy: Towards a more proactive approach

The mapping study found that in most countries university academics *were* contributing substantively to CCD policy development at country level. However, the mapping study also showed that involvement with such processes was largely *responsive* to the need for national reporting and/or policy development as framed by the UNFCCC processes and the development of NAPAs and so on. Most of the research for these policy development processes is government funded, the consequence being that there is little *proactive* research taking place to shape future policy agendas. There is therefore a need to shift policy research towards a more proactive approach.

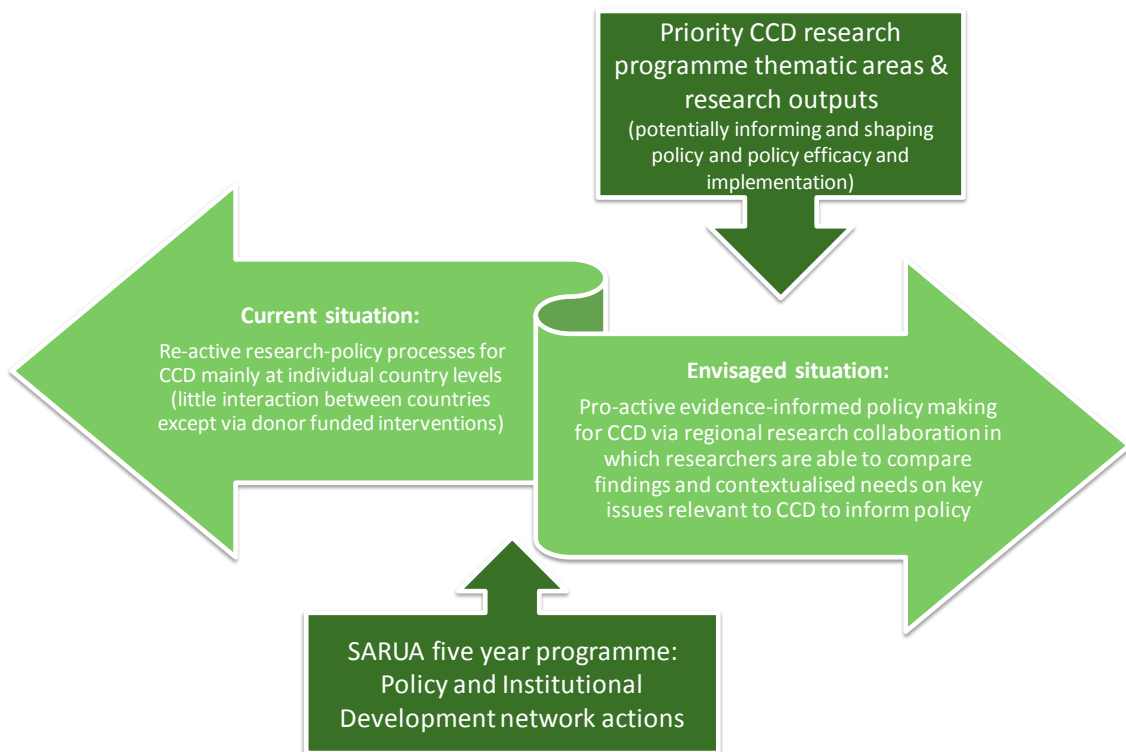


Figure 15: Diagram showing the potential role of research engagement in policy making

A number of policy research strategies are proposed **to strengthen a pro-active, evidence-informed approach to policy making** for CCD in SADC. These include, **but are not limited to**:

4.5.1.1 *Strengthen the quality and credibility of research outputs and research communication*

- Develop strong research publishing support programmes and support researchers to publish peer-reviewed research in internationally peer-reviewed journals and forums as this enhances the credibility of the research outcomes in national and international contexts, including policy contexts.
- Host and /or support regular policy dialogues between researchers and policy makers; this could be established via a policy dialogue forum within the wider SARUA

Knowledge Co-Production Framework. Such policy dialogues need to be local, national, regional and international.

- Translate research results into publications and other formats (e.g. policy briefs / news / social media broadcasts etc.) that can be shared with policy makers, especially in instances where ‘critical mass’ can be used to establish systematic, credible research findings (e.g. comparatives studies across countries; or large scale research projects using similar instruments and approaches across countries; consolidation of case study evidence; multi-scale and multi-site studies etc.). Journalism faculties and communication departments/ units in the KCPF research thematic areas could assist with this aspect of policy-research communications.
- Engage in policy research for CCD. Here it would be crucial to include political science faculties, humanities faculties and law faculties, and schools of public management in the proposed research cluster areas as outlined in section 4.4 above.

4.5.1.2 Strengthen the science-policy output of regional co-operative links and research capacity building programmes

- Maximise regional co-operation links with international and regional research and development partners to ensure maximum impact of research into policy. Examples that were identified in the mapping study include:
 - International partnerships such as UNDP, UNEP, UN Habitat who work with local partners and researchers, but also seek to make policy impacts at national and international levels;
 - Regional organisations and structures such as the SADC Climate Change Inter-Sectoral Technical Working Group (CTWG). This working group is already interested in incorporating and drawing on other CCD related initiatives in the region. This provides an opportunity for the SARUA programme to position its research outputs within a policy structure that can potentially inform both regional and national policy processes and outcomes;
 - SADC-level or broader regional structures that are facilitating research capacity building and networking such as the START (global change SysTEM for Analysis, Research and Training)¹⁴¹ programme, the Regional Agricultural and Environmental Initiatives Network – Africa (RAEIN-Africa), the Benguela Current Commission, SASSCAL, Africa Monitoring of the Environment for Sustainable Development (AMESD); Africa Environmental Observation Network (AEON), WATERNET; the NEPAD Water Centres of Excellence Network, the Famine Early Warning System (FEWSNET) and others were playing an important role in both research capacity building and research networking (see Appendix A), and were operating at a level that allowed for SADC researchers to interact, learn from each other and produce

¹⁴¹ <http://start.org/about>

new knowledge at a regional scale. As indicated in section 3, START may be a particularly important model to consider.¹⁴²

4.5.1.3 *Strengthen policy synergy and coherence, and knowledge of how to achieve such policy synergy and coherence*

- Strategies are also needed to enhance **policy synergy and coherence**, and this requires interaction with cross-sectorial policy institutions at national, provincial and local levels. The problem of a lack of policy synergy and coherence is, at the same time, an opportunity for policy innovation.
- The Knowledge Co-Production Framework research thematic areas could include, as one of their research areas, a stream on policy synergy and coherence, and seek practical ways to inform such policy processes, and communicate them well into policy systems, again drawing on the possibility of ‘critical mass’ that will become possible in a programme such as the SARUA programme.

4.5.1.4 *Strengthen policy understanding of CCD*

- Strategies are needed to ensure that there is a clearer understanding of, and conceptualisation of the relationship between CCD and sustainable development, and that dealing with CCD is a cross-sectorial and multi-levelled issue, affecting all institutions in society. Clear conceptual frameworks for CCD research need to be agreed upon and used across research programmes and interactions with stakeholders. Added to this is the need to mainstream CCD, as participants said it is often relegated to the area of geographers or scientists.
- Strengthening policy understanding of CCD also requires critical engagement with the multiplicity of new concepts that are being used within the broader framework of CCD and sustainable development.
- Additionally, cases that demonstrate the relationships between CCD and SD are needed to illustrate the issues in practice – at policy and at community levels, and especially also to inform local government policy implementation actions. Where possible, local policy institutions should be included in some way or other in transdisciplinary research teams, as this can potentially also strengthen understandings of CCD within the policy and policy implementation system.
- CCD will also need to be related in a coherent manner to the upcoming Sustainable Development Goals (SDGs), which will require careful engagement with the SDGs and the post-2015 agenda in ways that do not exacerbate confusion. Here the inter-relatedness of environment, society and economy (as in CCD) will be a central point of coherence between CCD and the SDGs.
- Added to this are the specific demands of the post-2015 climate agreement agenda, in which university researchers could play a key role in exploring critical policy-relevant

¹⁴² The work focuses on climate variability and change, disaster risk reduction, land-use/land-cover change, biodiversity conservation, urban development, human health, water resources management, agriculture and food security, and regional climate modelling and climate services. The actions of the programme target science, as well as the interface of science, policy and practice, and inform actions toward fostering more resilient and adaptable development.

areas such as loss and damages, and in formulating methodologies and technology for programmes to implement the emissions reduction actions and adaptation actions set out by countries.

- Critical engagement with policy concerns and discourses forms part of the actions required here as noted in the South African and Malawi mapping study workshops in particular.

4.5.2 Policy and research: Towards a stronger focus on policy implementation

In addition to the need for a more proactive approach to evidence-informed policy making, the mapping study also identified a need for research-based engagement with **policy implementation**. Across the 12 countries it was noted that countries were making progressive and far reaching policies for CCD. However, there was also concern, as reported in section 3.9.2 that while good policies are being developed, they are not being translated into practice. While this is a wider issue that prevails across the entire policy landscape in southern Africa due to various structural factors (e.g. inadequate policy implementation budgets and capacity), there are nonetheless some strategies that can be worked with to strengthen policy implementation.

- Key amongst these is adoption of action oriented, multi-stakeholder research approaches where these are most relevant; and translation of research outcomes into practice guidelines and/or support.

It was also noticeable in the mapping study that most governments had either recently finalised, or were in the process of finalising Climate Change Response policies in which many academics had been involved. The follow-on from this policy stage will require a shift of emphasis from policy making, to policy implementation.

- Policy implementation and the efficacy thereof should also be a key aspect of research within the Knowledge Co-Production research thematic areas. This focus on policy implementation, embedded into the research thematic areas, would help to address concerns identified in the mapping study on the relationship between science, policy and practice.

4.5.3 Research and community outreach and engagement

The mapping study has pointed to the potential of multi-, inter- and transdisciplinary research approaches and how they do and can further enhance **community engaged and co-learning approaches to research and knowledge production**. This is visible in the case studies of inter- and transdisciplinary research presented in the country mapping studies (see also Boxes 1, 2 and 3 in section 3.6.1). These approaches appear to be closing the gap that currently appears to exist between universities and their communities, despite the fact that there is much concern from universities and stakeholders that communities should be the primary beneficiaries of the knowledge that is being produced in universities, especially in applied science areas such as many of the CCD-related scientific areas. As shown in the mapping study, this gap between universities and their communities is partly to do with the fact that academics have large teaching loads, and do not easily find time for community outreach, and

also because they have been called upon to offer policy support for CCD in the past few years. However, there are a few strategies that emerged in the mapping study that can be pursued in the next phases of the SARUA programme on climate change and development. These include, but are not limited to:

- Strengthen commitment to, and opportunities for inter- and transdisciplinary approaches to research as they appear to be making the link between research and community outreach and engagement;
- Strengthen the use of curriculum strategies that allow for community outreach and engagement such as service learning; fieldwork; action research and demonstration practices (e.g. green energy technology demonstrations);
- Strengthen university policy on community outreach and engagement and incentives and time for academics to participate in community outreach;
- Strengthen the status of community engaged research and research into community engagement as this helps to develop knowledge of effective community engagement practice;
- Use approaches in teaching and research such as Community-Based Adaptation can also help to facilitate community outreach and engagement as they require field-based engagement with community concerns and practices; and
- Strengthen indigenous knowledge linked approaches to research as these require community-engaged approaches to research and in-depth engagements with communities in practice contexts.

4.6 Higher Education policy and strategy

4.6.1 Higher Education policy and strategy interventions to support 'critical mass' for CCD

This mapping study has shown that achieving CCD goals, as set out in national climate change response policies and strategies, is reliant on a well-functioning, effective science and technology research system. Such a system must be inclusive of all disciplines and it should work at the science-policy-practice interface. This, as shown in the mapping study also requires multi-, inter- and transdisciplinary approaches to knowledge co-production. There is agreement across national policies that science and knowledge production is at the heart of promoting innovation for CCD and sustainable development in southern Africa and in Africa more broadly.

However, as shown in this mapping study, southern Africa still lacks the resources and the 'critical mass' in its science and technology system, and in its HEIs for effectively responding to CCD priorities and challenges. Universities on their own cannot provide for the resources that will be needed, or the national research platforms and policy and strategy frameworks that are conducive for CCD at national and/or regional level. There is need for strong Science and Technology Innovation policy (which is inclusive of the social sciences, humanities and education), and strong Higher Education policy and strategy that can create an enabling environment for CCD research.

As outlined by ADEA (2012), the evidence on the situation of higher education and research is unambiguous: Africa has not invested adequate resources to play its rightful role in the global production of scientific, technological and industrial knowledge for sustainable development. The same can be said for southern Africa. However, there are enough initiatives that show that *the potential exists* for enhanced research and knowledge co-production for sustainable development in Africa, and in southern Africa specifically. CCD provides a clear trajectory in and through which this can take place.

Realising this potential, however, demands the establishment of robust policies and measures in the field of higher education, all of which can be taken forward in the SARUA five-year climate change and development programme. These include, **but are not limited to**:

4.6.1.1 Strengthen the role and status of CCD science and technology

There is a need to strengthen the representation and role of CCD science and technology, and multi-, inter- and transdisciplinary approaches to knowledge production in all education and training systems in the SADC region, from basic education to the university level, as was indicated throughout this mapping study in all countries. According to the Association for the Development of Education in Africa (ADEA) (2013), World Bank studies show that at least a third of graduates must be trained in science and engineering for technological assimilation to take place in a given country. A special effort should be made to train teachers for excellence in this area and to attract more women into the study of CCD related study fields. Thus, in taking this CCD Knowledge Co-Production Framework forward, the following measures are necessary:

- Promote science and technology related CCD knowledge production in all research priority areas but especially in health, agriculture, natural resources management, water, biodiversity and ecosystem services management, clean technology, energy efficiency, climate proof infrastructure development, climate sciences, urban and rural development, and renewable energy production systems (see Needs Analysis in section 2 and Appendix A).
- Prioritise PhD studies in these areas, to train teachers for excellence in these areas. This requires identifying existing lecturers in CCD science and technology who currently do not have PhDs in these areas, and through the SARUA research thematic areas, provide well-supported study 'niche areas' and a supportive institutional and knowledge co-production context for them to succeed. This includes research methodology training as noted above, and potentially developing research programmes across countries and campuses, and providing supervisors with additional training and support where needed.
- Promote the participation of more women in CCD related research areas.

4.6.1.2 Strengthen university / stakeholder partnerships for CCD at the national and sub-regional levels, as well as further afield

- As shown in this mapping study such partnerships involve regional organisations involved in CC and CCD research and development, local CCD related research networks, local and national government institutions and research councils and

institutions, as well as inter-university partnerships that also reach beyond national borders.

- In particular, this mapping study has identified specific nodes of expertise, centres of expertise, and centres of excellence around which such partnerships can develop at a regional level.
- These partnerships are vital for career development in CCD for students in universities, for employment creation and for addressing the disconnect between skills of graduates in universities and the challenging societal contexts and future development trajectories that they are faced with as they emerge from Higher Education. The CCD mapping study showed that there is a mismatch between what is offered in universities and what is required in practice; this is especially the case with rapidly changing new knowledge and response areas such as CCD. Policies for CCD are relatively newly developed in countries (most in the past five years, with some still in draft). The future implementation capacity for these will need to be supported in and through high quality university education.
- The mapping study has shown that such partnerships can also build bridges, create boundary partners and help structure university research in ways that can facilitate meeting the demands of complex societal and structural changes required by CCD, within a wider circle of sustainable development. Such partnerships are also necessary to support and build ‘clusters of innovation’ which, according to ADEA (2012), are much needed on the African continent to “create growth, added value and employment, drawing on the vast natural resources available to it” whilst also establishing sustainable, equitable and viable futures and livelihoods in a rapidly changing context. The mapping study via the research thematic areas have pointed to possible ‘clusters of innovation’ for CCD in southern Africa.

4.6.1.3 Expand the role that researchers in Africa are playing in the area of CCD

- Currently, researchers in Africa are playing a ‘tiny’ role in the production of knowledge and innovation at the global level in all fields, including CCD.
 - This can be expanded via providing concerted support for the proposed Knowledge Co-Production Framework outlined in section 4.4 above.
 - Additionally proactive approaches to supporting peer reviewed publications production should be implemented. The South African case study showed that a national policy intervention (in which Higher Education institution funding is linked to research output) significantly increased peer reviewed research outputs, enhancing the credibility of knowledge production.

4.6.1.4 Support interventions and practices that allow knowledge produced in universities to be shared with, and also developed with communities

The mapping study highlighted a concern that in most countries knowledge that is produced nationally is feeding into policy, but not into community engagement and / or social change practices as effectively as it might. However, new opportunities exist to address this problem through giving attention to:

- The rich indigenous knowledge that arises out of the diversity of cultures and skills and is produced both formally and informally (there was strong agreement across

countries that this was an important area of Higher Education Innovation for CCD). A research theme to address this has been identified in section 4.4;

- Improved policy and research practices for CCD that are more proactively established and that focus on policy implementation (as outlined above in section 3.5);
- Improved community engagement strategies for CCD (as outlined above in section 3.5);
- Mobilising the immense talent of a youthful continent with young people who have extensive capacity for innovation and creativity if supported to develop these skills through giving more attention to student involvement in CCD; and
- Engaging academically and proactively with national response plans for CCD published in the form of national communications and policies (as outlined above in section 3.5).

4.6.1.5 Strengthen Higher Education sector leadership commitment to CCD, including university leadership

As noted across all countries involved in this mapping study, Higher Education leadership and commitment, both at national level and at university level, are required for maximising CCD knowledge production potential. University leadership structures (nationally and at university level) need to support enabling research, publishing, teaching and research funding systems to facilitate CCD and other forms of knowledge co-production, dissemination of knowledge and community and policy outreach. University leadership is also critical for curriculum innovation for CCD as mentioned many times across the mapping study. As ADEA argues, the African continent should “put an end to the stagnation of resources devoted to research and invest at least 1 percent of GDP in the creation of theoretical and practical concepts that can generate and accelerate sustainable development”. It was said numerous times that lessons can be learned from the way that the SADC Higher Education sector worked collaboratively to address the HIV/AIDS issue. CCD requires a similar response from the sector as a whole, and from its university leaders. SARUA could facilitate further leadership dialogues, as it has done in the establishment of the programme for climate change and development in southern Africa, at the request of the Higher Education sector.

4.6.1.6 Invest in a proactive approach to institutional development pathways

The possibility also exists to invest in strengthening existing research groups, and supporting their growth into research centres and networks, research centres and networks into Centres of Expertise, and Centres of Expertise into Centres of Excellence, offering career pathways for active researchers, and also developing the ‘critical mass’ so needed for effective knowledge co-production. The mapping study has ‘mapped out’ where these nodes of expertise, centres of expertise, centres of excellence exist, together with the enabling research networks that they are linked to. This provides a strong platform for such institutional development pathways to be furthered. Postgraduate scholarship programmes are an integral part of this, as are measures such as postdoctoral fellowships, supervision training and support, PhD programmes, and Masters level curriculum innovations and participation in international research programmes (e.g. the Future Earth research plan; global renewable energy research programmes etc.). The research thematic areas create a possible avenue for proactively engaging with institutional development pathways, by linking nodes of expertise, with centres

of expertise, centres of excellence and the international research community in a proactive manner.

4.6.1.7 Implement policy interventions at national level that also facilitate international co-operation in CCD research

For this to be realised, countries need to put in place strong research plans and strategies that can attract regional co-operation and international research partnerships. The South African approach of defining National Grand Challenges with National Research Plans is showing that this approach is working to build research capacity, and also attracts international partnerships and research funding. This SARUA Knowledge Co-Production Framework provides for such a framework at a regional level. At least initially, considerable attention should be given to research capacity building within such policies and strategies. This also requires revision of national research incentive structures, and the creation of viable publishing routes for CCD related research.

4.6.2 Policy and practice interventions at university level

4.6.2.1 Review university policies to include sustainable development and climate compatible development commitments and incentives that support CCD knowledge co-production

The mapping study also showed, across all SADC countries, that at the university policy level, there is a need for stronger university policy and practice support for CCD related curriculum innovation, for staff development, and for supporting transformative learning approaches, and inter- and transdisciplinary teaching. Research funding at institutional level, together with incentives (e.g. promotion, career pathing etc.) are important enablers that can launch stronger engagement with CCD knowledge co-production processes, as are policies that place stronger emphasis on community engagement and student and stakeholder engagement in knowledge co-production and co-learning in universities.

4.6.2.2 Review university policies and campus management practices to include CCD 'modelling' on campuses and stronger forms of student participation

University level campus management and infrastructure development policies can also go a long way towards facilitating CCD research and practice, including providing students with 'living laboratories' and 'demonstration sites' of how transitions are to be made to low carbon, climate resilient futures. Green building development, sustainable campus management, and student action research projects are some of the mechanisms that can be supported at university policy and practice levels. Student environmental / climate change associations are also on the rise, and their interactions and networking also requires support from university leaders. The Africa Green Campus initiative is gaining traction amongst student organisations and some university managers. It could, however, be much more widely supported at university management level and at university management practice level as green campus activities not only reduce resource use on campus, but also provide creative, innovative learning opportunities for students.

4.6.3 Staff capacity development

As indicated above in section 3, one of the critical issues identified in the mapping study was that many of the academics becoming involved in CCD-related research are 'new' to the field. The mapping study also revealed a need for supporting research publishing, and for mentoring new academics into a new academic field, and into new forms of research. The questionnaire data showed high levels of interest and willingness to get involved in CCD related study fields and research, but low levels of enabling conditions for this to occur (e.g. no professional development programmes for staff).

A staff capacity development programme for CCD linked to the SARUA programme could therefore contain all the following:

- A dedicated programme for PhDs for university lecturers involved in CCD related research areas. This calls for a concerted programme focussing on staff capacity development, especially to strengthen more academics (and women academics) to obtain high quality PhDs in CCD related fields. There are a number of international programmes that provide possibilities for this, such as the soon-to-be started DIFD Future Climate for Africa programme, and the African Climate Change Fellowship programme. SARUA could potentially establish a strong partnership with some of these programmes to accelerate opportunities for university staff to obtain PhDs, as it was shown in this mapping study that those with PhDs are more likely to engage in research partnerships, produce publications, inform policy, and support and mentor others into the field. Thus strengthening the number of PhDs in CCD related fields can potentially also impact positively on the emergence of more proactive approaches to policy making. Provision should be made in higher education policies and practice to enable such staff development.
- A staff exchange programme for younger academics involved in CCD research and teaching to learn from others in other countries and universities; this can potentially also be a South-South collaboration programme, or a programme that provides opportunities for staff exchanges in a wider regional or international context.
- Publishing support for academic writing and publishing would also potentially help to enhance the CCD related research publishing. As shown in the mapping study there are few African researchers who are writing papers on CCD, whilst much CCD research is being undertaken in Africa. Academics are also leaving much of their research in the form of 'grey literature'. Collaborative writing sessions, 'writing workshops' and other publications support activities can therefore also be included in the SARUA programme. There are a number of programmes and initiatives that could provide support here, such as the African Scholarly Publishing Initiative (which was hosted at UCT), and various universities that offer such support services (e.g. University of Stellenbosch in South Africa).
- Mentoring of new academics into the field of CCD is another potential staff capacity development activity which can become possible if there are groups of researchers working together within a research programme framework, as proposed in section 4.4.

The items and proposed strategies raised above in section 4.6 and 4.7 provide starting points for the proposed Policy and Institutional Development network, and the Capacity Development network, discussed in more detail in section 5.

4.7 Summary of recommendations

The preceding sections of this report, together with section 4, have provided a range of specific recommendations to address constraints and issues highlighted by participants in the mapping study, and identified through the analysis and synthesis of the three data sources used in the mapping study (desktop review, workshops and questionnaires). These recommendations have shaped the development of the strategic suggestions for the Knowledge Co-Production framework presented in sections 4.1 to 4.6 above. Broader and related recommendations are summarised briefly below. Note that not all these recommendations can or should be addressed by SARUA. They will require action on the part of governments, national Ministries of Education, Environment, Science and Technology, and universities themselves. Through the engagement of, in particular, the Policy and Institutional Development network, a coordinated plan of action will be required to remain informed of major policy developments in the region, and also to influence these policies with well-supported research outputs.

- SARUA could play a key role in providing policy briefs to guide the SADC Education sector on integrating climate change among other cross-cutting and emerging issues, as part of the holistic education for sustainable development approach, in school, teacher education and curriculum development, and through the implementation of proposals for curriculum innovation and mainstreaming on climate change. Such an initiative would be supported by the SADC Environment sector which is keen to see mainstreaming of climate change into Higher Education and the school system. [2.1.3]
- The mapping study findings strongly underpin the need for *significant capacity development across sectors and institutions and at different levels*. Overall the data sources unearthed the critical need for improved education, public awareness, participation and access to information. A commonly cited institutional capacity gap was the *current weak climate change and CCD related curricula* and efforts to enable the development of new curricula across disciplines in tertiary, middle and primary education; as well as in Higher Education institutions themselves. As the Botswana data showed, developing a *networked critical mass of scientists and other expertise* to provide needed services in the entire spectrum of emerging climate change-related challenges is a priority in the country's ongoing response to climate change. What is *needed is a well-funded human resource development and comprehensive CCD capacity development strategy*. [2.3.10]
- Related to the findings on individual capacity gaps and the skills-mismatch between supply and demand, a key gap identified across a number of countries is for *a more professional and career-driven approach to climate change higher education*, and it is recommended that curricula begin to include emphasis on practical skills and developing technological abilities, to necessitate better partnerships between HEIs and the private sector in curriculum development. [2.3.10]
- As university leadership and research system development are closely intertwined, it is recommended that SARUA, in partnership with SADC's education sector, facilitate leadership dialogues on the leadership and institutional changes that are required for meaningful engagement with CCD knowledge co-production in southern Africa.
- National Ministries of Education, Science and Technology should collaborate with other relevant ministries such as Agriculture, Environment, Water etc. initiatives to

strengthen CCD research and research capacity, and to ensure that universities are well supported to provide the necessary scientific base for CCD at country level. Current patterns are that government is providing research funding for CCD research and it is recommended that this continue to support emerging CCD capacity in universities. *Cross-sectorial funding can be sought to strengthen a coherent and synergistic approach to CCD research and knowledge management.* Establishment of **national Climate Knowledge Centres** (as proposed for Mozambique) or a **Climate Change Research Council** (as proposed for South Africa) provides a strong mechanism for this, that can also support knowledge management and data sharing, both of which were identified as key issues in the mapping study.

- *Research institution building* also requires attention not only at national policy and funding system level, but *at university level*, and here *incentives* for academics such as adequate time for research, promotional criteria that allow for community engagement, and that reward research are needed. Additionally structural changes that allow for stronger collaboration across disciplines are needed if interdisciplinary research focussing on CCD is to take root. It is recommended that participating universities debate the implications of CCD research and teaching practice at university Council / Senate / Faculty Board and Departmental levels, also to strengthen understanding of mainstreaming of climate change and CCD into universities as a core development concern affecting the SADC region. As shown in the mapping study supporting high level research themes at university level, supporting establishment of interdisciplinary research centres or institutes on campuses is a strong mechanism to facilitate university-based CCD research institution building.
- *Capacity building of academic staff* needs to be seen as priority as the mapping study showed that those academics with PhDs were playing crucial roles in CCD policy making, research, network building, international partnership engagement, and mentoring of younger staff into a new and emerging research field. A focussed academic development, involving PhDs for those that are engaged in CCD research, and women researchers is needed across the SADC region. The SARUA programme is in a good position to facilitate engagement with this issue, together with partners.
- *Curriculum innovation* has been discussed in detail in sections 3 and 4. The recommendation is, however, to establish and give adequate support to a *curriculum innovation network and capacity building for curriculum innovation* to ensure quality curriculum innovation that reflects the CCD concerns [3.2.9 & 4.5].
- *Internationalisation, and improving the contribution of African scientists to CCD research* is the final recommendation. It involves strengthening peer reviewed journal publishing by African scientists involved in CCD, building strong partnerships with regional research organisations and networks, and international scientific councils and programmes. This can only be achieved if there is strong regional co-operation at SADC level, hence the potential value of this SARUA programme.

Section 5 provides a programme 'road map' for the recommended next steps towards attaining these ends.

5 ROADMAP AND SYSTEM DEVELOPMENT: INITIAL STEPS

5.1 Introduction

The mapping study has provided the knowledge base required for regional CCD network development. The roadmap presented in this section outlines clear action steps for the commencement of the next phase of the SARUA programme. A conceptual network development model, which has been adapted to suit the requirements of the SARUA programme, is presented in Appendix E and provides the broader framework in which these steps need to take place. Given SARUA's own restructuring in entering its second major funding phase in 2014, the network development roadmap focuses on short term actions required to (i) establish sufficient coordinating capacity, and to (ii) ensure collaboration and knowledge co-production activities can commence. **The immediate next steps for SARUA are outlined in section 5.4.**

While section 4 outlines the key research themes and priority areas, including specific recommendations on actions that could have a high impact on the region, the issue of central coordination for the proposed SARUA programme is not yet sufficiently clarified and requires priority attention. A number of potential scenarios exist – from a dedicated SARUA directorate to act as coordinating hub (as per the original programme design), to a contracted programme coordinator to act on behalf of SARUA, to a decentralised approach where universities directly take responsibility for network coordination, to a combination of the above – yet none of these are established.

Irrespective of the coordination approach preferred, the action steps outlined in the roadmap comprise what is deemed necessary to commence with implementation, with an emphasis on two first stages of network development:

- Initiation of research clusters and networks (defining their purpose); and
- Configuration of research networks and clusters (defining how they will operate).

The establishment of multiple networks on a regional level also require a sound governance framework to be put in place, to ensure activities, projects and outputs generated through the SARUA programme meet the required standards of quality and good management.

5.2 Roadmap scope and objectives

The summary outcomes of the SARUA programme, as refined during the course of the *Climate Change Counts* mapping study, inform the Knowledge Co-Production Framework and roadmap. In this sense, the collaborative networks defined in the Knowledge Co-Production Framework (KCPF) are designed to contribute to:

- The revitalisation of higher education in the SADC region to become a major contributor to political and economic development through the co-production of knowledge;
- The long-term development of SADC countries as a result of improved higher education;

- Enhancement of the regional scientific base which informs policy and decision-making on climate compatible development through projects involving institutions and researchers from SADC countries;
- Contextualisation of education within the broader regional and respective national development agendas; and
- Improved climate resilience and adaptation as a result of improved knowledge, policy development, collaboration and decision-making.

The KCPF further supports the achievement of the following long-term objectives as outlined in the mapping study inception documentation:

- Support universities in the SADC region to design and prioritise climate compatible development research and teaching, driven by policy and community needs, to improve the relevance, quality and usefulness of the CCD evidence base in the SADC region.
- Enhance African leadership, ownership and capacity in CCD research in order to advance an African-led research agenda reflecting southern Africa's CCD priorities and needs.
- Strengthen the capacity, coordination and collaboration of higher education institutions to influence and inform policy making and policy implementation, and help develop a pool of resources and Africa-based expertise from which African governments can draw.
- Strengthen networks and relationships between universities, decision makers and other stakeholders to advance better evidence-based policymaking and implementation in the region.

As a first step towards achieving these objectives, the roadmap is therefore focused on outlining action steps to achieve the following objectives:

- Identify the short-term measures required to kick-start the network development process. These measures should result in actions which promote, strengthen and increase innovation in CCD-related research, teaching and learning, community engagement and policy development.
- Define the roles and actions required to develop a coherent and practical agenda for regional collaboration that can inform effective implementation of the SARUA programme.
- Outline the critical next steps required for the Knowledge Co-Production Framework to be disseminated and for collaboration to commence, irrespective of the coordination model required.

The scope of this roadmap is therefore the short-term actions required in 2014, where after each network will follow its own defined network development path. This is illustrated below.

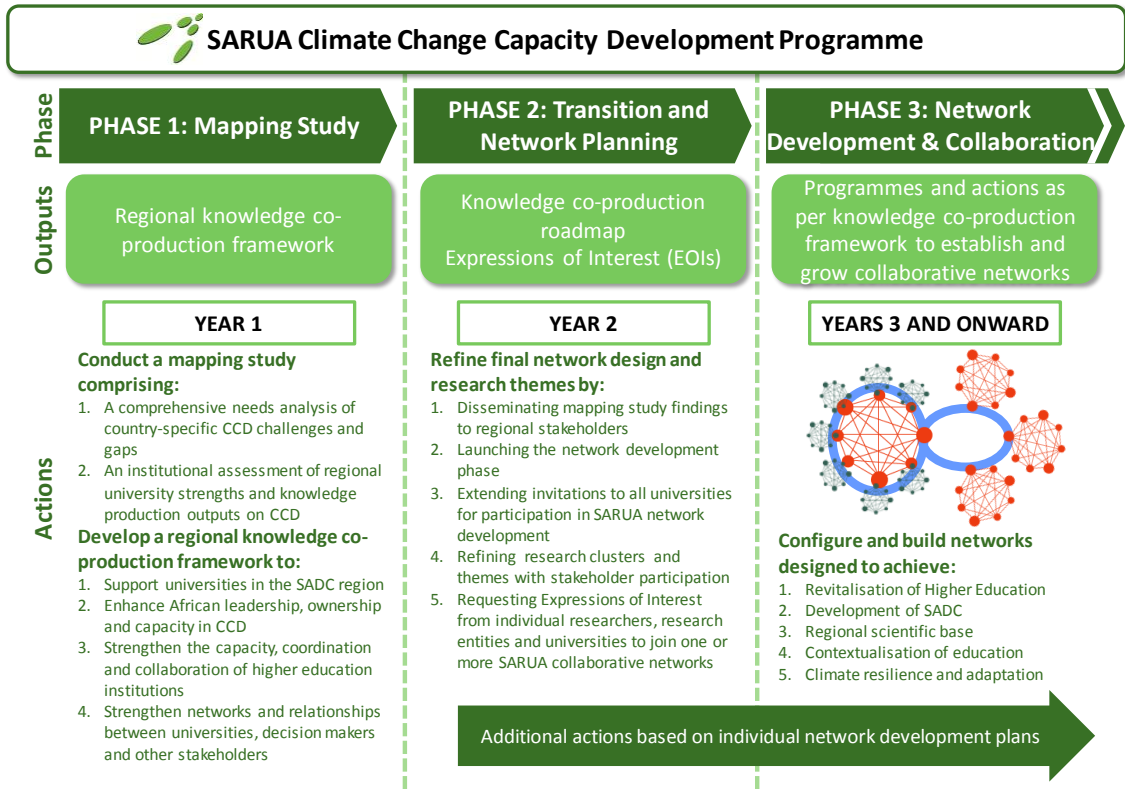


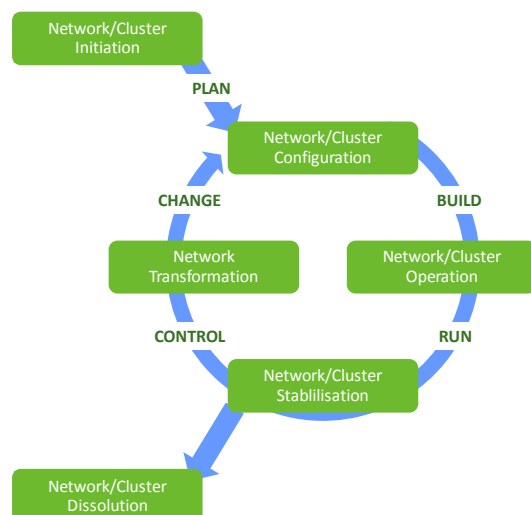
Figure 16: Scope of Knowledge Co-Production Framework roadmap and initial steps

5.3 Network development framework

A detailed network development framework is provided in Appendix E, which outlines the typical network cycle, comprising five potential stages: initiation → configuration → operation → stabilisation → transformation/ dissolution.

The network development framework is compatible with varying time frames and any type of coordination approach (centralised or decentralised). It provides clear guidelines on the necessary and optional roles to be assigned for successful knowledge co-production and steps to be followed by each research cluster or emerging network.

A key emphasis of this Knowledge Co-Production Framework is the identification of self-initiating activities – e.g. finding a champion within the SARUA membership to take the emerging database forward, or beginning with some preparation for at least one multi-site/ multi-institution Masters degree, or identifying the partners who could contribute to transdisciplinary research within proposed and/or re-designed research themes. For that reason the necessary network *roles* are identified and outlined in Appendix E, but flexibility is incorporated so that each network



can determine whether it requires separate entities to fulfil these roles and decide how responsibilities are allocated. A network role (e.g. coordinator) can therefore be assigned to a university, an individual researcher or manager, a government-based focal point, SARUA, or another entity.

It will not be possible, nor ideal, to commence with network establishment of all four networks, a process which should include refining and/or re-developing the proposed seven research clusters that were identified within this mapping study, at once; and this was not the intent of the original network design either. Each network will develop at its own pace depending on a combination of the following factors:

- Relevance of the identified themes to universities, and the processes involved in confirming and/or re-defining the proposed research themes;
- Interest and availability of a network coordinator, participating nodes (centres of expertise, institutional management and individuals) in becoming part of a proposed network;
- Funding and budget available for establishment and coordination activities;
- Extent of existing infrastructure / contacts / collaboration activities;
- Maturity of existing research / management practices within participating universities and organisations;
- Extent of policy preparation, lobbying and advocacy to “sell” the idea of the network to other regional stakeholders; and
- Ability and capacity of SARUA or another coordinating entity to provide establishment and ongoing coordination support.

In terms of network development, not all network partners need to be present and involved at the Network Configuration stage. A small group (e.g. centre of expertise/excellence identified in the Country Reports) can initiate activities, undertake an initial design and then present a more comprehensive networking model and approach to other potential network partners. Once some form of collaboration is established, additional partners (e.g. individual researchers, other centres) can join and this could continue until the Network Operation stage, when knowledge co-production activities will commence in earnest. The approach also makes provision during the Network Transformation stage for additional partners to join into a redesigned network. This is expanded upon in Appendix E.

5.4 Immediate steps

After Vice Chancellors of the SARUA network of universities met in Mauritius in October 2010 to agree on a collaborative programme of action, a Deputy Vice Chancellor Working Group on Research, Development and Climate Change was established by SARUA to oversee the development of the programme and to perform a quality review on the outputs of the mapping study. In order to proceed towards Phase 2 of the programme, SARUA's leadership need to engage with the findings and deliberate key mechanisms for implementation. A DVC working group session was held in February 2014 and the outputs of the mapping study were validated from a quality point-of-view. It was agreed that the Phase 2 process would focus on the following:

- Confirming the revised network structure as recommended in the Knowledge Co-Production Framework;
- Refining the proposed research themes by engaging the SARUA membership and checking for congruence with the SADC Climate Change Policy and Strategy, when these are released in draft form or finalised. Finalisation of policy directions may also require revision and/or development of new research thematic areas;
- Accepting/fine-tuning KCPF recommendations and the network development steps to be taken;
- Identifying any structures required to coordinate from the SARUA side, or individuals to be requested to fulfil an interim coordination role;
- Development of a programme and timeline for the effective dissemination of the KCPF report; and
- Clearly setting out the funding requirements for a project development process in a summarised project concept note that could be submitted to a funder to obtain a project development grant, which would be used to develop a full funding proposal and associated log frame.

SARUA, through its CEO and executive, will ensure:

- Endorsement of the reports by the SARUA Executive Committee;
- Confirmation of any further developments, additions and actions to the proposed road map;
- Coordination of the programme roll-out through an appropriate structure; and
- Communication of the programme roadmap, outputs and key network development initiatives.

Critical success factors

- Communication to all universities (SARUA members and non-members) and stakeholders to confirm the network framework, comprising the establishment of:
 - Macro research network (comprising proposed seven thematic research clusters);
 - Curriculum innovation network;
 - Policy and institutional development network; and
 - Capacity development network.
- Call for participation in networks to be coordinated and well-formulated;
- Activities of the coordination role to be clearly defined;
- Network roles to be appointed as soon as possible (at least coordinators);
- Network establishment: Memorandum of Understanding document / template to be developed and adopted;
- Researchers appointed or commissioned as network configuration commences; and
- Registration requirements to become part of network need to be clearly defined and communicated.

6 CONCLUSION

This Knowledge Co-Production Framework calls for a dedicated response by SARUA and the SADC universities' leadership. It strongly emphasises the element of regional development and collaboration between governments and institutions.

The mapping study illustrates the existence of several initiatives in most of the countries surveyed that show great potential to significantly contribute to climate compatible development in the region. These initiatives need to be strengthened and taken forward.

In conjunction with these findings, the study has specifically identified those elements that restrict the capacity and ability of HEIs to optimally fulfil their roles as knowledge producers and contributors to regional development. The measures required to address these challenges are spelt out in the framework. In addition, the study will also provide a policy learning brief directed at Ministries of Higher Education and funding and research institutions to provide support to the enabling factors needed to co-develop knowledge on CCD. The Policy Brief will in particular draw on the insights gained into structures and mechanisms that either constrain or enable learning, change and research based innovation in southern African universities.

Furthermore, the study findings in particular point out that the way forward will hinge on effective collaboration with existing international CCD development initiatives that show potential to provide increased synergies through collaboration with SARUA universities. For example, the link between the SARUA mapping study and the Future Earth Global Sustainability Research Plan re-iterates the need for international collaboration.

The Future Earth goals are to provide early warning signals of environmental risk and change and to find the best scientific solutions to multi-faceted problems to satisfy human needs for food, water, energy and health. Future Earth also aims to foster and encourage young scientists. In an African context, there has been a commitment from government Ministers that declared their intent to adopt the findings of the UNEP 'Africa Adaptation Gap Technical Report', which cautions that even if the current situation is reversed and the world does manage to keep warming below 2°C, Africa's adaptation costs will remain high, at around \$35 billion per year by the 2040s and \$200 billion per year by the 2070s.

Against the above background it is regarded as imperative that the required funding is secured to take the initiatives as outlined in this mapping study and roadmap.

Appendix A: Country summaries: needs analysis and institutional assessment

For a detailed analysis of the research process, workshop participants and findings in each country, please refer to Volume 2 of this series, which comprises 12 individual Country Reports.

7 ANGOLA

7.1 Angola needs analysis

7.1.1 Context that frames needs

Angola has an already well-established warming trend, with surface temperatures having increased by between 0.2 to 1.0°C between 1970 and 2004 in the coastal areas and northern regions; and between 1.0 and 2.0°C in the central and eastern regions. Rainfall information is unreliable as only 20 of the 500 rainfall stations are functional. Climate models indicate that there will be a rise of 3.0 to 4.0°C in the surface temperature of Angola in the East, and a slightly smaller increase in the coastal and northern regions in the next 100 years.

Within this context, the mapping study needs analysis for Angola revealed that while some progress has been made in identifying research and capacity needs in broad terms, the status of CCD knowledge and research is inadequate for the responses that are required. According to Angola's Initial National Communication to the UNFCC (GoA 2012), a major priority that cuts across all sectors is the need to generate information and knowledge for all adaptation and mitigation priorities that have been identified so far. In this regard, the findings of the needs analysis could be helpful in the updating of the National Strategy of Climate Change (currently in process) and in preparation of the Second National Communication to the UNFCC (also currently in process).

Consistent with the socio-economic context and Angola's post-conflict status, overarching barriers to adaptation indicated in all three data sources include poor quality information and knowledge of the nature of climate change risks and appropriate adaptation, mitigation and CCD responses; limited research engagement with these issues; low levels of technical capacity; and insufficient financial resources to address climate change adaptation and mitigation challenges. The workshop responses identified a range of cross-cutting needs for responding better to CCD, amongst which are capacity development, enhanced and better resourced and managed research institutions, curriculum innovation, and mainstreaming of CCD into national policy and implementation practices. Additionally a need was identified to create platforms where climate change research and development initiatives undertaken by the UNDP and donor organisations could be shared into the higher education system to inform curriculum innovations. A further need was for more climate related information in Portuguese, as most climate information is being produced in English.

7.1.2 Specific knowledge and research gaps

Workshop participants felt that there was sufficient legislation on environmental issues that could be used to promote CCD across government, business and civil society structures. However the lack of skilled human resources was repeatedly noted in CCD areas such as water management, climate related health risk assessment and management, infrastructure adaptation planning and implementation, disaster risk reduction and management, and biodiversity assessment and management (in both workshop and policy data). These were the most regularly cited areas requiring specific research and knowledge development related to

adaptation. Mitigation knowledge and research needs focused primarily on renewable energy and clean technology research, transport and forestry research and development. Clean technology research and development is a key opportunity in Angola given the scale of its oil industry. Underpinning these adaptation and mitigation research and knowledge needs are additionally critical research and knowledge gaps. These include: assessing vulnerability (especially local-level vulnerability mapping); providing more accurate and expansive meteorological information and projections (observational data to underpin climate assessments and vulnerability on water resources, agriculture, biodiversity, sea level rise and infrastructure planning, and human health). Accessing and drawing on community knowledge was identified as an important adaptation and CCD priority, given the high dependence on subsistence production in rural areas, and the high levels of poverty experienced in these areas. The mitigation demands and need for clean technology create research needs linked to technology, energy research and engineering development, or science and technology innovation typically associated with the energy research sector. Workshop participants emphasised the need for clean technology and renewable energy technology development.

7.1.3 Cross-cutting needs

Key cross-cutting needs are the need for improved co-ordination across sectors within government and implementation partners, improved awareness raising and capacity development, and platforms for knowledge sharing, and production of climate knowledge in accessible languages and forms (Portuguese knowledge resources were emphasised a number of times). Inadequate funding for responding to CCD priorities was also repeatedly noted. Cross-cutting educational concerns involved the lack of climate change education programmes in universities, and the lack of curriculum innovation for CCD related concerns. Similarly there was concern about the lack of postgraduate programmes that focus on CCD issues, and very little professional development of existing university lecturers and educators to engage with CCD concerns. Low levels of research capacity for CCD related issues also reflect a need for research capacity development.

7.1.4 Individual capacity needs

Individual capacity needs were identified in policy documents and in workshop discussions as a lack of specific skills related to: Hydrology and Hydro-meteorology; Geology; Agro-meteorology; Epidemiology; Meteorology and Climatology; Maritime Meteorology; Statisticians; Disaster Risk Reduction and Management and Early Warning Specialists. All these are related to observation, modelling, and analysis of climate related data. Other individual capacity gaps were relevant to environmental management activities such as Coastal Zone Management; Agriculture and Climate Risk Management; Local Government Environmental Management; Environmental landscapers and Forestry Development experts and Biodiversity scientists. Technology development related scarce skills were identified in the following areas: Clean Technology and Engineering; and Engineers and Construction Company Project Managers with climate resilience knowledge and skills. From a social change perspective, the following scarce skills were identified: Sociology, Education and Communication specialists with special reference to Environmental Education / Education for Sustainable Development specialists.

7.1.5 Institutional capacity gaps

Specific institutional capacity gaps emerging from documentation and the workshops show an overall lack of institutional capacity on climate change issues, which is not surprising for a post-conflict country in which few people were able to access tertiary education until recently. There is consensus across the data that there is a need to substantively strengthen capacity for information and research development for CCD, and to develop appropriate knowledge sharing platforms between universities and other research-based stakeholders, especially international organisations supporting innovative forms of CCD research. The lack of an adequate national research infrastructure, and research funding is another issue that urgently needs attention to expand climate change research capacity in Angola. There was also a need identified for improved political and institutional capacity for enabling technical cooperation between different institutions; and for integrating climate change into the country's legislation and plans. There is also a lack of an information management system that pulls together national data on different sectors; and there are socio-cultural barriers and capacity gaps, especially related to communications and learning in and from rural areas. Financial barriers and capacity gaps as well as insufficient financial resourcing were also identified as a key institutional capacity gap. Lack of an effective and efficient legal framework; and lack of capacity in the designated national authority to prepare Clean Development Mechanism (CDM) projects was also identified as an institutional capacity gap. It was also noted that Angola does not have an energy policy and strategy. Additionally, local institutions were said to work in isolation, and in general, there were insufficient training programmes and education and training expertise to develop curricula and teach new programmes related to CCD.

Co-production of knowledge and its reliance on improved cross-sectorial institutional capacities can be seen as a significant area of concern for Angola. How this knowledge is shared, and how research is responded to by decision makers, was of particular concern among workshop participants. These specific knowledge and research gaps pose particular relevance for the implementation of the future National Climate Change Strategy and Action Plan for Angola (in development in 2013/14), which relies on research and knowledge (co) production processes, and this section of the Country Mapping Study for Angola has shown that it would be important that the diversity of these knowledge needs should be well articulated in such policy at a suitable level of detail. As indicated by a policy advisor to the Minister of Environment:

“Climate change is not only an environmental problem, but a problem for socio-economic development.”

7.2 Angola institutional assessment

There are numerous complex knowledge, research, individual and institutional capacity needs expressed by stakeholders and university staff themselves. Of greatest significance is the obvious lack of institutional capacity for CCD in the country which, as mentioned above can be explained by the fact that the country is in a post-conflict period. CCD research is a new area of research, and universities have not been established for long in Angola as a result of the disruptions created by the war. The institutional assessment has shown that climate change

research is a very new area of research and development in Angola, and that most progress so far has been in initial policy development. The institutional analysis shows that very few Angolan university professionals appear to be engaging in CCD research. It was said that more established forms of research related to CCD could be found in environmental sciences and related fields, but even within these more established fields, little CCD related research was taking place. Government is playing an important role in initiating and also conducting CCD related knowledge, but this is not 'carrying through' into HEI research programmes or curriculum innovations at present. The general comment from the workshop was that very little was being done in terms of research for CCD and those projects that were being undertaken are not well disseminated or shared, and the number of scientific reports and publications are very limited.

The institutional assessment revealed that there were few courses focusing on CCD in teaching programmes, and this was linked to a lack of curriculum innovation capacity, and lack of appropriate and adequate materials in Portuguese, as well as professional capacity of university staff members who were generally also overloaded with large undergraduate teaching programmes. It was further noted that expansive and specifically dedicated knowledge networks for CCD are almost non-existent in Angola as most of the work on CCD is done through government institutions and project platforms such as the National Adaptation Plan of Action and the First National Inventory. Encouraging however, is the fact that these platforms have allowed for high levels of consultation at both a provincial and national level, allowing stakeholders to discuss climate change issues and engage in policy development. There are, however, a range of affiliated or associated knowledge networks that can form a basis for CCD related knowledge networking (outlined in Table 7 below).

The Angolan institutional assessment also revealed that there are *new institutions and programmes emerging* that can potentially provide strong platforms for CCD knowledge co-production in future. These are the newly established Centre for Climate Change and Tropical Ecology, a newly established Centre of Excellence for Sustainable Development Research and a newly funded large scale UNDP climate resilience development programme (that is research-led, linked to the university, using knowledge co-production approaches) – see Table 7 below. However, these institutions require capacity building, as indicated by research participants who commented on the lack of resources, capacity, research planning and scope and focus of the Climate Change and Tropical Ecology Research Centre, which has so recently been established.

Table 7: Identified sources of expertise for CCD in Angola

University	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
Agostinho Neto University José Eduardo dos Santos University	Early establishment of a <i>Climate Change and Tropical Ecology Research Centre</i> at José Eduardo dos Santos University None other identified in the mapping study	<i>National Plant Genetic Resource Centre (CNRF)</i> at Agostinho Neto University as a centre of expertise for germoplasm research <ul style="list-style-type: none"> ■ Linked with Research Institutes for Agriculture and MINAGRI (extension services). ■ Part of the SADC network of genetic resources centres <i>Development Workshop (NGO)</i> with cross-country research projects and links focusing on CCD – also linked to universities and major international organisations and funders.	Newly Established: <i>Centre of Excellence for Sciences Applied to Sustainability (CESSAF)</i> <ul style="list-style-type: none"> ■ Head: Professor Joao Sebastiao Teta. Linked with Newcastle Institute for Research on Sustainability (NIReS), UK ■ Also partnered and supported by the Planet Earth Institute and the Ministry of Higher Education, Science and Technology ■ First intake of students, 2013 	<ul style="list-style-type: none"> ■ REDE MAIOMB Umbrella Environmental NGO ■ ABA Associação dos Biólogos de Angola – Angolan Biology Association ■ AQA Associação dos Químicos de Angola – Angolan Chemistry Association ■ CEIC Centro de Estudos e Investigação Científica of the Angolan Catholic University ■ DNA Designated National Authority for Angola ■ DW Development Workshop ■ JEA Ecological Youth of Angola ■ BCC Benguela Current Commission ■ EEASA Environmental Education Association of Southern Africa ■ GCLME Gulf Current Large Marine Ecosystem Programme ■ ODINAFRICA The Ocean Data and Information Network for Africa ■ SADC REEP Southern African Development Community Regional Environmental Education Programme ■ SADC Remote Sensing Centre ■ SADC Drought Monitoring Centre ■ SASSCAL Southern African Science Service Centre for Climate Change and Adaptive Land Management

Note: This analysis is based on best available evidence. With further information and evidence, it can be expanded, and also used for monitoring and updating of CCD expertise in Angola. Relevant contact details for researchers associated with this table – as established with best available information at the time of the mapping study (2013) are included in the Angola mapping study (see Volume 2).

The institutional assessment has shown that there is an urgent need for capacity building in CCD related matters amongst the Angolan research community. As shown above very little is happening in the area of CCD teaching, research, community and policy outreach in universities in Angola, and there is a strongly and clearly articulated need for support in this area, both from within policy which emphasises the need for research, and amongst stakeholders and practitioners and university professionals. There is a need for disciplinary capacity development for CCD research, as well as for more innovative and expansive forms of transdisciplinary research and teaching.

The institutional assessment has also highlighted that it is extremely important for universities in Angola to become more strongly engaged with issues of CCD knowledge co-production concerns, so that they can be located within key climate change dialogues, and so that they are able to better support and inform policy and CCD practice. Key areas identified for Angola include curriculum development and innovation, research institution capacity development, individual professional development and research competence development, knowledge sharing, and community and policy outreach.

8 BOTSWANA

8.1 Botswana needs analysis

8.1.1 Context that frames needs

Botswana is a landlocked, hot and dry country with highly erratic rainfall patterns. These characteristics, combined with the identified mismatch between skills needs and supply, mean that Botswana's vulnerability to the projected climate changes is high. Amongst the most severe and wide-ranging impacts will be the projected water shortages. The significance of these changes was debated by workshop participants, who recognised that important steps now are to plan and act for increased unpredictability and variability.

Within this context, the mapping study needs analysis for Botswana has revealed that despite progress on identifying research and capacity needs in broad terms, the status of CCD knowledge and research will need to be enhanced significantly in both specific and cross-cutting ways to address the considerable observed and projected climate impacts. In this regard, findings of the Needs Analysis could be helpful in the ongoing development of Botswana's Climate Change Strategy and Action Plan. Of the numerous, complex research and capacity needs expressed by stakeholders and university staff, and described to some degree in policy documents, such as the SNC, the lack of national institutional capacity for CCD, including a lack of support for CCD research and development, is arguably the most significant. Identified capacity constraints in the NGO sector exacerbate this situation, particularly in rural areas. Developing a networked critical mass of scientists and other expertise to provide needed services in the entire spectrum of emerging climate change-related challenges is a priority in the country's ongoing response to climate change.

Consistent with the socio-economic context¹⁴³, overarching barriers to both adaptation and mitigation indicated in all three data sources include lack of funding and the means to access that funding, lack of co-ordination horizontally and vertically in government and with other stakeholders; lack of supportive policies and legislation; insufficient community participation and broader societal awareness; and inadequate political will and support. These will constitute key areas for cross-cutting capacity development. Many constraints were related to the lack of coordination and of adopting a holistic approach – for example, in addition to government fragmentation, university departments are working with a narrow focus, which led to a strong call for collaborative approaches and increased networking.

¹⁴³ See Botswana Country Mapping Study in Volume 2 for the socio-economic context – as is the case for all the Country Mapping Studies.

8.1.2 Broad adaptation and mitigation needs

There is general agreement amongst the three data sources (policy, workshop, questionnaires) on the *broad priority focus areas for responding to climate change*. Education, training and knowledge management are at the top of the list, together with information sharing and stakeholder engagement. With Botswana's history of drought and the projected impacts on water availability, a critical priority area is enhanced water management, and making the agriculture sector resilient, including the country's vast livestock herds. Energy and infrastructure needs for climate compatible development, especially in the rural areas, are also highlighted. The nexus of sustainable rural livelihoods, poverty alleviation and enhancing community resilience is a key area, with strong connections to the food security priority.

8.1.3 Specific knowledge and research gaps

Knowledge gaps emerging from the data sources include the future effects of temperature rise and precipitation changes on ecosystems, biodiversity, water, agricultural systems and rural livelihoods. The lack of downscaled climate projections is seen as a significant area for research action. In addition to generating relevant climate change data and information, capacities are needed for articulating locally appropriate solutions. Technology transfer and localisation is needed in the areas of solar energy, biomass, biogas, coal washing and dealing with coal bed methane, water treatment technologies, rainwater harvesting, technologies to reduce emissions from livestock, and conservation tillage.

8.1.4 Cross-cutting needs

Knowledge management and the need to better appreciate and explore the potential contribution of indigenous knowledge systems (IKS) to coping with and adapting to climate change were cross-cutting issues highlighted. A number of gaps relate to the absence of supportive policies and institutions, as well as the inadequacy of support structures for rural areas. Limited knowledge and research on what types of CCD responses exist in the country, and the lack of political and corporate will to support CCD research, are related points.

8.1.5 Notable themes

Emerging from the Botswana workshop and questionnaire data were the importance of not only exploring indigenous knowledge systems (IKS) for contributions to developing resilient livelihoods, but also firstly acknowledging and valuing IKS; as well as the importance of integrating the poverty dynamic into the CCD framework.

8.1.6 Individual capacity gaps

While the mapping study has identified a range of individual capacity areas that need to be strengthened to enhance Botswana's response to climate change, the three data sources confirm the priority need for improving modelling and early warning capacities, and capacities needed for appropriate climate change data collection, analysis and dissemination. Specific discipline areas highlighted include suitably skilled educationists; biologists and agriculturalists to teach climate resilient agro-ecosystems, conservation farming, water harvesting techniques,

integrated pest management and biological control; and nutritionists. Re-training of local experts in cross-cutting issues and holistic thinking within disciplines involved in environmental management emerges as a priority for strengthening individual skills, with the related point of focussing on the capacities needed to fine-tune and implement EIAs, as an existing mandated tool, as adaptive measures. Finally, also along the lines of developing skills for more integrated approaches, negotiation capacities and social exchange capacities were highlighted.

8.1.7 Institutional capacity gaps

All three main data sources (workshop participants, questionnaires, policy documents – mainly the SNC) point to the need for specific financial support to encourage the development of new skills, and capacities, which is a major inhibiting factor in how Botswana prepares itself for climate change. These institutional capacity gaps have a direct effect on the individual, knowledge and research gaps identified, as insufficient levels of CCD capacity in the education institutions reduces the opportunity for CCD knowledge and research to flourish, subsequently reducing individual capacity opportunities. The need for information sharing, collaboration and integrated approaches to environmental management point also to the fragmented nature of the current institutions, and the insufficient communication and knowledge sharing needed to prepare the country for CCD research and development. Both the SNC (2011) and participants in the mapping study have highlighted the need for a national policy to add a level of coherence and support for CCD action, in this way pulling together the stakeholders – government, NGOs, universities and private sector – into a common framework.

8.2 Botswana institutional assessment

This mapping study has identified existing initiatives amongst the higher education institutions (HEIs) in Botswana and their partners where activities such as research, teaching, policy engagement and community outreach are addressing climate change-related needs. The institutional assessment has shown that HEIs in Botswana have significant expertise and capacity for responding to climate change and moving towards CCD, in the form of some extremely experienced and internationally acknowledged scientists, many of whom have PhDs and over ten years experience, some over 20 years. Active researchers identified in this mapping study are listed in Volume 2, Botswana mapping study Country Report, and CCD areas of expertise in Botswana, mainly with respect to universities, are summarised in Table 17 of the same report. University staff are actively contributing to the policy processes in Botswana, and to international assessment processes to inform policy – such as the three authors from the Department of Environmental Science at UB who contributed to the IPCC Fourth Assessment Report. There is in general less involvement in community outreach, with the exception of some researchers whose work is extremely community-based. There has been some involvement in awareness raising on climate change, such as Joyce Lepetu of Botswana College of Agriculture who was very involved in creating public discussions in North East Botswana, Gaborone and Maun on climate change as part of a pre- and post-COP17 initiative.

However, these areas of capacity for work on CCD will need to be supported through dedicated capacity development activities. Across the data sources, the mapping study has found a strong call for building research capacity on CCD, and for integrating CCD into curriculum and

teaching. As this is a multidisciplinary issue, such capacity building should take both a specialist (to develop specialist research capacity) and a multidisciplinary approach that allows for knowledge exchange and the development of collaboration. Important nodes for multidisciplinary research lie within the Botswana Global Change Committee, and the Okavango Research Institute. Both these organisations seem to have good experience in multidisciplinary research and capacity development, and could play a valuable role in CCD capacity development, within an overall supportive framework that is needed, and could be developed through the CCS&AP process. A further key area is to enhance the integration of climate change and CCD into Botswana's education system, including public education and grass roots community programmes, within the context of sustainable development. Institutional barriers to collaborative research include limited government support in the form of appropriate legislation, incentives and facilitation, narrow assessment standards and performance management tools within universities, and the lack of a National Research Foundation that could, *inter alia*, provide an overall framework to enable this kind of research in general, as well as for CCD purposes.

What is clear from this picture of Botswana's overall research concerns is the need for a more integrated, collaborative approach, which is working towards some form of unified policy and action plan. While there is valuable, long-term CCD related research happening in different departments at UB and BCA, there is a common concern that there is a major missed opportunity for how this research can enter into new research networks, policy development and implementation, and stronger community engagement.

The implementation of the SASSCAL programme in Botswana has the potential to develop and strengthen Botswana's existing expertise for collaborative knowledge co-production, given the requirement for transdisciplinary research. Given SASSCAL's orientation, it could consider convening a national discussion amongst key stakeholders on the findings and recommendations of this mapping study, in order to develop a roadmap for Botswana on strengthening response to climate change through knowledge co-production. This could be further developed on a regional basis, at least in the countries in which SASSCAL is currently active.

Table 8: Identified sources of expertise for CCD in Botswana

University	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
University of Botswana	<p>Research in environmental, agricultural, climate, water, wetlands, biological and energy issues</p> <p><i>Faculty of Science:</i></p> <ul style="list-style-type: none"> Department of Environmental Science: Core group including very experienced researchers, carrying out research and policy engagement on wide range of CC-related topics, including mitigation analysis; gender and CC; applied climatology, climate policy and climate and development <p><i>Faculty of Education:</i></p> <ul style="list-style-type: none"> Department of Languages and Social Sciences: research on curriculum development; ESD and integrating climate change into this <p><i>Faculty of Agriculture:</i></p> <ul style="list-style-type: none"> Department of Agriculture: research on how CC will affect rangeland and livestock sector; reducing livestock methane emissions; <p><i>Okavango Research Institute:</i></p> <ul style="list-style-type: none"> Multidisciplinary research on natural resource management in the Okavango River Basin; 	<p><i>UB Centre of Study in Renewable and Sustainable Energy (CSRSE)</i></p>	<ul style="list-style-type: none"> SADC Climate Services Centre, located within the Botswana Department of Meteorological Services Training in climate prediction for personnel in the National Meteorological/Hydrological Services (NMHSs), and with an end-user focus; programme activities such as attachment of SADC Visiting Scientists to the Centre and running workshops, including the Southern Africa Regional Climate Outlook Forum (SARCOF) Climate Data Processing and Production System (CLIDAP) comprises two parts: the Data Centre and the Task Centre SADC Regional Early Warning Centre (REWC) – at SADC 	<ul style="list-style-type: none"> Botswana Global Change Committee (BGCC) – initiated by UB Department of Environmental Science; interdisciplinary approach; enables collaborative research among human and biophysical sciences researchers; capacity building of scientists through training, networking and provision of an institutional framework for research; promotes policy dialogue and disseminates research Energy and Environment and Climate Change Research Centre (EECG)¹⁴⁴ – consultancy headed by Peter Zhou SASSCAL programme

¹⁴⁴ <http://www.eecg.co.bw/about.html>

University	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
	specific research programmes focused on climate change		headquarters in Gaborone; hub to link with National Early Warning Centres	
Botswana College of Agriculture (BCA)	<p><i>Department of Animal Science and Production and the Forestry Unit</i> (http://www.bca.bw/)</p> <ul style="list-style-type: none"> ■ Manipulation of feeding systems of ruminant livestock to reduce methane production; agroforestry research; livestock waste production of biogas 			
Botswana International University of Science and Technology-BIUST	<p><i>The Earth and Environmental Science Department</i> (as BIUST is a very new institution, this is more of a potential than an actual node of expertise at this stage)</p>			

Note: This analysis is based on best available evidence, within the constraints of the mapping study. With further information and evidence, it can be expanded, and also used for monitoring and updating of CCD expertise in Botswana. Relevant contact details for researchers associated with this table – as established with best available information at the time of the mapping study (2013) are included in the Botswana mapping study Country Report (see Volume 2).

9 MALAWI

9.1 Malawi needs analysis

9.1.1 Context that frames needs

Malawi has an already established warming trend. The UNDP Climate Change Country Profile notes that the mean annual temperature has increased by 0.9°C between 1960 and 2006. During the same period, the number of hot days and nights per year has increased by 30.5 and 41 days respectively, and Malawi has experienced observed an increase in the incidence of extreme weather events, notably, droughts, floods, hailstorms and strong winds. In general, Malawi is expected to experience higher temperatures and lower rainfall in the future. The 2011 Second National Communication reports that mean annual temperature in Malawi is likely to increase by 1°C by 2020, 2°C by 2075, and 4°C by 2100. Mean monthly and annual rainfall is projected to decrease in the future, ranging from -4.8 to -0.7 percent. The incidence of rainfall that occurs in heavy events will increase by 19 percent by 2090, under a scenario of high global greenhouse gas emissions.

Within this context, the mapping study needs analysis for Malawi revealed that while progress has been made in identifying research and capacity needs in broad terms, the status of CCD knowledge and research remains inadequate for the responses that are required. According to the draft National Climate Change Policy (GoM 2013) a priority that cuts across all sectors is the need to undertake research, engage in technology innovation and share knowledge through education and communication approaches. In this regard, the findings of the needs analysis could be helpful in the implementation of the draft National Climate Change Policy, as the needs analysis provides a refined view of the status quo of knowledge production and knowledge co-production in Malawi.

Consistent with the socio-economic context of Malawi, in which approximately 80 percent of Malawians depend on renewable natural resources for livelihoods, the Malawian government has identified a number of adaptation, mitigation and cross-cutting priorities at policy level, and it has also established a new Ministry of Environmental Affairs and Climate Change Management. Overarching barriers to adaptation and mitigation have also been recognised. These relate to poor quality information and knowledge which in turn is related to limited human capacity in terms of numbers, skills range and depth; and limited systematic climate change data observation, collection and storage, and limited institutional capacity which includes limited coordination of climate change research and interventions, an ageing telecommunication system, and the non-functioning of three of the four climate-related early warning systems. Socio-cultural barriers such as poverty and illiteracy, slow diffusion and adoption of technological innovation, and limited funding for longer-term climate change research and programmes creates further barriers to CCD in Malawi.

9.1.2 Broad adaptation and mitigation needs

There is broad agreement amongst the data sources used to compile this mapping study report (mainly documents and workshop data as questionnaire responses were limited) on the

broad priority focus areas for adaptation – namely, water resources management; agriculture; forestry and other land uses; biodiversity, wildlife and ecosystems; fisheries; health; and human settlements. These reflect the climate vulnerabilities of Malawi, especially for its majority rural populations. The data sources also agree on *broad mitigation priorities and needs*, which encompass measures related to agriculture; forestry management and REDD+; energy; waste management; transport; industrial processes (clean technology); making better use of the Clean Development Mechanism; and climate proofing housing and infrastructure developments. Workshop and questionnaire data emphasised these priorities too, but also gave attention to the importance of CCD education, training and capacity building, gender mainstreaming of CCD issues, population growth and human resource development. These are also outlined as cross-cutting issues in the draft National Climate Change Policy.

9.1.3 Specific knowledge and research gaps

The Malawi draft National Climate Change Policy states that “there is need for more research in climate change issues and capacity needs assessments and training needs assessments have indicated that more work has to be done”. Policy outlines a number of specific research and capacity gaps, which include improving data production, management and storage, observation systems, and research capacity. The draft National Climate Change Policy includes a specific objective on research, technology development and transfer, and systematic observation which involves rehabilitating and upgrading, and expanding weather monitoring stations around the country. It also includes supporting the documentation of indigenous knowledge for CCD. Specific research priorities are identified for adaptation priorities, which includes vulnerability and risk assessments, ecosystem service assessments, biodiversity change monitoring and assessment, and research for new technology and practices (e.g. aquaculture; renewable energy; clean technology, and eco-health approaches). Workshop participants tended to agree with these research needs, but also indicated that there was a need for environmental education and training research to improve education and training approaches and programmes; and human resource planning research, as well as socio-cultural change research. Issues of limited data, research capacity and knowledge in relation to all the different priority areas were identified. Questionnaires raised a few additional research priorities, related to the need for malaria research, and social-ecological systems research linked to ecosystem service approaches to research. It was said that these more integrative approaches were not widely practised as researchers tended to work in disciplinary silos and adoption of system-based approaches was not widespread.

9.1.4 Interesting cross-cutting issue

An interesting cross-cutting issue was that of population growth and climate change, and the knowledge gap associated with indigenous forms of family planning, and exploring the acceptability of contraceptives among youth and society. The question of what the ideal family size might be, considering the constraints placed on Malawian society by climate change was an interesting and controversial knowledge and research question raised in the workshop. Capacity to document and evaluate the relevance of indigenous knowledge in relation to western scientific knowledge and to work with both knowledge systems was also noted as a key research gap, as was policy and institution development research.

9.1.5 Individual capacity needs

Individual capacity needs were identified in policy documents and in workshop discussions as a lack of specific skills related to higher degree training in climate change and its relevance to the fields of Agriculture, Engineering, Environment, Wildlife, Meteorology, Climatology, Modeling, Statistics, Mathematical Sciences, Physics, Chemistry, Biology, Geography, Earth Sciences, Sociology, Environmental Education and Psychology. In addition to this the policy recommends that specific capacity gaps lie in computer simulation and climate change modeling. Ensuring the inclusion of climate change in primary and secondary school curricula and providing teachers with the skills, tools and resources to educate the children and youth about climate change was emphasised in the workshop, as was skills development for the media (journalists). Workshop participants also called for improved capacities of researchers in the renewable energy sector, particularly engineers, economists and policy experts. Expertise in GIS, carbon assessment (carbon trade economists), natural resources assessment, waste management and mathematical modeling was called for. Workshop participants called for more epidemiologists, environmental scientists, EIA scientists and social scientists. The workshop also gave rise to a discussion on the need for the skills (political, negotiation, critical thinking) for critical engagement with climate change related issues at a national-global level.

9.1.6 Institutional capacity gaps

Specific institutional capacity gaps emerging from documentation and the workshops show an overall lack of institutional capacity on climate change issues. There is, however, a strong awareness of this in policy, and in workshop and questionnaire data. There is consensus across the data that there is a need to substantively strengthen capacity for information and research development for CCD, and to develop appropriate stronger multi-sector knowledge sharing platforms between universities and other research-based stakeholders. The lack of an adequate national research infrastructure, and research funding was another issue that emerged often, especially also the lack of a national research strategy for CCD. Lack of political will and a rigidity and resistance to change were also cited as institutional gaps. Poor coordination, management and monitoring of progress were other issues cited. Information access through institutions was poor, due to a lack of sharing and the absence of a central database. Policies contain limited innovation and there is a noticeable lack of favourable policies that promote innovation. Of those policies that do exist, workshop participants felt that they were limited in their implementation and enforcement as there were no robust policy and legal instruments available. In addition to this, coordination between government, NGOs and the private sector was limited. Finally a commonly cited institutional capacity gap was the current weak climate change and CCD related curricula and efforts to enable the development of new curricula across disciplines in tertiary, middle and primary education.

Co-production of knowledge and its reliance on improved cross-sectorial institutional capacities can be seen as a significant area of concern for Malawi. The knowledge, research, individual and institutional capacity gaps pose particular relevance for the implementation of the future National Climate Change Policy, which relies on research and knowledge (co) production processes. This section of the Country Mapping Study for Malawi has shown that there is need for careful planning and resource allocation to **address** these knowledge and

institutional gaps, which should be taken forward into the strategy and action planning that will accompany the release of the National Climate Change Policy, which was in draft form in 2013.

9.2 Malawi institutional assessment

There are numerous, complex knowledge, research, individual and institutional capacity needs expressed by stakeholders and university staff themselves. Of significance is the obvious lack of strongly established institutional capacity for CCD in the country which, as mentioned above can be explained by the fact that CCD research is a new area of research and there is still relatively little engagement with CCD, although a few nodes and centres of expertise in this area could be identified (see Table 9 below).

The institutional assessment has shown Malawi has made progress with initial analysis of CCD related priorities and policy development but that there is a need for more university professionals to get involved in CCD related research. It was also noticeable that more established forms of CCD research were found in the natural resource management, agriculture, water, forestry and energy areas, with other areas still weakly developed (e.g. rural sociology, environmental education, law and policy studies, CC and health, CC gender mainstreaming etc.). Government, supported through international development partners, is playing an important role in initiating and also conducting CCD related knowledge. It was also noticeable that those academics with strong track records in this area of research, and with PhDs and/or professorships were able to initiate and drive implementation of major CCD related research and development initiatives in partnership with government and other stakeholders. However, there were only a few such individuals identified, and there is need for a much stronger 'critical mass' and thus for capacity development to strengthen high level research capacity amongst a broader group of researchers. It was also encouraging that some women were engaged in CCD research, but it was also clear that this was a male dominated research area. It was also noticeable that few of the academics involved in CCD research had obtained PhDs. In general it was felt that scientific capacity for CCD was still weak, and in its infancy in Malawi, although there were some good examples of CCD relevant research. This also showed up in publications where much of the very useful local research is not being published except in 'grey literature' form, making it difficult to track and use such knowledge in knowledge co-production processes.

The institutional assessment revealed that there were still few courses focusing on CCD in teaching programmes, and where this was happening CCD integration was following the model of integration into existing disciplines, mainly at the undergraduate level, although there was some integration of CCD into other mainstream postgraduate degrees. One interesting exception was the CC-DARE project that developed a M.Sc in Environment and Climate Change through a multi-stakeholder and multidisciplinary approach to research and curriculum development. This has also heightened awareness of the need for CCD curriculum innovation, and there is more discussion on this issue now, especially in the Lilongwe University of Agriculture and Natural Resources, where the CC-DARE curriculum innovation project was located. A new programme, named the Capacity Building for Managing Climate Change in Malawi (CABMACC) has recently been established with links to CARD, one of the identified

centres of expertise in Malawi (see Table 9). It was further noted that specifically dedicated knowledge networks for CCD are still in development in Malawi, and where these existed, they tended to be linked to major development projects, in which universities were involved (e.g. the CCABMAC). The sustainability of these projects, however, remained a problem for the longer term as most CCD implementation and research work in Malawi is quite dependent on donor funding. Organisations such as LEAD SEA at Chancellor College in Malawi were, however, playing a strong role in building national and regional (Africa wide) understanding of CCD and also in training for leadership of CCD through links to LEAD Africa and the wider LEAD network.

The Malawian institutional assessment also revealed that there are a number of Centres at universities which play an important role in bridging multidisciplinary research, and in research programme development and research partnership building. It seems that having such semi-autonomous centres is a core part of the functioning of Malawian Universities, although these are few, and only a few are focused on CCD as their 'core business'. It is encouraging therefore that the draft National Climate Change Policy of Malawi suggests strengthening Centres of Excellence for CCD research and practice in Malawi. From the evidence in this mapping study, these are a key institutional structure that is *enabling* of the kind of research and knowledge production necessary for CCD. However, these Centres also appear to be vulnerable to changes in donor funding patterns, and are also heavily reliant on donor funding for their research and development activities. While it was difficult to obtain evidence to this effect, it seems that CCD initiatives that start, often end when donor funding ends, creating an unstable environment for knowledge co-production in the longer term.

Table 9: Identified sources of expertise for CCD in Malawi

University	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
University of Malawi, including: Chancellor College, Polytechnic, College of Medicine and Kamuzu College of Nursing	<ul style="list-style-type: none"> ■ <i>Faculty of Science</i> (individual researchers contributing to NAREC) ■ <i>Faculty of Law</i>: policy and institutional development research ■ <i>College of Medicine</i>: Welcome Trust Malaria Research 	<ul style="list-style-type: none"> ■ <i>Natural Resources and Environment Centre</i> (NAREC) in the Faculty of Science, Chancellor College Malawi. Involved in CC adaptation research in Shire River basin, Soil carbon mapping; agro-ecosystem services research and water resources research linked to NEPAD Centres of Excellence Network. ■ <i>Centre for Water, Sanitation, Health and Appropriate Technology</i> (WASHTED) at University of Malawi Polytechnic; involved in a range of CCD research including vulnerability studies, technology development, monitoring and renewable energy 	<ul style="list-style-type: none"> ■ NEPAD Water CoE at University of Malawi ■ LEAD Southern and Eastern Africa (Chancellor College): Centre for research and development; focus on leadership training and development for environment and SD, includes three large CCD research and development programmes. Linked to LEAD Africa and LEAD international; UNEP MESA Programme, and UNU Centres of Expertise in ESD. Local community radio station 	<ul style="list-style-type: none"> ■ Malawi Research and Knowledge Networks cited in the workshop include: ■ Civil Society on Agriculture Network (CISANET) ■ Civil Society Network on Climate Change (CISONECC) ■ National Technical Committee on Climate change ■ LEAD Southern and Eastern Africa ■ WATERNET – especially the gender component ■ Centre for Environment for Environmental Endowment and Advocacy (CEPA) ■ Malawi Environment Endowment Trust (MEET) ■ Regional Environmental Research Centres and knowledge networks include:

University	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
Lilongwe University of Agriculture and Natural Resources (LUANAR)	<ul style="list-style-type: none"> ■ Agricultural scientists engaged in CCD research ■ Natural Resource Management Scientists engaged in CCD research ■ Rural sociology and Extension researchers engaged in CCD research 	<ul style="list-style-type: none"> ■ <i>Centre for Agricultural Research and Development (CARD)</i>, which undertakes agriculture and agricultural policy research, with some links to CCD research, and the Faculties of Natural Resources, Rural Sociology and Extension. Linked to the new CABMACC research programme. ■ <i>NEPAD Regional Fish Node (RFN)</i>, focusing on biodiversity research, monitoring, aquaculture practices and fisheries policy and extension. Aims to become a Centre of Excellence. Has regional network. Not very clear about CCD specific related research although basic research is relevant to CCD. 		<ul style="list-style-type: none"> ■ SARUA (Southern African Universities Association) ■ SADC Vulnerability Assessment Committee ■ SADC Early Warning Unit ■ SARCOF (Sothorn African Regional Climate Forecasting) ■ SADC REEP (Regional Environmental Education Programme) ■ EEASA (Environmental Education Association of Southern Africa) ■ FEWSNET (Famine Early Warning Systems)

University	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
Mzuzu University	<ul style="list-style-type: none"> Forestry Sciences 		<p>Centre of Excellence in Water and Sanitation which was established in 2009 within the Faculty of Environmental Sciences</p> <ul style="list-style-type: none"> Focus is on effectiveness of sanitation, water supply interventions, water quality and practical application of research findings through training and outreach. Not all research is CCD related, but the basic research has CCD adaption relevance. 	
Private Universities, including Catholic University of Malawi Adventist University of Malawi	<p><i>Social Sciences and CC research:</i></p> <ul style="list-style-type: none"> Department of Social Work and Department of Education 			
Other tertiary institutions such as the Malawi College of Fisheries	<ul style="list-style-type: none"> Fisheries monitoring research 			

Note: This analysis is based on best available evidence. With further information and evidence, it can be expanded, and also used for monitoring and updating of CCD expertise in Malawi. Relevant contact details for researchers associated with this table – as established with best available information at the time of the mapping study (2013) are included in the Malawi mapping study Country Report (see Volume 2).

The University of Malawi has a Green Campus Initiative that involves students in CCD related activities such as tree planting, waste management, community based forest management, and engagement with renewable energy technology promotion and use – solar, biogas etc. The College of Education at the University of Malawi also houses the Project Citizen Malawi (PCM) from which students participate in civic programmes focusing on some CCD related activities in Malawi schools.

Stakeholders and university professionals in Malawi showed a clear understanding that CCD was closely related to both adaptation and mitigation and sustainable development. The institutional analysis also showed that amongst the university community there were some examples of transdisciplinary research, but that these were always linked to donor funded projects such as the Lake Chilwa Basin Climate Change Adaptation Programme which is being directed from LEAD SEA. The CC-DARE programme was interesting as it involved a transdisciplinary, multi-stakeholder research programme that informed curriculum development of a new MSc programme, as well as community education and outreach activities, showing how this kind of research can seed curriculum innovation. This will no doubt be taken forward through the newly funded CABMACC project, which also seeks to strengthen capacity of LUANAR staff members and their curriculum innovations, research and outreach roles. The project context, however, creates a 'real life' context for CCD research and appears to enable a strong relationship between knowledge co-production and use to develop and flourish, the LCBCCAP at LEAD SEA being a good example of this process in action. However, as mentioned above, these programmes are vulnerable to donor funding pattern changes, and knowledge co-production on key programmes can cease to exist if funding dries up. A more sustainable national source of research funding would help to address this problem.

The institutional assessment has shown that there is an urgent need to expand capacity building in CCD related matters amongst the Malawian research community to strengthen critical mass and ensure sustainability of the research trajectories that already exist, and to expand these to other disciplines and to greater effect. While there are some good examples of CCD related curriculum development and research, there is still a need for basic disciplinary capacity development for CCD research, as well as for expanding more innovative and expansive forms of transdisciplinary research and teaching as these tend to be located within the ambit of a few that have developed expertise in this area over the past ten or more years.

Given the severity of the projected impacts of climate change on the natural resource productivity base of Malawi, and the associated risks of droughts and floods, and the levels of vulnerability, the institutional study highlights that it is extremely important for universities in Malawi to become more strongly engaged with issues of CCD knowledge co-production concerns *across faculties and in interdisciplinary formations within and between universities*, so that they are able to better support and inform policy and CCD practice. Key areas identified for Malawi include curriculum development and innovation, research institution capacity development, individual professional development and research competence development, knowledge sharing and research publishing, and community and policy outreach and stronger approaches to student involvement.

10 MAURITIUS

10.1 Mauritius needs analysis

10.1.1 Context the frames the needs

As a small island state, with the world's third largest coral reef, Mauritius has high levels of vulnerability to climate change but also unique assets to protect. The republic's marine biodiversity is under threat from sea level rise, coral bleaching and ecosystem damage. It is feared that 50 percent of the beaches in Mauritius could disappear by 2050, should current global emissions levels continue unabated. This, together with impacts on the water resources and agricultural systems, would have severe effects on the economy and on many people's livelihoods. Many Mauritians who participated in this mapping study showed a strong understanding of the need for CCD and of the gaps in the national response, which went beyond their disciplines or mandates to reveal a broad understanding of climate change that bodes well for a more interdisciplinary response.

Within this context, the needs analysis for Mauritius revealed that despite existing emerging expertise in the field, CCD knowledge and research will need to be enhanced significantly in both specific and cross-cutting ways to address the considerable observed and projected impacts. In this regard, findings of this study could be helpful in future policy development and implementation in Mauritius, building on the 2013 Mauritius National Climate Change Adaptation Policy Framework.

10.1.2 Broad adaptation and mitigation needs

A clear set of broad priority areas distilled from the workshops, the questionnaires and policy documents comprises Coastal Zone, Agriculture, Water Resources, Human Health, Tourism and Marine Resources. Sectors already impacted upon are: infrastructures that support community livelihoods, water resources, coastal areas, coral reefs, fisheries and other marine-based resources, agriculture, tourism, human health and biodiversity.

10.1.3 Specific knowledge and research gaps

Key prioritised **knowledge gaps** encompassed adaptation, mitigation and larger cross-cutting themes. Within Energy and Industry, key priority areas highlighted included: transport sector energy consumption, renewable energy, energy efficiency and building design. Education and planning priorities consisted of a need for increased public awareness on the concept of climate change; mainstreaming CC in curriculum at all levels from pre-primary to tertiary levels; capacity building of all stakeholders at all levels and community engagement. Participants felt that key marine and coastal management priorities included: marine biodiversity management (mining and fishing industries), exploring the effect of climate change on the marine ecosystem, examining the effect of climate change on coastal zone and finally the effect of climate change on fisheries. Prioritised research gaps raised concern about the need for exploring the impact of climate change on different sectors and improving communication strategies to share findings. Research into curriculum development and the

need for multidisciplinary and interdisciplinary research was highlighted. Mitigation research focusing on sustainable energy technology in transport and construction was a key focus, as was research into natural resource management, and monitoring sea level rise and its effect on development.

10.1.4 Cross-cutting needs

Data was found to be a critical cross-cutting issue: establishing benchmarks and baselines long-term studies to generate such data was constantly cited, as was the need to improve access to and sharing of knowledge, and expanding knowledge resourcing across sectors, specifically marine resource management, tourism and education. Standardisation and harmonisation of data between research institutions was also required – for example, in the context of the impacts of climate change on marine biodiversity. Underlying human capacity and resource constraints included a significant need for training to develop the necessary skilled personnel, including capacity development of HE staff. Further cross-cutting gaps were the need for increased public awareness and community engagement, and mainstreaming climate change into the curriculum at all levels.

10.1.5 Notable themes

In Mauritius, these included the commonly cited need to change mind-sets, including a sense of stewardship towards the environment, which would engender behavioural change; and the focus on energy, industry and transportation research areas, which was less commonly stressed to this degree in other countries.

10.1.6 Individual capacity gaps

Both the policy assessment and the workshop discussions highlighted a variety of key individual capacity gaps, that focused primarily on climate services, specifically identifying climate trends, forecasting, handling existing climate models (including GCMs), downscaling from regional scale to island scale, and scenario building; as well as expertise in communication, education and management being the most commonly cited capacity needs. There is a general shortage of qualified and experienced staff in the executing agencies with responsibility for policy formulation, management and enforcement in Mauritius. Overall participants felt that there were insufficient specialised skills in climate change research and CCD: key areas highlighted were in developing and using environmentally friendly technology such as renewable energy, transportation technologies, green building and a number of industrial areas; as well as advanced capacities in instrumentation use in Meteorology/ Energy/ Transport/ Water Resource Assessment. The mapping study further found the need to shift mindsets and behaviours of people at different levels, including for citizens to realise the severity of the situation, and for researchers to prioritise addressing identified challenges.

10.1.7 Institutional capacity gaps

A key institutional capacity gap across all data sources related to enabling climate change and CCD knowledge sharing and access to information, including developing a repository for

climate change data, research and knowledge. Generally, workshop participants called for a more active involvement of institutions in enabling climate change and CCD research in Mauritius, as well as local networking of climate change researchers and the development of institutional synergies within this field. They also highlighted the need for improving arrangements for transboundary marine environmental plans; developing institutional structures for improved feedback loops on environmental outcomes; and institutional prioritisation to develop a curriculum framework incorporating CCD.

10.2 Mauritius institutional assessment

This mapping study has identified existing initiatives amongst the HEIs in Mauritius and their partners where activities such as research, teaching, policy engagement and community outreach are addressing climate change-related needs. The study has shown that HEIs in Mauritius do have relatively good expertise and capacity for responding to climate change and moving towards CCD, as do other stakeholders. Active researchers identified in this mapping study are listed in Volume 2, and CCD areas of expertise in Mauritius, mainly with respect to universities, are summarised in Table 15 in the Mauritius Country Report in Volume 2.

The combination of an engaged growing policy movement and a broadening understanding of the particular needs for climate change and CCD in Mauritius creates a fertile environment for the development of knowledge co-production possibilities. Even with the growing engagement of government, participants felt this was not enough and a more attentive, motivated and well-resourced approach was required from government. In general, an integrated approach to knowledge, research, individual and institutional capacity development was called for in Mauritius. Alongside this improved **transfer of knowledge** and dissemination of research and more dedicated funding and **resourcing of CCD** in Mauritius were highlighted. In further developing knowledge co-production opportunities, two key priority areas were established. These included **curriculum development**/ awareness raising and improved involvement of government and policy makers in revising and **expanding policy and legislation** for CCD. A further need identified by the mapping study was for a coherent and strategic research plan / strategy on climate change and CCD, which would be consistent with the NCCAPF. From these and other interventions, appropriate research agendas and curriculum development can arise, further enabling the wider climate change and CCD related research community in Mauritius.

Table 10: Identified sources of expertise for CCD in Mauritius

University/organisation	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
University of Mauritius	<ul style="list-style-type: none"> ■ <i>Faculty of Science</i>: Chemistry Department – research on climate change modelling and CZM ■ <i>Oceanography and climate change</i> ■ <i>Faculty of Social Studies and Humanities</i>: small research group in the Department of Economics and Statistics on energy, economics, and climate change ■ <i>Faculty of Agriculture</i>: sustainable agriculture and soil and water management in the climate change context, insufficient information available 		No SADC accredited centres of excellence were identified in Mauritius	<ul style="list-style-type: none"> ■ Mauritius Ile Durable ■ Indian Ocean Commission ■ SADC Drought Monitoring Centre ■ Mauritius Wildlife Foundation ■ ESSA: Education for Strong Sustainability and Agency ■ WIOMSA : Western Indian Ocean Marine Science Association
Université des Mascareignes	<ul style="list-style-type: none"> ■ <i>Faculty of Sustainable Development and Engineering</i>: Research and training in the field of renewable sources of energy (wind resource assessment, photovoltaic, online daily traffic fluidity monitoring; Rain water harvesting and green roof, low impact development (LID), courses related to Environmental Engineering, Management and Economics 	<i>Mauritius Institute of Education</i> : includes a group focused on teacher education for ESD; curriculum review for CCD; consultancy on national and international programmes		<ul style="list-style-type: none"> ■ Environmental Protection and Conservation Organisation (EPCO) – community-based climate change preparedness in coastal communities

Note: This analysis is based on best available evidence, within the constraints of the mapping study. With further information and evidence, it can be expanded, and also used for monitoring and updating of CCD expertise in Mauritius.

Relevant contact details for researchers associated with this table – as established with best available information at the time of the mapping study (2013) are included in the Mauritius mapping study Country Report (see Volume 2).

11 MOZAMBIQUE

11.1 Mozambique needs analysis

11.1.1 Context that frames needs

A warming trend is already well established in Mozambique, although this is not uniform across the country, with mean annual temperatures having increased by 0.6°C between 1960 and 2006.¹⁴⁵ In the same period, the number of hot days per year has increased by 25 while that of cold days has decreased by 14; and the number of hot nights has increased while that of cold nights has decreased. The mean annual rainfall has decreased at an average of 2.5mm per month per decade between 1960 and 2006. Rainfall variability has increased in the southern and central regions since the 1990s, while the number of heavy rainfall events has increased between 1960 and 2006. There are indications of a later start to the rainy season, and an increase in dry spell length. The mean annual temperature is projected to increase by between 1.0 and 2.8°C by 2060, and by between 1.4 and 4.6°C by 2090, with higher rates of warming occurring in the interior compared to areas close to the coast. The INCG 2009 report points out that if global mitigation efforts are insufficient, temperatures could rise by between 2 and 2.5°C by 2050, and by between 5 and 6°C by 2080. Mozambique is particularly prone to an increase in natural disasters, and to the impacts of sea level rise on coastal communities.

Within this context, the mapping study needs analysis for Mozambique revealed that while some progress has been made in identifying research and capacity needs in broad terms, the status of CCD knowledge and research is inadequate for the responses that are required and for the significant development challenges that Mozambique faces as a result of its high vulnerability to climate change. A major priority that cuts across all of Mozambique's climate change policies and planning is to develop capacity for risk reduction and preparedness, within a broader framework of longer-term adaptation and climate resilience.

Consistent with the socio-economic context and Mozambique's post-conflict status, overarching barriers to adaptation indicated in all three data sources include poor quality information and knowledge of the nature of climate change risks and appropriate adaptation, mitigation and CCD responses; limited research engagement with these issues; low levels of technical capacity; and insufficient financial resources to address climate change adaptation and mitigation challenges. One important aspect identified is the need to engage the private sector in climate change mitigation, especially related to green / clean technology and investments in the national climate change adaptation and resilience building strategy, especially given the current expansion of investments in oil, natural gas and coal extraction possibilities. The workshop and questionnaire responses identified a range of cross-cutting needs for responding better to CCD, amongst which are capacity development and knowledge

¹⁴⁵ INGC. 2009. UNDP Climate Change Country Profile.

exchange (including dissemination of climate information to communities), revision of legislation to include CCD in all sectors, and integration of CCD knowledge into development programmes and projects and government priorities, and the need for increased opportunities for understanding and awareness building, and knowledge exchange programmes between universities, sectors, and communities. There was also a concern with community preparedness for adaptation to predicted changes and the knowledge needs of communities. The issue of providing climate related information in Portuguese was raised, as most climate information is being produced in English.

11.1.2 Broad adaptation and mitigation needs

There is general agreement amongst the data sources used to compile this mapping study report on the *broad priority focus areas for adaptation and climate resilience building* – namely, coastal protection, preparing cities and local governments, water resources management, agriculture and food security, including soil erosion management, biodiversity and forest management, human health, and human settlements. Core to all is the need for improved meteorological data and capacity. These reflect the climate vulnerabilities of Mozambique, especially for its majority rural populations. The data sources also agree on *broad mitigation priorities and needs*, which encompass measures related to improved energy management and use of renewable energy resources, rural electrification and forestry to reduce deforestation and establishment of clean energy production systems and sustainable transport systems. Mozambique, as noted above, has identified significant natural gas and coal resources, and workshop participants identified the need for assessment of technology needs, and clean technology development as a key mitigation need, a need that is also articulated in policy. Policy also suggests the need to seek ways of developing renewable energy technologies, and of developing use of natural gas technologies for national energy supply needs.

11.1.3 Specific knowledge and research gaps

Workshop participants felt that there were still significant policy and implementation gaps that were linked to inadequate knowledge and research. Analysis of all data sources showed that there were key knowledge and research gaps related to adaptation which include: agriculture and food security (including soil conservation, the need for more resilient cultivars, and improved land use management), coastal zone management and protection (including protection of mangroves and studies on ecosystem vulnerability and sea level rise implications); preparing cities; water resources management. These were the most regularly cited areas requiring specific research and knowledge development related to adaptation. Mitigation knowledge and research needs focused primarily on renewable energy and clean technology research, transport and forestry research and development. Private sector engagement in climate change mitigation research, especially engineering research into green and energy efficient technologies, was identified as being important in Mozambique. Underpinning these adaptation and mitigation research and knowledge needs are additionally critical research and knowledge gaps. These include: systematic observation, monitoring, modelling and risk and vulnerability assessments. This involves assessing vulnerability (especially local-level vulnerability mapping); providing more accurate and expansive

meteorological information and projections (observational data to underpin climate assessments and vulnerability on water resources, agriculture, biodiversity, sea level rise and infrastructure planning). Technology development was also repeatedly emphasised in workshop and questionnaire data. Accessing and drawing on community knowledge was identified as an important adaptation and CCD priority, given the high dependence on subsistence production in rural areas, and the high levels of poverty experienced in these areas.

11.1.4 Cross-cutting needs

Key cross-cutting needs emphasised in Mozambique amongst workshop participants is the need for improved co-ordination across sectors within government and implementation partners, improved awareness raising and capacity development, and production of climate knowledge in accessible languages and forms (Portuguese knowledge resources were emphasised a number of times as was concept clarification and understanding of climate change concepts and responses). Cross-cutting educational concerns involved the lack of curriculum contextualisation and curriculum development for climate change in schools and universities. Low levels of research capacity for CCD related issues also reflect a need for research capacity development.

11.1.5 Individual capacity needs

Individual capacity needs were identified in policy documents and in workshop discussions. A strong need was identified for professionals with the skills to participate in **systematic observation** of parameters of climate change, process climate change data for application and implementation, and to conduct vulnerability evaluations and assess adaptation options. Other key fields requiring capacity support include: Climate Change Modelling; Atmospheric Chemistry; Risk Assessment and Management; Marine Pollution; Environmental Auditing; Information and Communication Technology (ICT); Geographic Information Systems; Physics; Disaster Risk Planning and Urban Resilience, and Sustainable Development Planning. Technology development related scarce skills were identified in the following areas: Clean Technology and Engineering. From a social change perspective, the following scarce skills were identified: Sociology and Environmental Education, Extension and Communication specialists, Curriculum Innovation and Community based Communication competences. Consultations revealed an overall lack of technical and scientific capacity, due to insufficient specialised training.

11.1.6 Institutional capacity gaps

Specific institutional capacity gaps emerging from documentation and the workshops show an overall lack of institutional capacity on climate change issues, which is not surprising given the scope of climate vulnerabilities in Mozambique and post-conflict development context, and socio-economic realities. There is consensus across the data that there is a need to substantively strengthen capacity for information and research development for CCD. The lack of research funding and incentives will require attention to expand climate change research capacity in Mozambique. There was also a need identified for improved political and

institutional capacity for enabling technical cooperation between different sectors and for integrating climate change into the country's legislation and development plans. There are socio-cultural barriers and capacity gaps, especially related to communications and education. Financial barriers and capacity gaps as well as insufficient financial resourcing were also identified as a key institutional capacity gaps. Workshop participants felt that institutions need to improve their capacities for offering professional careers associated with climate change, which also includes providing professional internships for recent graduates.

Co-production of knowledge and its reliance on improved cross-sectorial institutional capacities can be seen as a significant area of concern for Mozambique. How knowledge is shared, and how research is responded to and used by decision makers, was of particular concern among workshop participants. More and more credible research facilities are also needed for the production of *systematic* knowledge of climate change and climate compatible development pathways.

11.2 Mozambique institutional assessment

There are numerous, complex knowledge, research, individual and institutional capacity needs expressed by stakeholders and university staff themselves. Mozambique's INGC (2003) highlighted four major institutions responsible for research concerned with climate change: the National Meteorological Institute, the National Institute for Agronomic Investigation, the University of Eduardo Mondlane, and the Universidade Pedagógica, and noted the absence of a framework to facilitate inter-institutional linkages. Under theme seven of INGC's second phase, a **Climate Change Centre of Knowledge** will be established that will build the country's knowledge base and information management capacity on climate change through research, education, awareness building and provision of advisory services. Information packages, from research findings, will be targeted at management, administrative and technical staff at both provincial and district levels. Multidisciplinary research projects will be employed to generate solutions to adaptation.

Of greatest significance is the obvious lack of institutional capacity for CCD research in the country in relation to the seriousness of the climate vulnerabilities. The institutional assessment has shown that climate change research is a very new area of research and development in Mozambique. There is, however, some research emerging in the UEM, Universidad Lurio, the Catholic University of Mozambique and the Pedagogical University. CCD related research is strongest in the UEM, especially in the Faculties of Agronomy and Forestry Engineering, Veterinary Sciences, Humanities and Arts (Geography) and the Education Faculty. However, the university still lacks a 'critical mass' of researchers in this area. The institutional analysis shows not many Mozambican university professionals appear to be engaging in CCD research, and fewer still are publishing this research in international arenas. Most local research is used to inform policy and government information needs, and the government, especially via the Agricultural Research Institute of Mozambique (IIAM) and the Mozambique Meteorological Research Institute (INGC) are leading CCD related research. As such, government – supported by various donor organisations – is playing an important role in initiating and also conducting CCD related knowledge, but this is not 'carrying through' into HEI research programmes or curriculum innovations with great strength as yet. The general

comment from the workshop was that very little was being done in terms of research for CCD and those projects that were being undertaken are not well funded, disseminated or shared, and the number of scientific reports and publications are very limited. There was also acknowledgement that CCD research requires an epistemological shift towards more community-engaged research.

The institutional assessment revealed that there were a few courses focusing on CCD in teaching programmes, mostly integrated into existing programmes at undergraduate level. There were however, some CCD related Masters degrees on offer at UEM in the Faculty of Agronomy and Forestry Engineering focusing mainly on disaster risk reduction and adaptation. This appears to be a research strength in Mozambique. The Education Faculty is also preparing a Masters degree in Climate Change and Education for Sustainable Development, but this is at the planning stage. The need for curriculum development capacity building was noted. A number of research programmes (mostly government or donor organisation based) were identified and some research networks that could facilitate CCD related knowledge co-production.

The Mozambican institutional assessment also revealed that there are *new institutions and programmes emerging* that can potentially provide strong platforms for CCD knowledge co-production in future. These are the soon to be established Climate Change Knowledge Centre (linked to the Ministry of Environment (MICOA) and INGC), and the already existing Mozambique Institute of Agricultural Research which works closely in partnership with the Faculty of Agronomy and Forest Engineering and Faculty of Veterinary Sciences in the area of agricultural CCD. However, these research institutions, along with smaller emerging nodes of research expertise (e.g. in the Geography Department at UEM) require capacity building, as indicated by research participants who commented on the lack of resources, capacity and research planning.

Table 11: Identified sources of expertise for CCD in Mozambique

University	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
University of Eduardo Mondlane (UEM) Pedagogical University of Mozambique (PU) Catholic University of Mozambique (CUM) Universidad Lurio (UL)	Catholic University of Mozambique: <ul style="list-style-type: none"> Is undertaking CCD research and curriculum development in at least three faculties (Marine Sciences, Agriculture, Economics and Management) University Eduardo Mondlane: <ul style="list-style-type: none"> Department of Physics Faculty of Humanities and Arts: Geography Department Technical University of Mozambique <ul style="list-style-type: none"> UDM 	<ul style="list-style-type: none"> Agronomy oriented disaster and risk reduction research expertise (at UEM's Faculties of Agronomy and Forest Engineering and Veterinary Sciences) and linked to CIGAR, IIAM and other regional and international agricultural research CCD partners. Environmental education / ESD research in UEM and in the Pedagogical University as well as in Universidad Lurio (UEM and PU are linked via the UNU and SADC REEP Regional Centre of Expertise in Education for Sustainable Development (also linked to MICOA and other stakeholders engaged in ESD) 	Potential exists for the soon to be established Climate Change Knowledge Centre to serve as a Centre of Excellence for CCD knowledge co-production	<ul style="list-style-type: none"> CGC: Centro de Gestão de Conhecimento GIMC: Grupo Interministerial de Mudanças Climáticas FDC: Fundo de Acção para o Desenvolvimento da Comunidade IIAM: Instituto de Investigação Agronómica de Moçambique INAM: Instituto Nacional de Meteorologia de Moçambique INDA: Instituto Nacional de Desenvolvimento da Aquacultura INGC: Instituto Nacional de Gestão de Calamidades ISPC: Instituto Superior Politécnico de Chókwe MICOA: Ministério para a Coordenação da Acção Ambiental RNMC: Rede Nacional de Mudanças Climáticas

Note: This analysis is based on best available evidence. With further information and evidence, it can be expanded, and also used for monitoring and updating of CCD expertise in Mozambique. Relevant contact details for researchers associated with this table – as established with best available information at the time of the mapping study (2013) are included in the Mozambique mapping study Country Report (see Volume 2).

No active student based centres with potential for enhancing knowledge and awareness of climate change and CCD were identified in Mozambique.

Stakeholders and university professionals in Mozambique showed a clear understanding that CCD was closely related to both adaptation and mitigation and sustainable development. The institutional analysis also showed that amongst the university community no examples of transdisciplinary research could be identified. However, at a broader level one example of transdisciplinary research was identified but these were being spearheaded by international organisations and national NGOs (UNDP and CARE) and were being documented by CDKN. A key finding of the institutional analysis was that there was a need for knowledge exchange platforms between universities and such programmes. Workshop participants recognised the potential role of regional organisations such as SASSCAL and SADC centres for providing capacity building support in Mozambique, and in some cases Mozambique researchers are drawing on these international research networks such as CGIAR and ACCRA.

The institutional assessment has shown that there is an urgent need for capacity building in CCD related matters amongst the Mozambican research community. There is a strong and clearly articulated need for support in this area, both from within policy which emphasises the need for research, and amongst stakeholders and practitioners and university professionals. There is a need for basic disciplinary capacity development for CCD research, as well as for more innovative and expansive forms of transdisciplinary research and teaching.

The institutional assessment has also highlighted that it is extremely important for universities in Mozambique to become more strongly engaged with issues of CCD knowledge co-production concerns, so that they can be located within key climate change dialogues, and so that they are able to better support and inform policy and CCD practice. Key areas identified for Mozambique include curriculum development and innovation, research institution capacity development, individual professional development and research competence development, knowledge sharing and epistemological change, research incentives, and community and policy outreach.

12 NAMIBIA

12.1 Namibia needs analysis

12.1.1 Context that frames needs

Namibia is one of the driest countries south of the Sahara, with a mean annual rainfall ranging from less than 25 mm in the southwest and west to just above 700 mm in the northeast of the country. The warming trend is already well established in Namibia, with maximum temperatures increasing over the past 40 years, as observed in the frequency of days exceeding 35°C, and a reduction in days below 5°C. There is a high degree of certainty that the country will become hotter throughout the year, with a projected increase in temperature of between 1°C and 3.5°C in summer and 1°C to 4°C in winter in the period 2046 – 2065. The projected temperature increases will result in increased evaporation and evapotranspiration of 5-15 percent, further reducing water resource availability and dam yields. Groundwater recharge may suffer a reduction of 30-70 percent across the country, with a potential exception in the recharge of alluvial aquifers originating in central areas. The dryland conditions, and the high dependence on traditional subsistence sector economic activities, as well as the resource-intensive nature of the primary economic sector activities, make Namibia vulnerable to climate change, and are key drivers of the need for CCD responses in Namibia.

Within this context, the mapping study needs analysis for Namibia revealed while much progress has been made in identifying research and capacity needs in broad terms, the status of CCD knowledge and research is inadequate for the responses that are required. The recent Climate Change Strategy and Action Plan (CCS&AP) for Namibia (GoN 2012) clearly defines thematic areas for adaptation, mitigation and cross-cutting issues. A major priority that cuts across all sectors is the need to generate information and knowledge for all adaptation and mitigation priorities that have been identified so far.

Consistent with the socio-economic context overarching barriers to adaptation and mitigation indicated in all three data sources used in this mapping study (document analysis, workshop and questionnaire data) is the recognition of insufficient information and knowledge of the nature of climate change risks and appropriate adaptation, mitigation and CCD responses; political and institutional barriers, and socio-cultural barriers. The workshop responses identified a range of cross-cutting needs for responding better to CCD, amongst which are the need for political leadership; education, training and public participation, and cultural change. There was recognition that Namibia had made good progress with CCD related policy development, but implementation and policy coherence across sectors remained a challenge. Other discussions pointed to the deep-seated paradoxes that are situated in the social change process that is needed for climate compatible development. It was said for example that *“there is a need to confront the paradoxes within trends of developed countries for consumerism and high levels of resource utilisation, and the aspirations of developing countries, which are now following this path”*.

12.1.2 Specific adaptation and mitigation priorities

Namibia's Second National Communication to the UNFCCC (GoN 2011) commits the country to focus predominantly on low carbon development and to secure appropriate long-term sustainable resources for adaptation to the effects of climate change. Associated with the vulnerabilities to CC and a policy commitment to climate resilient, low carbon development are clearly identified thematic areas for adaptation, mitigation and cross-cutting issues, which are identified for action in the Climate Change Strategy and Action Plan (CCS&AP) for Namibia (GoN 2012b). Climate change **adaptation** is addressed through four themes: 1) Food security and sustainable biological resource base; 2) Sustainable water resources base; 3) Human health and well-being (or Security); and 4) Infrastructure development. **Mitigation** is addressed through the following themes 1) Sustainable energy and low-carbon development; and 2) Transport. A number of **cross-cutting issues** or themes on adaptation and mitigation are also identified and are included in the strategy and action plan. These include: 1) Capacity building, training and institutional strengthening; 2) Research and information needs, including how to use climate change information; 3) Public awareness, participation and access to information; 4) Disaster reduction and risk management; 5) Financial, resource mobilisation and management; 6) International cooperation and networking; 7) Technology development and transfer; and 8) Legislative development.

12.1.3 Specific knowledge and research gaps

The Climate Change Strategy and Action Plan for Namibia (CCS&AP, GoN 2012) identifies specific knowledge and research needs under '*Cross-cutting Issues, Theme 2: Research and information needs, including how to use climate change information*'. These are: research on the collection and application of data in climate change models at national, regional and local levels, research on monitoring of ecosystem and biodiversity changes and their impacts, climate proofing research especially in relation to crops, livestock, forests and fisheries and water infrastructure. Research on sea level rise was also prioritised, as was research on the macro-economic and sectoral impacts of climate change. A special research theme focussing on the documentation of traditional / indigenous knowledge and coping practices was also identified. Additionally specific research and knowledge needs were identified for all adaptation and mitigation priorities, and for some of the cross-cutting needs. Research related to the following specific adaptation themes were identified: food security and sustainable resource base; water security; human health and well-being; and infrastructure adaptation. Additionally there are research and knowledge needs associated with mitigation priorities especially for sustainable energy and low carbon development. Workshop participants prioritised research in the following, related areas: marine biodiversity management, non-timber forest products and their commercialisation, sea level rise, which included a focus on coastal erosion, and increased storm activity at sea and its potential consequences for off-shore mining.

12.1.4 Cross-cutting needs

Key cross-cutting needs are the need for improved co-ordination across sectors within government and implementation partners, improved awareness raising and capacity

development, and political leadership and cultural change. Workshop discussions focussed a lot on cultural norms and how to bring about cultural, social and behavioural change raising this as an important research need. Cross-cutting educational concerns involved the inadequacy of climate change education programmes in universities, and the lack of interdisciplinary co-operation on CCD issues. Similarly there was concern about the lack of adequate postgraduate programmes that focus on CCD issues, and the lack of adequate professional development of existing university lecturers and educators to engage with CCD concerns. The issue of community education, and training of political leaders was also mentioned numerous times.

12.1.5 Individual capacity needs

Individual capacity needs were identified for improved spatial planning, including town and regional planning and engineering, capacity building for academics and professionals to apply and interpret climate models, application of economic principles to CCD policy interventions, capacity development for preparation and appraisal of CDM projects, capacity building for local commercial banks, and further theoretical and practical training on renewable energy technologies (RETs) technicians, government officials and NGOs. Other individual capacity recommendations were for training of rural communities, research scientists, women's groups, coastal communities and coastal zone managers, natural resource managers and foresters and forest management experts. Individual capacity building was also needed at different levels for water resources management i.e. at household, community, and watershed management levels. Local government officials, financial managers, health care workers, and infrastructure sector experts also needed to be trained in CCD related approaches, as were agricultural extension workers. It was also said that there was a need to strengthen and develop more engineers with CCD expertise, meteorologists and foresters. To strengthen CCD awareness it was noted that there was need for training of journalists, NGOs and civil society organisations to expand CCD activities at community level. A need was also identified to strengthen the individual capacity of curriculum developers to integrate CCD priorities into curricula at all levels of the education and training system. Engaging the youth in CCD was also identified as a key area for individual capacity development.

12.1.6 Institutional capacity gaps

This includes the need for capacity building of boundary organisations to facilitate climate change feedback loops between science institutions, policy makers, and land users, noting that this requires capacity to access, interpret, translate and communicate climate change science and concomitant local level indicators. It was also noted that climate change research needed to be properly coordinated and the benefits optimised to meet the needs of policy makers and communities in Namibia. A number of institutional capacity gaps related to specific CCD adaptation and mitigation priorities were identified, including but not limited to: more enabling scientific environments, more effective extension services; improved planning, governance and decentralisation of decision making, improved transport planning and access to social grants, as well as incentives for investments in CCD related technologies and practices. A need was also expressed for organisational restructuring and reform to strengthen key government and other agencies that deal with CC, and to establish institutional capabilities

for co-ordinating the generation, processing and storage of CC information, and that could also facilitate access to the information and its successful dissemination. This shows a key gap in CC related knowledge management, which was also raised as an issue amongst workshop participants who noted that while data exists, it is difficult to access it, and data is not being shared across institutions to strengthen knowledge production on CCD. A further institutional capacity gap identified was for financing mechanisms development for CCD and social change. Workshop participants in particular identified the lack of adequate research infrastructure and funding as a major institutional capacity gap, as well as problems associated with educational quality. The efficacy of political structures was also discussed.

Co-production of knowledge and its reliance on improved cross-sectorial and interdisciplinary institutional capacities can be seen as a significant area of concern for Namibia. The mapping study identified that there are already some steps in place to begin to address these research and capacity needs. The National Climate Risk Management (CRM) Capacity Development Plan (CDP) for Namibia comprises a detailed five-year strategy and a longer-term vision for addressing climate change adaptation needs in Namibia, based on consultations with public and private sectors. Key findings are that CRM capacity must be developed cross-sectorially, and that much wider enabling competencies and support are needed, over and above specific knowledge, to engender CRM action. How data and knowledge is shared, and how research is responded to by decision makers, and how such research benefits communities was of particular concern among workshop participants. Namibian workshop participants were clear that CCD could not emerge without giving attention to social and cultural change, and that educational quality and ethical political leadership were important dimensions of this process.

12.2 Namibia institutional assessment

There are numerous, complex knowledge, research, individual and institutional capacity needs expressed by stakeholders and university staff themselves. Activities and partner organisations are identified to assist in the implementation of the Climate Change Strategy and Action Plan for Namibia (GoN 2012), which has been developed as a tool to implement the National Climate Change Policy (NCCP). UNAM and the Polytechnic of Namibia are seen as important research, policy implementation and capacity building partners in Namibian climate change policy and strategy implementation and members of the **Multidisciplinary Research Centre** at UNAM, for example, have representation on the National Climate Change Committee.

Namibia's main framework for research and development appears to be the Research, Science and Technology (RS&T) Act (2004), which provides for the establishment of a National Commission on Research, Science and Technology and an associated research fund. Research regulations emerging from the RS&T have recently been published, but appear to be contested and are said to be restrictive. The main university institution that is connected to the provisions of the Act is the Multidisciplinary Research Centre (MRC) of the University of Namibia. It was established to conduct basic and applied research in national priority areas; conduct human and institutional capacity building in national priority areas; and coordinate the implementation and management of research and development activities, product development, innovation, value addition and patenting. The overall vision of the national research policy (which includes the contribution of the MRC) is to transform Namibia into a

Knowledge Based Society. The Climate Change Strategy and Action Plan for Namibia (CCS&AP) describes the possible development of a national research centre / network to co-ordinate climate change research. It was not clear whether the MRC would fill this role, or if another centre is envisaged.

Of greatest significance is the obvious lack of adequate institutional capacity for CCD research in the country in relation to the seriousness of the climate vulnerabilities. The institutional assessment has shown that climate change research is a relatively new area of research and development in Namibia, and most academics engaged in this research area had only been doing so for approximately three to five years. Various sources of funding and partnership support exist for CCD research in Namibia, including government funding and donor funding. Government funded research feeds directly into policy, and tends to involve both, university and government partners, as well as research consultants and international research organisations such as the IIE. Donor funding appears to fund pilot studies in key intervention areas which needs further funding to be scaled up. Research tends to be strongly government driven.

There is some research emerging in UNAM and at the Polytechnic of Namibia. CCD related research is strongest in UNAM, especially in the Faculties of Agriculture and Natural Resources, Science (Department of Biological Science), Department of Geology, and there is some social science related CCD research into Gender and CCD taking place in the Faculty of Humanities. At the Polytechnic, the School of Natural Resources and Tourism's Integrated Land Management Institute undertakes CCD related research. A key institution that is seeking to develop 'critical mass' around CCD research is the Multidisciplinary Research Centre (which, while established a few years ago, has a newly established climate change and vulnerability assessment research programme). It has three sub-divisions that are engaged in some way with CCD related research: 1) The Life Sciences Division – engaged with a research project on Climate Variability and Climate Change Adaptation and Disaster Risk Reduction which has three sub-programmes on DDR and vulnerability assessments; impact assessment on existing Community Based Adaptation (CBA) programmes; and IK integration into CC activities; 2) The Science, Technology and Innovations Division which has a research theme on renewable energy technologies, and 3) The Social Sciences Division – which has a research programme on flooding and the impact of flooding on the livelihoods of communities. These are all, however, said to be in need of expansion and additional capacity.

There are also other active interdisciplinary research programmes in the Faculty of Agriculture and Natural Resources where research focusing on crop varieties resistant to drought was found; and in the Faculty of Science, where research on carbon dynamics in soils and vegetation is taking place; and where an interdisciplinary research programme is underway focusing on soil, honey and bees in CC adaptation. In the Faculty of Humanities interdisciplinary co-operation is taking place between the departments of Geography and Sociology to research climate change perceptions, and gender and climate change issues. Other research activities identified were single discipline studies with no evidence of interdisciplinary interaction. CCD research is taking place in both the natural and the social sciences, but interdisciplinary co-operation, while taking place is still emerging as a new area of

practice. Most of the interdisciplinary work taking place was within the same Faculty, rather than across faculties, as is also shown by the sub-divisions of the MRC.

The institutional assessment revealed that there is some existing work taking place with regard to CCD curriculum innovation at UNAM. Questionnaire responses indicate that *there are few specialist courses in climate change and CCD at UNAM*, but that CCD issues are being integrated into existing courses, and that there is cross-faculty teaching on climate change and CCD taking place (the MRC appears to have had a big influence on the possibilities for cross-faculty teaching). According to the respondents (who are also seen to be some of the most active climate change- and CCD-related researchers and lecturers in UNAM), *there is almost no inter- and transdisciplinary curriculum work taking place, and only one faculty member reports making use of a strong service learning approach*. Courses that develop critical thinking and integrated problem solving skills are generally seen to be present, while there appears to be a mixed response to whether courses include a focus on development of social and/or technical innovation and ethical actions. Climate change work is seen to be partially integrated into examination and assessment work. Staff willingness and staff ability to get involved in CCD related teaching and learning issues is seen to be relatively high. There is interest in establishing a multidisciplinary Masters degree in CCD, but this is yet to be planned and it was said that *“however, given the severity of the matter it will be a good idea to introduce it”*. There was also a suggestion that UNAM should collaborate with, for example, the University of Cape Town in South Africa to see how they established a Masters degree in Climate Change and Development.

The Namibian institutional assessment also revealed that while CCD research activities and institutions (e.g. the MRC) exist, and curriculum integration is emerging, all these are new and require capacity building, as indicated by research participants who commented on the lack of resources, capacity and research co-ordination. Staff involved in the MRC identified the need for a strong capacity building initiative to support the work of the MRC as it was said that *“we would like to create an institutional set-up for enhanced knowledge management – all we have is a vision, but no database or other system”*.

Table 12: Identified sources of expertise for CCD in Namibia

University	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
University of Namibia (UNAM) Polytechnic of Namibia	<p>Nodes of expertise identified at UNAM include:</p> <ul style="list-style-type: none"> ■ <i>Faculty of Sciences</i>: Biological Sciences, Geology and NRM interdisciplinary research ■ <i>Faculty of Agriculture and Natural Resources</i>: Agricultural crop diversification research (rice varieties) ■ <i>Faculty of Humanities</i>: Research on Gender, community perceptions and CC ■ Polytechnic of Namibia, School of Natural Resources and Tourism, Department of Land Management has an <i>Integrated Land Management Institute</i> that conducts research on sustainable land use management, and is now including CCD related issues (soil, NTFPs etc.) into its research portfolio 	<p>Potentially and emergent:</p> <ul style="list-style-type: none"> ■ <i>Multidisciplinary Research Centre</i>, especially its Life Sciences Division which is undertaking risk and vulnerability research, and research linked to CBNRM and an intention to conduct substantive IK research <p>The other divisions of the MRC appear to not be highly active in CCD research yet.</p> <p>As noted above, the MRC is a new institution, and requires capacity development and support.</p> <p>Namibia has also recently established a UNU linked Centre of Expertise in Education for Sustainable Development, with links to UNAM's Faculty of Education.</p>	<p>A SADC Centre of Excellence in CCD research is located in Gobabeb, Namibia. It is a joint initiative of the MET and the DRFN, a research-led NGO). The Gobabeb Centre conducts research in a wide range of fields that have relevance to CCD including: archaeology and anthropology, biodiversity and climate change and ecology in its broadest sense. It tests, demonstrates and promotes appropriate technologies. Currently the Gobabeb CoE is developing a Hybrid Energy System. It works with a range of national and international partners.</p>	<ul style="list-style-type: none"> ■ Namibian Association of CBNRM Support Organisations (NASCO) ■ Namibian Environmental Observation Network (NaEON) ■ Benguela Current Commission ■ Namibian EE Network ■ Regional Agricultural Environmental Initiatives Network – Africa (RAEIN-AFRICA) ■ Africa Monitoring of the Environment for Sustainable Development (AMESD) ■ Consultancy services such as: Integrated Environmental Consultants Namibia; Consulting Services Africa (CSA), LaquaR Consultancy, Lithon Project Consultants. ■ Southern Africa Development Community Regional Environmental Education Programme (SADC REEP) ■ SADC Remote Sensing Centre ■ SADC Drought Monitoring Centre ■ SASSCAL Southern African Science Service Centre for Climate Change and Adaptive Land Management

Note: This analysis is based on best available evidence. With further information and evidence, it can be expanded, and also used for monitoring and updating of CCD expertise in Namibia. Relevant contact details for researchers associated with this table – as established with best available information at the time of the mapping study (2013) are included in the Namibia mapping study Country Report (see Volume 2).

The School of Nursing and Health Sciences, Department of Biology in the Faculty of Science, the Department of Geography in the Faculty of Humanities, and the Department of Fisheries and Aquatic Sciences in the Faculty of Agriculture and Natural Resources at UNAM cited higher levels of student involvement in CCD related matters, than other departments who responded to the questionnaire. The following student organisation was cited as having potential for engaging more with CCD issues:

UNAM Natural Resources and Environmental Science Society which involves students from the Department of Geography, Department of Biology and the Department of Fisheries and Aquatic Sciences.

Stakeholders and university professionals in Mozambique showed a clear understanding that CCD was closely related to both adaptation and mitigation and sustainable development. The institutional analysis identified some examples of interdisciplinary research, and only one example of what can be categorised as transdisciplinary research. The importance of building research leadership in CCD areas was also noted as it was said:

“When you deal with cross-cutting issues, there is often lack of a champion who has the time and willingness to push the transdisciplinary / interdisciplinary agenda forward. Trying to do so at a local level is also not influential enough.”

Member of the Multi-Disciplinary Research Centre, Namibia

Workshop participants recognised the need for better co-ordination amongst themselves within universities, and between universities and stakeholders, as well as between UNAM and the Polytechnic, which, it was said requires university leadership engagement and support. There was also recognition of the importance of working more regionally, and internationally. Questionnaire data showed, however, that it was the more senior and experienced researchers (with PhDs) that tended to be engaged in international and regional collaborative research. The potential role of regional organisations such as SASSCAL and SADC centres for providing capacity building support in Namibia is appreciated, and Namibia hosts a SADC Centre of Excellence at Gobabeb (see Table 12). In some cases Namibian researchers are drawing on and contributing to these and other international research networks such as RAEIN-Africa and the Benguela Current Commission’s research programmes. There was a general sense that international collaboration was ‘quite challenging’ to establish.

The institutional assessment has shown that there is a strong and clearly articulated need for support for research capacity building in Namibia on CCD related research areas, and especially for stronger multi-, inter- and transdisciplinary approaches to research. There is a need for basic disciplinary capacity development for CCD research, as well as for more innovative and expansive forms of transdisciplinary research and teaching.

The institutional assessment has also highlighted that it is extremely important for universities in Namibia to become more strongly engaged with issues of CCD knowledge co-production concerns, so that they can be located more strongly within key climate change dialogues, and so that they are able to better support and inform policy and CCD practice, and provide their students with contemporary perspectives that enhance educational quality and relevance in their teaching. Key areas identified for Namibia include curriculum development and

innovation (potentially also for a Masters degree programme), research institution capacity development especially for multidisciplinary research co-operation and knowledge management, individual professional development and research competence development, knowledge sharing, and community and policy outreach.

13 SEYCHELLES

13.1 Seychelles needs analysis

13.1.1 Context that frames needs

Climate change threatens the economy and survival of the Seychelles. This was a clear message from all data sources of the mapping study. Like all Small Island Developing States (SIDS), Seychelles is particularly vulnerable to climate change, and will be affected by global sea level rise and associated increased storm surges and coastal inundation, leading to increased coastal erosion that will affect coastal agriculture. The projected climate impacts on coral reefs and fisheries, through warming of the ocean and ocean acidification are threats that would undermine food security and livelihoods in Seychelles.

Within this context, the mapping study needs analysis for Seychelles revealed that despite progress on identifying research and capacity needs in broad terms, the status of CCD knowledge and research will need to be enhanced significantly in both specific and cross-cutting ways to address the considerable observed and projected impacts. In this regard, findings of the Needs Analysis could be helpful in future policy development in Seychelles, to build on the existing National Climate Change Strategy and the Sustainable Development Strategy (2009).

Overall the workshops and questionnaires revealed the critical need for improved education, public awareness, participation and access to information. Currently it was felt that top-down decision making may not result in appropriate and climate resilient infrastructure. Research and governance systems in Seychelles require improved knowledge co-production, and collaborative responses that are embedded in stronger networks regionally and internationally, including across the SADC countries.

13.1.2 Broad adaptation and mitigation needs

There is broad agreement amongst the three data sources (policy, workshop, questionnaires) on the *broad priority focus areas for responding to climate change*, namely, Fisheries, Agriculture, Water, the Coastal Zone Sector, and Health. Within these broad priorities, the impacts of sea level rise and of rising sea surface temperatures were frequently cited as priority impacts to understand and respond to. Disaster risk management was identified as a key cross-cutting priority. A number of participants in the mapping study noted that one of the highest priorities is to really tackle energy efficiency and renewable energy such as solar, which would have developmental benefits and would reduce Seychelles' GHG emissions from fossil fuel.

13.1.3 Specific knowledge and research gaps

When comparing the workshop, questionnaire and policy data, the knowledge and research priorities that would further enable the institutional and human development needs of Seychelles covered a variety of key areas. One clear priority was for enhanced knowledge and

research on climate modelling, scenario building and methodological development for adaptation. Within the linked areas of food security and coastal/marine management, fisheries require further knowledge and research into the links between temperature rise, coral damage, acidification, and how this affects Seychelles' "blue economy"¹⁴⁶, which also includes tourism. Due to Seychelles' interconnected vulnerability in these areas, it is important for future responses to coastal and marine development to take a transdisciplinary approach, as the interplay between sea-level rise, ocean warming, tropical storms and coastal development will have a myriad of potential interconnected factors affecting CCD in Seychelles. With regard to energy and water security, specific research and knowledge priorities lie in improved assessment of energy and water use and how physical planning and development can accommodate this, specifically with waste water management systems, improved renewable energy use and enhanced water storage and water resources management, which would impact positively on human health. Knowledge and research gaps relating to the effect of climate change of human health in Seychelles include research on the impact and management of climate related diseases, public awareness, mapping and enhanced management of current sewerage networks, disease surveillance and the development of emergency response systems. Coastal zone management and disaster risk management require a variety of specific knowledge production activities, including baseline mapping in order to respond more effectively to extreme events and climate-proof existing infrastructure. Mitigation responses in Seychelles were seen to need improved research and technological innovation in energy, transportation, agriculture, and waste management sectors.

13.1.4 Cross-cutting needs

These were well articulated in Seychelles, and key ones are the need for baseline data, access to information and knowledge transfer, and knowledge management in general; access to and adequacy of methodologies to assess climate impacts and develop localised adaptation strategies; addressing fragmentation of efforts and research, which is not long-term, and the lack of value placed on researchers; policy/research/practice linkages – linked to a discussion on the need for more evidence-based policy making, backed up by long-term scientific studies e.g. on impacts on specific ecosystems / sectors; monitoring and evaluation of the environment and of policy, pointing also to the need to develop and monitor appropriate indicators; and finally the need for innovative and creative approaches.

13.1.5 Notable themes

Emerging from the Seychelles workshop and questionnaire data were the importance of developing and using creativity and innovation in the response to climate change – CCD needs to be made more exciting, in order to build a widespread and concerted response; and the

¹⁴⁶ The 'blue economy' means a further development of the green economy. See http://en.wikipedia.org/wiki/The_Blue_Economy:_Design_Theory

potential role of the private sector, both as a knowledge co-production partner, but also with respect to economic opportunities that climate change confers, such as technology development for renewable energy. Seychelles participants repeatedly highlighted the need to mainstream climate change into EIA and social impact assessment (SIA), and the need for enhanced use of these planning tools when assessing plans, technologies and development proposals, to ensure climate resilience.

13.1.6 Individual capacity gaps

The individual capacity needs to meet these priorities require a focus on expanding capacities for curriculum development and the training and professional development of a variety of Seychelles stakeholders and researchers, with specific reference to policy makers, teachers, government officials, farmers, extension officers, meteorologists, water resource managers, financial executives, oceanographers, hydrologists and engineers. Lack of capacities to promote and apply energy efficiency, renewable energy resources, and efficient use of water resources were also identified.

13.1.7 Institutional capacity gaps

It was agreed that improved institutional capacity is needed to respond to specific research and development needs in improving policy, funding, monitoring, knowledge networks, data management, knowledge transfer, modelling/early warning systems, curriculum and renewable energy development. The workshops identified the *inadequate integration of climate change across the board*, including the gender-differentiated and HIV/AIDS aspects, into *policies, plans and strategies at all levels*, including *economic development planning*. A further requirement is for an auditing/monitoring system to both track donor funding going into climate change and CCD-related projects and research, and to track the effectiveness of the response.

13.2 Seychelles institutional assessment

A fundamental issue from an institutional perspective for Seychelles in responding better to climate change is the limited supply of human resources in a small country of dispersed islands, with a total population of 90 000 people. As participants at the workshop noted, it is challenging enough to simply get the identified knowledgeable people together, as everyone is covering broader areas of work than they would in a larger country. The skills shortage is exacerbated by inadequate transfer of technology and knowledge when international consultants are employed to work in Seychelles. Nevertheless, Seychelles has shown great leadership in mainstreaming environmental sustainability into policies, programmes and activities, and in international negotiations on climate change. Seychelles policy and stakeholders recognise that CCD is part of sustainable development, and that the approach is highly relevant for Seychelles. The limited presentation and publishing of research on climate change and CCD was cited as an area in which significant improvement was needed, in both the workshops and the questionnaires. The mapping study has further shown the need for improved, long-term baseline data to inform policy and decision making, and for a range of knowledge management issues to be addressed, including data management and transfer.

The knowledge management issues identified in this mapping study relate to one of the key functions of the National Climate Change Committee, which is to maintain national and relevant international climate change information (inventory) at the National Climate Change Information Centre, located at the Meteorological Services. This inventory/database is in place, in a preliminary form, but will need to be further developed to underpin enhanced knowledge co-production on CCD. Another critical institutional constraint identified in the workshop was for a strategic and prioritised national research framework on climate change /CCD, which relates as well to another function of the NCCC, which is to provide overall co-ordination of the development and implementation of the National Climate Programme and Climate Change Research.

This mapping study has identified existing initiatives amongst Seychelles stakeholders, including the HE sector, where activities such as research, teaching, policy engagement and community outreach are addressing climate change-related needs. The institutional assessment has shown that while UniSey currently has limited capacity for responding to climate change and moving towards CCD, given the youthfulness of the institution, it has made a good start in mainstreaming climate change into two undergraduate courses in the Faculty of Science, as well as into the BEd degree. There is furthermore CCD expertise in other stakeholder groups, as summarised in Table 12 in the mapping study Country Report for Seychelles in Volume 2. However, these areas of capability for work on CCD will need to be supported through concerted efforts to build the capacity of researchers, develop additional strategic partnerships for collaboration, and formulate a national strategic research framework, with an implementation plan, for enhancing CCD research in Seychelles.

Table 13: Identified sources of expertise for CCD in Seychelles

University	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
Seychelles University of Seychelles (UniSey)	<p><i>Faculty of Science:</i></p> <ul style="list-style-type: none"> Department of Environmental Science, University of Seychelles (currently this is a potential node of expertise, research is largely in the form of student dissertations) 	None identified	None identified	<ul style="list-style-type: none"> Sustainability for Seychelles: NGO focusing on environmental education and climate change adaptation and mitigation; strong community outreach ENGOS (environmental non-government organisations): work in connection with the Ministry of Environment and Energy, pooling data on research and innovation practices
	<p><i>Ministry of Environment and Energy:</i></p> <ul style="list-style-type: none"> Individual researcher (Prof. Rolph Payet) working on islands, biodiversity and climate change; Environmental education unit 			<ul style="list-style-type: none"> Mangroves for the Future: NGO, climate change and climate smart development integrated into all projects; strong community-based focus Seychelles Eco-Schools Programme (actively co-ordinated by the Ministry of Environment)

Note: This analysis is based on best available evidence, within the constraints of the mapping study. With further information and evidence, it can be expanded, and also used for monitoring and updating of CCD expertise in Seychelles. Relevant contact details for researchers associated with this table – as established with best available information at the time of the mapping study (2013) are included in the Seychelles mapping study Country Report (see Volume 2).

14 SOUTH AFRICA

14.1 South Africa needs analysis

14.1.1 Context that drives needs

South Africa already has a well-established warming trend. Even under emission scenarios that are more conservative than current international emission trends, it has been predicted that by mid-century the South African coast will warm by 1 to 2°C and the interior by around 2 to 3°C. By 2100 warming is projected to reach around 3 to 4°C along the coast, and 6 to 7°C in the interior (RSA 2011a¹⁴⁷). This will significantly affect human health, biodiversity and ecosystem services, agriculture, other water-intensive economic sectors, such as the mining and electricity generation sectors as well as the environment in general. Increased occurrence and severity of veld and forest fires, extreme weather events, floods and droughts and sea-level rise will also have significant impacts (RSA 2011a).

It is against this context that a set of clearly defined adaptation, mitigation and cross-cutting strategies are put forward at policy level that also commit the country to making the transition to a climate-resilient and low-carbon economy and society. This is to be achieved through balancing mitigation and adaptation responses and, in the long term, redefining competitive advantage and facilitating structural transformation of the economy by shifting from an energy-intensive to a climate-friendly path, as part of a pro-growth, pro-development, and pro-jobs strategy (RSA 2011b¹⁴⁸). Across all the policy and strategy documents, workshop inputs and questionnaire data used to inform this mapping study, there is a very clear recognition that this will have to be done **by building the knowledge base and capacity** to upscale mitigation efforts, while also adapting to the inevitable impacts of climate change in key affected sectors, and by enhancing early warning and disaster reduction systems.

14.1.2 Adaptation and mitigation priorities identified for South Africa

The National Climate Change Response White Paper (RSA 2011b) identifies a set of clearly defined adaptation measures for the following areas: water security; agriculture and commercial forestry; health; biodiversity and ecosystems adaptation; human settlements (urban, rural and coastal); disaster risk reduction and management. There are also mitigation targets identified which include: setting a performance benchmark for GHG emissions, identifying desirable sectoral mitigation contributions, defining carbon budgets for significant GHG emitting sectors and/or sub-sectors, developing and implementing a wide mix of mitigation approaches, policies, measures and actions that optimise mitigation outcomes as well as job creation and other sustainable development benefits, using market instruments and monitoring and evaluation. These are important priorities, as South Africa is one of the

¹⁴⁷ RSA. 2011a. *National Climate Change Response White Paper*. Pretoria: Government Printers.

¹⁴⁸ RSA. 2011b. *Second National Communication to the UNFCCC*. Pretoria: Department of Environmental Affairs.

highest emitters of GHG per capita in the world. Broader objectives for systemic change, including policy and regulatory alignment, co-ordinated sectoral response, integrated planning, facilitated behaviour change (using incentives and disincentives) and resource mobilisation are also set out in the same policy. Two priorities that are particularly important for this mapping study are the intention to prioritise research, systemic observation, knowledge generation, information management and early warning systems that increase national abilities to measure and predict climate change and the implications of its adverse effects on the economy, society and environment. Additionally education, training and public awareness are prioritised and recommended actions are to integrate climate resilient development principles into national curricula and into higher education curricula and teaching programmes, to strengthen research capacity in universities, and to undertake labour market research to inform the emergence of a green Technical and Vocational Education and Training (TVET) system.

14.1.3 National research themes and knowledge needs

South Africa has a Ten-Year Innovation Plan that defines five National Grand Challenges for research, including Global Change and Energy. The **Global Change Grand Challenge** has a well-defined National Research Plan that was produced by a broad community of Global Change researchers. The research plan identifies research needs and research questions that cover both the earth system sciences, the ecological sciences, and the social sciences, using a framework of four 'knowledge challenges' which include: *Understanding a Changing Planet* (with five research themes: observation and monitoring, dynamics of the oceans around southern Africa, dynamics of the complex internal earth systems, linking the land, air and sea, improving model predictions at different scales); *Reducing the Human Footprint* (with four research themes: waste minimisation methods and technologies, conserving biodiversity and ecosystem services, institutional integration to manage ecosystems and ecosystem services, doing more with less); *Adapting the way we live* (with four research themes: preparing for rapid change and extreme events, planning for sustainable urban development in a South African context, water security for South Africa, food and fibre security for South Africa); and *Innovation for Sustainability* (with five research themes: dynamics of transition at different scales, resilience and capability, options for greening the developmental state, technological innovation for sustainable social-ecological systems, and social learning for sustainability, adaptation, innovation and resilience). The **Energy Grand Challenge** National Research Plan has identified four major thrusts which are also relevant to CCD, namely: *Clean coal technologies* for environmentally friendlier processes; nuclear energy generation; *renewable energy technologies* with focus on commercialisation and coherent policy interventions; and *hydrogen* with the goal to place South Africa (which holds 87 percent of the known platinum reserves) in the emerging fuel cell market. The Second National Communication to the UNFCCC, and the National Climate Change Response White Paper, and the Long Term Mitigation and Adaption Scenario's also identify research needs. These provide important nuance, and refinement on the broader research themes identified in the Grand Challenge National Research Plans, showing reflexivity amongst research communities, which is made possible by the existence of coherent national research plans.

Workshop participants identified social-ecological systems, social learning and social innovation, integrative and systemic approaches, human settlements, climate change and health, and agriculture and water as key research priorities, with the Department of Environmental Affairs emphasising the need for coherent direction setting, shared common goals for adaptation and mitigation and a national system of monitoring and evaluation as priorities. Questionnaire data shows more detailed engagement and contextualisation of these broader research themes, for example priorities on adaptation and livelihoods in rural areas, how heritage shapes social learning engagements with new sustainable practices, renewable energy technology development, life cycle assessments of various construction materials, passive ventilation and lighting methods for health care facilities, sustainable landscaping on national highway roads, landscape level adaptation practices, water security in catchment contexts, transitions to green economies and so on. This more refined engagement with national research themes is evident in this citation from a questionnaire:

“There is relatively little knowledge in Sub-Saharan Africa regarding the impacts of CC on human health, particularly the multiplier effect of CC on large scale current public health challenges such as malnutrition; waterborne diseases; HIV and malaria.”

Workshop and questionnaire respondents also raised other dynamics of the CCD research agenda oriented towards a broader social change agenda, not quite as visible in policy and research plans such as *“Changing social values and aspirations, shift from 19th century political ideologies to a political ideology that is relevant to the challenges of the 21st century”*, and *“Restructuring of law and economics and social change with a specific emphasis on poverty alleviation and protection of vulnerable people to increase human and environmental security and resilience”*. Workshop participants particularly raised the need for critical research, and also for systems approaches, especially focussing on social-ecological systems and resilience at multiple levels and scales.

14.1.4 Individual capacity gaps

As can be seen above, the South African climate change vulnerability context and policy response objectives create a challenging environment for capacity development. South Africa’s education system continues to suffer from poor quality basic education which affects higher education provisioning in numerous ways. There are high levels of dropout in the schooling system, and South Africa continues to come last in international benchmarking tests in literacy, mathematics and sciences. The educational quality problems are both fuelled by, and exacerbated by high levels of social inequality, which continue to persist, despite social policies that seek to transform contexts of poverty (the Gini coefficient is still between 0.66 and 0.69, one of the highest in the world). A spate of recent human capital development strategies and plans in and for the environment and sustainable development sector point to high levels of

skills¹⁴⁹ shortages in key occupations relevant to CCD. Attempts to quantify skills shortages are ongoing, and in 2010 the Department of Environmental Affairs noted shortages of over 600 environmental science professionals, and over 800 environmental technicians in the public sector alone. These include oceanographic sciences, ecologists, hydrologists, managers, environmental technicians and so on. The Department of Environmental Affairs National Environmental Sector Skills Plan for South Africa concludes that the skills development system in South Africa has been 'reactive' rather than proactively engaged with the provisioning of environment and sustainable development skills.

The Department of Science and Technology in its human capital development plan for the Global Change National Grand Challenge identified shortages of skills in specialist areas such as Biogeography and evolution; Climatology and climate modelling; Development studies; Disturbance, population and dispersal ecology; Ecophysiology, both terrestrial and marine; Environmental history, particularly over the past 300 years; Human demography; Geomorphology; Hydrology; Paleoecology and paleoclimatology, including palynology; Physical and biological oceanography; Resource and environmental economics; Social anthropology and sociology; Systems ecology and biogeochemistry. These, it was argued, "*are the core disciplinary skills needed to address fundamental Earth System questions, including the analysis of the human subsystems coupled to the biosphere*".

The South African National Biodiversity Institute, working on human capital development planning for biodiversity management in South Africa, has also identified a variety of scarce skills, including GIS specialists, bioinformatics, marine taxonomy, resource economy, leadership (amongst others). Important for this mapping study, and its intention to strengthen the education, training and research system, is the identification by both the Department of Environmental Affairs, and the SANBI studies that environmental education / human capital development skills are also 'scarce skills' in South Africa, and are in short supply given the scope of environmental education and training that is required across the system. Green Economy planning and the new national infrastructure programmes are also highlighting scarce skills, especially in energy and natural resources management development areas. Plans are in place to address the national shortage of environmental engineers (estimated at 300) for the structural infrastructure programme, while efforts are underway to strengthen energy technology skills (e.g. for installation of solar water heating systems) in FET colleges. Workshop participants commented on the need for cross-scale, integral systems thinking; capacity for dealing with complexity; capacity for engaging with indigenous knowledge in science contexts; skills for accessing and working with climate data; and systems innovation skills as being important for CCD.

¹⁴⁹ Note: the use of the term 'skills' here recognises that skills do not exist without knowledge and values, and it is all these that need attention in education, training and capacity building systems.

14.1.5 Institutional capacity gaps

While South Africa has a relatively well-developed research infrastructure and set of research institutions, there are still institutional capacity gaps, especially in the context of transitioning to a low-carbon, climate resilient society. The National Climate Change Response White Paper (NCCRWP) recognises that the institutional infrastructure for Science and Technology in South Africa is inadequate for building a climate resilient future, especially to support a 'robust' climate change response. The policy suggests the need for a climate change foresight exercise, because the response to climate change is so complex. Out of this foresight exercise, the government seeks to deliver a robust human capital development plan for climate science and technology informed by the country's climate change response requirements and the outcomes of the National Employment Vulnerability Baseline and Assessments as well as the Sector Jobs Resilience Plan (RSA 2011a). Additionally it seeks to develop a complementary science and technology development plan for climate change, and a climate change technology roadmap. The DST will also conduct a feasibility study into development of a specialised funding agency: the proposed **Climate Change Science Council**, and to further develop funding instruments for research and development. This will hopefully respond to a) the inadequacy of current research infrastructure for CCD, and b) inadequacy of research funding mechanisms. As one workshop group noted *"research funding is needed that allows for robust piloting and experimental development in the region of tens of millions is needed, not three or four million"*. This, the group noted *"would also allow for longer term – at least ten year – research cycles"* which are needed for serious research into the use of urban open spaces for social-ecological system mitigation and adaptation in cities for example. Similar points were made in relation to rural livelihoods development research for adaptation and so on. The key point was that the kind of CCD research that is required for substantive impact is not short term, and requires substantive funding for real impact, especially if such research is also to operate across scales, and if it is to adopt integrative social-ecological systems approaches. Workshop participants noted that research funding cycles were currently too short, and were linked to government budget cycles which were not substantive enough for enabling large scale, interdisciplinary and multi-site / multi-scale research programmes. Other institutional capacity gaps identified in the mapping study include scientific infrastructure such as modern laboratories and science institutes, supervision capacity and adequate bursary funding that could attract more black South African scholars into postgraduate studies, provisioning of funds for international scholars, cross-sectorial collaboration, policy synergy. Issues associated with leadership and commitment were also noted, and it was said that for CCD goals to be achieved, as per the policy, then dynamic organisations and leadership was needed, and that there was a need for better understanding of practical mandates, responsibilities and outcomes related to adaptation and mitigation and the relationships that exist between mitigation and adaptation practices. From a technical perspective, whilst South Africa probably has some of the best observational research capacity in southern Africa, it was still noted that a key challenge is a lack of permanent observation and monitoring sites, and sites used are often of a sub-optimal size. Key areas are also under-represented in monitoring work such as arid and semi-arid areas, forests and woodlands, mountains, agro-ecosystems, and rural areas (RSA 2011b), and there is need for a more integrated system for monitoring and observation, which includes provisioning of sensing imagery and imaging devices, state-of-the art data

processing and analysis hardware and software, relevant laboratory space and equipment as well as robust and accessible information management systems. Workshop participants, however, warned of a technology and science bias to the approach to the problem, and noted that the current science planning tended to disregard, and underfund the contributions of humanities and social sciences in climate change research environments. It was also suggested that more attention should be given to strengthening humanities, and social research systems and institutions for CCD research, and to the development of research institutions that can 'model systems thinking'. Another institutional capacity gap cited was a lack of adequate forums that support curriculum innovation, and lack of university management support for sustainable development related directions in universities. There was also a 'gap' between researchers and societies, and current research incentives structure perpetuated this as it did not reward multidisciplinary, transdisciplinary, or community engaged approaches to research, despite much rhetoric surrounding these 'new' approaches. It was also said that there was a fundamental tension between CCD / SD and social justice related intentions of CCD, and the intentions of the 'neo-liberal' capitalist drive, which was said to also be 'shaping Higher Education directives and the research funding environment'. It was further noted that there was a lack of appropriate institutional forums for engaging with public-private partnerships that need improvement.

From the above, it is clear that South Africa has made strong commitments to a climate-resilient development pathway in response to its projected vulnerabilities. It is also clear that research and knowledge production is a key element of this. Given the complex array of skills shortages and the need for new specialisms for social-ecological sciences and systems thinking approaches, much needs to be done to strengthen the pathway for knowledge co-production approaches to flourish. Especially important perhaps are the discussions on more sustained, longer term and substantive funding for real impact to emerge in social-ecological systems research, and a stronger commitment to social science and systems-based research.

14.2 South Africa institutional assessment

There are numerous, complex knowledge, research, individual and institutional capacity needs expressed in various human capital development strategies produced by the Department of Environmental Affairs, the Department of Science and Technology (for the National Global Change Science Plan), the water, waste and biodiversity sectors, as well as by those involved in Green Economy planning and energy sector planning, other national stakeholders and university staff themselves. The Second National Communication (RSA 2011b) and the South African National Climate Change Response White Paper (RSA 2011a) highlight a number of major institutions responsible for research concerned with climate change. The Department of Science and Technology is responsible for implementing the National Research and Development Strategy (NRDS) and the Ten Year Innovation Plan which contain the five Grand Challenges (Global Change and Energy are included).

The DST works closely with the National Research Foundation who supports the South African Environmental Observation Network (SAEON), the African Earth Observation Network (AEON), and has a system of Centres of Excellence (which includes the Applied Centre for Climate and Earth System Sciences (ACCESS)), South African Research Chairs (SARChi) located at

universities, and other research programmes such as the Global Change Society and Sustainability National Research Programme (GCESSNRP) and the South African National Energy Development Institute (SANEDI). There is also a recently established Technological Innovation Agency (TIA); all of which are to address the ‘innovation chasm’ – the gap that exists between knowledge generators, society and the market within a knowledge economy framework. Additionally there are other research councils that carry out research in the field of climate change, for example the Council for Scientific and Industrial research (CSIR) and the Human Sciences Research Council (HSRC), the Water Research Commission (WRC) and the Agricultural Research Council (ARC) and the South African National Biodiversity Institute (SANBI). South Africa is the country with the highest R&D expenditure in the region. Science production on the African continent is dominated by South African research, with paper publications rising from 3 617 in 2 000 to 7 468 in 2010. From this it can be seen that while South Africa’s publications are still low compared to other countries, research outputs have grown exponentially.

According to the 2010 ASAAF PhD study, South Africa has a total of 1 274 doctoral graduates or 26 doctoral graduates per million of the country’s population, which is seen to be low compared to other countries, and is one of the major challenges in the South African research system. South Africa has **2 637 rated scientists**. Scientists are rated via a formal peer review system involving national and international reviewers within a five-year cycle according to the following categories: Promising young researcher; Established researcher; Internationally acclaimed researcher; and Leading international researcher (the highest category). Every five years researchers have to re-apply for their rating, which may stay the same or improve. The majority of researchers in South Africa are within the category ‘established researcher’, but there are increasing numbers of internationally acclaimed and leading international researchers. A search of this database showed that there are a number of researchers, in all categories noted above, that are involved in climate change research, and research fields that are closely associated with, or that are necessary for CCD research. South Africa currently has **92 NRF funded research SARCHI Chairs (as of 2012)** and a number of Department of Science and Technology Centres of Expertise, some of which are relevant to CCD research (as shown in Table 14 below).

As the South African research environment is extremely complex, the summative analysis below presents information on expertise per university, based on best available information compiled from a variety of data sources including Internet sources, workshop data, questionnaire data (only 40 questionnaires were obtained however), and the second national communication. Table 14 below only covers nodes of expertise and centres of expertise, as well as Centres of Excellence although these are not focussed on one institution only.

For constructing the South African institutional analysis, the NRF rating system was taken as a proxy for nationally recognised researchers that operate as ‘nodes of expertise’. Table 14 should ideally be more fully verified at individual university level, a process which would need to take place in the follow-up phase of the SARUA mapping study. This information is therefore *indicative, rather than fully comprehensive*.

Table 14: Nodes and Centres of Expertise identified in South Africa, for CCD research (covering all 23 South African universities)

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
Cape Peninsula University of Technology, Western Cape	<p>The Cape Peninsula University of Technology has 23 NRF rated researchers with most being promising young researchers, and /or established researchers. Fields of expertise that are applicable to CCD research issues identified in this mapping study, involving established researchers are:</p> <ul style="list-style-type: none"> ■ Renewable energy, thermal energy systems ■ Food product development and preservation ■ Medicinal plants and bioactivity of natural antioxidants ■ Nutrition and Health, bacteriology ■ Fish farming using renewable energy (Department of Mechanical Engineering) 	<p>Centre for Environmental Toxicity and Remediation (Prof Odendal)</p> <p>The Energy Institute (Prof Uken), includes research on low cost high efficient solar water heating systems; off the grid aquaculture facilities and others.</p>
Central University of Technology, Free State	<p>The Central University of Technology, Free State has 7 NRF rated researchers, with two of the established researchers having expertise relevant to the CCD research issues identified in this mapping study:</p> <ul style="list-style-type: none"> ■ Food safety, biocatalyst and food microbiology 	<p>CUoT has a sustainable development strategy and a Department of Built Environment that focuses on sustainable building (Prof Ngowi)</p>
Durban University of Technology, KwaZulu-Natal	<p>The Durban University of Technology has ten NRF rated researchers, all in the category of established researcher. Areas of research expertise relevant to the CCD issues identified in this mapping study include:</p> <ul style="list-style-type: none"> ■ Microbiology, traditional medicine and indigenous knowledge systems ■ Innovation in technology management, including integrated water resources management and treatment, environmental modeling ■ Health promotion and disease prevention, ethics, health sciences 	<p>DUoT has an Institute of Systems Science (Prof Duffy) and an Institute for Waste and Waste Water Technology (Prof Bux)</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
<p>Mangosutho University of Technology, KwaZulu-Natal</p>	<ul style="list-style-type: none"> ■ Biotechnology <p>The Mangosutho University of Technology has two NRF rated researchers, one of which is an established researcher, focusing on environmental geology and medical geology.</p>	<p>MUoT has a Research Centre for Algal Biotechnology which focuses on the identification, optimisation and commercialisation of value added compounds from indigenous species of algae. Technology innovation to optimise the production of micro algal cellular lipids or oils, used in the synthesis of biodiesel. This is the first centre to produce high quality biodiesel from an indigenous strain of microalgae. Ongoing research with CSIR Biosciences and the Waste and Wastewater Technology (DUT) and School of Biological and Conservation Sciences at UKZN (Prof Anandraj)</p>
<p>Nelson Mandela Metropolitan University, Eastern Cape</p>	<p>The Nelson Mandela Metropolitan University has 62 NRF rated researchers, most of whom are established researchers.</p> <p>Leading international researchers have expertise that is relevant to CCD research issues as identified in this mapping study include:</p> <ul style="list-style-type: none"> ■ Restoration ecology, conservation science, plant diversity ■ Natural resources and sustainable development, geodynamics, stratigraphy, earth observation (Prof De Wit; founding member of AEON); is heavily involved in leading AEON <p>The following internationally acclaimed and established researchers have expertise relevant to CCD:</p> <ul style="list-style-type: none"> ■ Political and historical geography ■ Sustainability Science, Adaptive Systems, Complexity theory, Human Ecology Resilience (Prof Fabricius, also heads up the 	<p>The University has the following identified research units, where groups of researchers are working together:</p> <p>African Earth Observation Network (AEON is a centre for Earth Systems Science (ESS) that provides a research and educational environment to seek consilient knowledge amongst earth and life sciences, engineering, resource economics and the human sciences. AEON is forging Earth Stewardship into a Science that can sustain the planet and its people. AEON fosters cutting-edge, internationally connected, science and analytical learning using advanced tools and technologies in an environment that encourages interdisciplinary science to explore our Earth, and society, particularly in Africa. AEON is underpinned by dedicated programme-based hubs and a central hub managed out of the Nelson Mandela Metropolitan University in Port Elizabeth and involves EarthLAB, EarthCare, EarthLIFE, EarthTECH,</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<p>Sustainability Research Unit at the George Campus, and is Scientific Co-ordinator for the International Resilience Alliance, and has recently obtained a large research grant from the Belmont forum for coastal adaptation).</p> <p>Conservation Ecology, Conservation Planning and Freshwater management and conservation</p> <ul style="list-style-type: none"> ■ Conservation Ecology, plant-animal interactions; Conservation planning, GIS; Biogeography, Population ecology, evolution; Estuarine ecology, stress ecology, plant ecology; Freshwater conservation, social learning, freshwater management and aquatic conservation; Microbial water quality, bacteriology <p>Renewable energy</p> <ul style="list-style-type: none"> ■ Photovoltaics, solar heating, solar energy, semiconductors (Prof Van Dyk: Head of the Centre for Energy Research) <p>Science and environmental literacy and education, indigenous knowledge and science education (Prof Webb)</p> <p>The university also has a research policy which states that one of its key thematic areas is research into environment and natural resource management, with established strengths in the areas of:</p> <ul style="list-style-type: none"> ■ The environment and ecology (including environmental law) ■ Marine and estuarine studies ■ Architecture and the built environment <p>NMMU are also starting a new degree in Human Settlements in 2014.</p>	<p>EarthWISE, EarthSystem (Prof de Wit) (www.aeon.org.za)</p> <p>Sustainability Research Unit (head: Prof Fabricius) hosts a number of sustainability oriented research projects focusing on learning and reflection for adaptive co-management of ecosystems, water security, social networks and social capital, ecosystem change and society, transformations towards earth stewardship in social-ecological systems. A recent project is a coastal adaptation project (funded by the Belmont Forum)</p> <p>Centre for African Conservation Ecology (head: Prof Graham Kerley) places emphasis on conservation and conservation ecology, as well as environmental education.</p> <p>Ecology Coastal and Marine Research Unit (head: Prof Janine Adams) focuses on integrated environmental and coastal marine research, focusing on the dynamic changes in marine and coastal ecosystems.</p> <p>Centre for Energy Research (head: Prof Ernest van Dyk) was established in 2006, and focuses on solar energy development. They specialise in solar energy in the form of photovoltaic (solar cells) and solar water heating, energy management and control in the field of automotive energy, wind energy, energy efficiency, energy economics, and energy materials. The Centre brings together experts in science, engineering, the built environment, information technology, economic sciences, conservation ecology and manufacturing technology.</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
<p>North West University</p>	<p>The North West university has 141 NRF rated researchers, most of whom are established researchers. The North West University however, have important nodes of expertise that have particular relevance for CCD. These include:</p> <ul style="list-style-type: none"> ■ Environmental law and governance: Constitutional law, Environmental law, International environmental law, Environmental governance; Climate law; Legal pluralism; Human rights, Water rights, International Human Rights law ■ Clean energy and clean coal technology development: Gasification, coal beneficiation; Clean coal technology, Reaction Kinetics ■ Renewable energy: Fuel cells, hydrogen generation, hydrogen economy, electrocatalysis, membrane technology; Energy management, energy efficiency, energy engineering ■ Mining and applied environmental science, clean technology: Gold mining, environmental pollution reduction and remediation, environmental chemistry, water resources management ■ Plant sciences, Conservation and Rehabilitation: Plant stress physiology, rehabilitation, ecology, plant physiology; Conservation, ecological monitoring, restoration and rehabilitation of semi-arid rangelands; Urban ecology; Biodiversity conservation, herpetology, parasitology ■ Agricultural entomology, entomology and biological control ■ Soil sciences: Soil management, soil microbiology, mine dump rehabilitation, soil biology/fertility; Environmental soil sciences, soil characterisation and amendments ■ Bacterial biotechnology, alien invasive plants, environmental microbiology, IKS ■ Ecotoxicology, environmental chemistry, pollution and environmental management (water, marine); Terrestrial ecotoxicology 	<p>The mapping study showed that the university has applied for a DAAD Centre of Excellence in Climate Law and Governance, but this is pending approval. (Prof Kotze – NRF Prestigious award)</p> <p>The University also hosts the Unit for Environmental Sciences and Management that provides extensive training for business and government. (Head: Prof Leon van Rensburg)</p> <p>It also houses the Africa Unit for Trans-disciplinary Health Research (AUTHeR). It is not clear if this unit is engaged in CCD health related issues, but it has a strong commitment to a transdisciplinary research focus, and has a research programme that focuses on enhancing health and quality of life in various contexts on individual, community, social and systems levels. (Head: Prof Annamarie Kruger)</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<ul style="list-style-type: none"> ■ Climate change and land conflicts (Faculty of Agriculture, Science and Technology) ■ Legal principles of climate change (Faculty of Law) 	
Rhodes University	<p>Rhodes University has 70 NRF rated researchers, most of them established researchers. Rhodes University have the following nodes of expertise relevant to CCD research:</p> <ul style="list-style-type: none"> ■ Biological Sciences and Conservation: Marine biodiversity, conservation biology, aquatic biology; Biosystematics, Phytogeography, Biodiversity, Population genetics, insect plant associations; Biological oceanography, zooplankton ecology; Plant Eco physiology, ecology, climate change. ■ Fisheries Sciences: Life history, evolution, evolutionary genetics, fisheries management; Fish biology and bio resource modeling; aquatic ecology; Aquaculture and fish reproduction; Fisheries Management and ecology ■ Environmental, Climate and Ecological Sciences: Wetland and plant ecology; community forestry, climate risk and vulnerability, adaptation and livelihoods; interdisciplinary environmental sciences; rural livelihoods; climate change adaptation ■ Aquatic and Oceanographic Sciences: Applied hydrology; Hydrologic modeling (including climate modeling), surface hydrology, water resources management; Transdisciplinary water security and IWRM research ■ Physical geography and environmental change: Paleoceanography, marine biochemistry, earth history; Physical geography, environmental change, geomorphology, Antarctica ■ Environmental Biotechnology: Algal biotechnology; agricultural biotechnology, plant growth regulators 	<p>Southern Ocean Group: This research group is based in the Department of Zoology and Entomology and is involved in a programme on biological oceanography at the sub-Antarctic Prince Edward Islands in collaboration with a physical oceanographic research group at the University of Cape Town. Amongst other foci, the research includes a focus on interactions between the island ecosystem and frontal systems. (Prof McQuaid and Prof Froneman)</p> <p>Environmental Biotechnology Research Unit: The main focus is on biotechnology innovation and development of bioprocesses related to remedial technologies, waste water treatment, alternative energy and biofuels, technology transfer and assessment, mine water treatment, exploration of micro-algae biomass as feedstock for renewable energy production, bioremediation of coal and hydrocarbon wastes (Prof K Cowan)</p> <p>Institute for Water Research: The main focus is wise use of natural water resources in southern Africa; researchers are working on water and climate change (modeling), and water quality and its application in risk assessment as well as transdisciplinary water security studies under the GGCSSRP (includes the Unilever Centre for Environmental Water Quality) (Prof Hughes and Prof T. Palmer)</p> <p>Environmental Learning Research Centre: Its main focus is</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<ul style="list-style-type: none"> ■ Environmental Education / Education for Sustainable Development / Social Learning: Curriculum innovation, social learning, climate change education, water and biodiversity education, teacher education, environment and sustainability education in universities ■ Sustainability Leadership for Business: business leadership and climate change; green economy; sustainability reporting 	<p>environmental learning at the people-environment interface; social learning; curriculum innovation for sustainability in schools, TVET and higher education. Includes a focus on climate change education; houses the Makana and Rural Eastern Cape United Nations University linked Regional Centre of Expertise for Education for Sustainability and Chair of Environmental Education (Prof Lotz-Sisitka)</p> <p>SARCHI Chair in interdisciplinary environmental sciences and rural livelihoods – also has a link to climate change adaptation research (Prof C. Shackleton)</p>
University of Stellenbosch	<p>Stellenbosch University has 311 NRF rated researchers. The following areas of expertise were identified for CCD:</p> <ul style="list-style-type: none"> ■ Ecological Sciences, Modeling and Biological Sciences: Ecological network analysis, fisheries, ecological modeling; Fungal ecology; microbial ecology; Climate change impact and vulnerability: evolutionary ecology, physiological ecology, thermal biology, functional morphology Arid zone ecology, vegetation dynamics and restoration; Invasive alien species, conservation ecology, biodiversity conservation; Ecological modeling, macro ecology, invasion biology, conservation ecology; Plant ecology, terrestrial ecology, conservation biology; plant pathology, microbiology, biotechnology; Climate change and insects responses; see also the Centre of Excellence in Invasion Biology below ■ Sustainable energy development, clean technology and environmental engineering: Sustainable energy technologies, life cycle management; Bioenergy, bioprocess engineering; electric motor drives, electric machines; 	<p>US has the following Centres, Programmes and Institutes that have particular relevance to CCD:</p> <p>Centre for Renewable and Sustainable Energy Studies: focuses on development of renewable energy to facilitate economic growth in the area of renewable energy. The hub of the programme is in the Faculty of Engineering. It has a strong postgraduate research programme. It has a staff of eight research engineers. It co-operates with numerous departments and faculties inside the university, and with the Universities of Cape Town, NMMU, North West University, Wits University, the Fort Hare University Institute of Technology, the University of KwaZulu-Natal, the University of Pretoria, the Energy Research Centre at the University of Cape Town. The Centre is the national academic hub for renewable and sustainable energy studies. The US track record in conducting solar energy research is 30 years, and it has undertaken research that improves the efficiency of water use in power stations. The research includes</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<ul style="list-style-type: none"> ■ Environmental nanotechnology and biotechnology: nanotechnology and biotechnology applications in water ■ Conservation Sciences, Biodiversity: Conservation of natural resources, phytogeography; Conservation planning – science and social aspects; Systematics, marine biodiversity, evolution; Entomology and parasitology, conservation ecology, veterinary parasitology; Marine protected areas, fisheries management, conservation genetics, phytogeography ■ Environmental Management, IWRM, Sustainable Development and Environmental Economics: Integrated environmental assessment, climate change policy, water, waste and biodiversity planning, environmental and resource economics; Water demand analysis and management, water demand modeling, water distribution systems analysis; Environmental engineering, waste and water treatment, environmental management, membranes ■ Environmental governance, public policy and sustainable development: Environmental governance and public management, sustainable development, environmental policy, organisational transformation; Scenario methods, strategic knowledge, strategic analysis; Sustainable development, community development, design and planning, urban development, development economics, African economy ■ Agriculture and Soil Sciences: Soil chemistry, ecology, soil crusting; Agricultural entomology, conservation biology; Agriculture, Antarctic biology, plant ecophysiology; Agriculture policy analysis, land reform, rural development, agricultural development and economics ■ Environmental Ethics and Education: Environmental ethics, applied ethics, business ethics and climate change ethics; Environment and Science education 	<p>solar thermal power generation cooling. The university was also the first to build a solar research roof, and the university has large solar roof labs (1000 m²). (Director: Prof Wikus van Niekerk).</p> <p>It also works closely with:</p> <p>The SARCHI Biofuels Research Chair which is implemented in partnership with SANERI (now SANEDI) which co-hosts different Masters and PhD programmes with the University of Cape Town: MSc/PhD at the Department of Microbiology (US); MscEng/PhD in Chemical Engineering at the Department of Process Engineering (US) and MS(Eng) / PhD / PostDoc at the Department of Chemical Engineering at UCT</p> <p>Stellenbosch University Water Institute: combines water research groups in five US faculties under one umbrella. Current research focused on water and health, agriculture and food, a sustainable environment, nanotechnology and filtration, effluent treatment and social aspects surrounding water. It also hosts / co-ordinates the NEPAD network of water Centres of Excellence (nepadwatercoe.org)</p> <p>The Centre for Corporate Governance in Africa at the Stellenbosch Business School focuses on researching corporate responsibility and sustainable development in the business sector in order to develop criteria for best practice. The Centre for Corporate Governance in Africa at the University of Stellenbosch Business School is one of the four core project partners in a global initiative analysing Sustainability reporting policies and practices worldwide along with the Global</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<ul style="list-style-type: none"> ■ Disaster Risk Reduction and public health <p>The university has defined Sustainability as one of its focus areas for the forthcoming years. It has an Integrated Sustainability Management Policy, and has a flagship programme called the HOPE programme which adopts a transdisciplinary approach to science-in-society, and links a number of research programmes, centres and faculties.</p> <p>The university has a committee for sustainable development in the Faculty of Health Sciences.</p>	<p>Reporting Initiative (GRI), the United Nations Environment Programme (UNEP) and KPMG Climate Change & Sustainability Services (Director: Daniel Malan)</p> <p>The Environmental Education Programme (EEPUS) at the Faculty of Education endeavours to include environmental education into all the programmes of the Faculty of Education, and to train trainee teachers for environmental education (Prof Chris Reddy)</p> <p>The Sustainability Institute in co-operation with the University's school for Public Leadership focuses on ecological, community and mental development, and offers sustainable practices and a demonstration site for green technologies and ecological economics. It co-hosts the Masters degree in Sustainable Development (an interdisciplinary degree programme run with input from a range of different faculties). (Head: Prof Mark Swilling, also involved in Tsama Hub PhD in transdisciplinarity and sustainability)</p> <p>The Tsama Hub is a co-ordinating mechanism that utilises the transdisciplinary potential that exists among various faculties and departments of the university that have interests and expertise in sustainability, sustainable development and complexity. The focus of the programme is to do science <i>with</i> society through a process of co-learning. Researchers and stakeholders learn together how to develop a shared understanding of the real-world problems at hand, and how to translate these into theoretical problem statements and researchable questions. (Programme Manager: John van Breda;</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
		<p>Project leader: Prof Mark Swilling)</p> <p>The US also houses:</p> <p>The DST Centre of Excellence for Invasive Biology, which studies the impacts of invasive species on South Africa's plants and animals. Some researchers associated with the centre are also involved in climate change related research linked to the main focus of the CoE. The CIB explores the impacts of biological invasions on biodiversity and aims to improve understandings of how interactions amongst global change drivers might further influence the impacts of invasions, and to facilitate and formulate appropriate policy interventions. (http://academic.sun.ac.za/cib/research.asp)</p>
<p>Tshwane University of Technology</p>	<p>The Tshwane University of Technology has 34 NRF rated researchers, most of which are established researchers. They have the following expertise related to CCD:</p> <p>Mining, clean technology, water resources management and treatment: Water and effluent management and treatment; Waste water re-use, bioremediation, groundwater contamination, industrial water management, waste water bioremediation; Water resources management, arid zone hydrology, groundwater, health related microbiology, environmental biotechnology</p> <p>Renewable energy technology: Power electronics, electrical motor drives energy auditing, power quality; Power systems, power engineering</p> <p>Innovation acceptance and uptake</p>	<p>Centre for Energy and Electric Power (Department of Electrical Engineering); works with the SANEDI on thermal solar systems (Dr Munda)</p> <p>Postharvest technology group (Department of Crop Sciences) – research on linking small-scale farming operations with respect to climate change and reducing post-harvest loss of produce (Prof Sivakumar)</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
University of Cape Town	<p>The University of Cape Town has 408 NRF rated researchers, with some of these working in CCD related research areas:</p> <p>Climatology and Climate modelling and Climate Change Adaptation, including impact and vulnerability assessment and analysis</p> <p>Conservation, Ecology, Biodiversity, Plant Sciences, Zoology, and Environment and Global Change Science: Conservation biology, Biodiversity conservation, Conservation ecology, Wildlife conservation, Animal ecology, Applied ecology, Foraging ecology/behaviour, Biodiversity, Phylogenetics, Terrestrial ecology, Plant-herbivore interactions, Grassland, Savanna ecology, Landscape Ecology, Ecophysiology, Fire ecology, Evolutionary ecology, Coastal ecology, Estuarine ecology, Biosystematics, Mammalogy, Restoration ecology, Functional morphology, Evolutionary biology, Biostatistics, Taxonomy of African succulents; Ornithology, Population modelling; Invertebrate physiology, Aquaculture, Invertebrates - Taxonomy, Speciation/hybridisation, Plant Ecohydrology, Terrestrial ecology, Stable light isotopes, Climate change - Impact, Drought, Animal ecology</p> <p>Soil Sciences: Soil biology/fertility, Soil bacteria, Biological nitrogen fixation, Ecology and environmental science, Agronomy, Sustainable agriculture, Plant nitrogen, Plant-soil relations, Agriculture</p> <p>Oceanographic Sciences and Meteorology: Antarctic/Southern ocean; Physical oceanography, Climate change, Climate, Climate variability, Atmospheric and ocean modelling, Meteorology; Oceanography, Ocean atmosphere interaction, Climate variability, Agulhas, Southwest Indian Ocean, Satellite oceanography; Satellite oceanography, Physical oceanography, Antarctic regions - Circumpolar current, Variability of</p>	<p>UCT has a ‘whole system’ approach to climate change research, and established the Africa Climate and Development Initiative (ACDI) (http://acdi.uct.ac.za). The ACDI is the leading CCD research institution on the African continent. Its focus is to improve human well-being, but within the constraints of the need for low carbon development and the mounting impacts of climate variability and change. It is an interdisciplinary research hub that brings together academics and NGOs, business and government. It has research themes that include: climate smart development, low carbon energy and poverty alleviation, African Earth System responses to global warming, Climate scenarios and information systems, impacts of and resilience to climate variations and change, institutions, governance and economics of climate change, global to local scale issues and linkages. Departments that are working with the ACDI include:</p> <ul style="list-style-type: none"> ■ Botany Department (Prof Hoffman: climate change monitoring through vegetation change ■ Graduate School of Business (Prof Hamann): business and climate change; governance ■ African Centre for Cities (Anton Cartwright, Warren Smit): development economics and climate change; CityLAB – Mistra Urban Futures Climate Change CityLab programme ■ Centre for Film and Media Studies (Dr Saleh): climate crossroads: politics, media and climate ■ School of public health and family medicine (Jonny Myers): climate change, health and health policy ■ Centre of Criminology (Tom Herbstein): environmental security programme focussing on communities managing risks associated with climate change ■ Climate System Analysis Group (CSAG) – www.csag.uct.ac.za

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<p>the ACC., Primary production distribution in the Southern Ocean in relation to physical forcings, Antarctic/Southern ocean, Southern Ocean frontal dynamics</p> <p>Marine Climate Sciences, Fisheries Sciences and Geoscience: Marine biodiversity, Climate change, Benthic marine algae, Biosystematics, Ecological modelling, Fishery assessment and management, Marine geoscience, Palaeoceanography, Sedimentary geochemistry; Ecosystem modeling, Fishing - Effect of ecosystem on, Fisheries, Fisheries management, Trophic webs, ecosystem indicators; Biological oceanography, Ecology of marine small pelagic fish, Structure and functioning of marine pelagic food webs, Climate change impacts on marine pelagic ecosystems, Management of fisheries for small pelagic fish, Ecosystem approach to fisheries management Ecological modelling and Ecosystem modelling: Population modelling, Marine biophysical modelling, Marine ecology, Plankton ecology</p> <p>Integrated Water Resources Management: Urban Water Management, Urban storm water – Engineering, Water engineering, Water-supply, Rainwater harvesting, Water demand – Management, Water management, Wastewater, Environmental hydraulics, Engineering hydrology; Water supply and management: Water-supply, Water leakage, Water demand - Modelling, Water distribution system - Modelling, Reliability engineering</p> <p>Health Sciences: Health policy, Antimalarial drugs, Malaria, Malaria control, Clinical pharmacology, medicinal chemistry, anti-malarial drugs (also anti-TB, anti-HIV drugs), Medicinal chemistry, Drug discovery</p> <p>Development Studies and Labour Economics: Development economics, Labour economics, Household poverty dynamics, Survey econometrics,</p>	<p>(Prof Bruce Hewitson): climate modelling, two projects – Wild Coast Living Laboratory (systems research); Healthy Futures (predicting climate risk in Africa, disease risk mapping, focus of research is on East Africa)</p> <ul style="list-style-type: none"> ■ Environmental Evaluation Unit (EEU) (Sandra Rippon): Touws River Solar Energy Facility environmental authorisation process research ■ Department of Chemical Engineering (Prof von Blottnitz): environmental process systems engineering ■ Department of Social Anthropology (Lesley Green): contested ecologies research group focussing on informational and relational ways of knowing ■ Department of Sociology (Dr Frank Matose): defragmenting African Resource Management (conflict resolution) aspects of climate change and related concerns ● Gordon Institute for Performing and Creative Arts (Jay Pather): brings scientists and artists together to probe the relationship between climate change and its representations in the creative and performing arts ● Schools Development Unit (Andrew Petersen): teacher education on climate change / science and environmental education. <p>The Environmental Evaluation Unit at UCT (Prof Merle Sowman) covers the following thematic areas:</p> <ul style="list-style-type: none"> - Coastal and fisheries governance (MPAs, small scale fishers, co-management) - Biodiversity and social justice (includes projects on bio prospecting, bioscience and bio politics, seed security) - Environmental management and sustainability (includes

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<p>Labour market – Economics, Policy formulation, Economics of education, Poverty, Research, Development economics, Poverty, Inequality, Labour economics, Policy</p> <p>Palaeontology and Archaeology: Palaeontology: Vertebrate; Palaeoenvironments, Palaeoecology; Archaeology - Iron Age, Archaeology - Cultural heritage; Biomolecular archaeology, Palaeoenvironments, Stable light isotopes, Environmental isotopes, Biological anthropology, Pre-colonial archaeology, Archaeology – African, Archaeology – Stone Age</p> <p>Energy, Waste and Clean Technology: Climate change, Waste management, Sustainable energy, Strategic planning, Multicriteria decision analysis, Clean technology</p> <p>Environmental Law, International trade law, Coastal Zone Law, Environmental law, Energy Law, Climate Change law</p> <p>Renewable Energy: Wind power, Power electrical engineering, Power systems dynamics, Power system stability, Power systems analysis, Renewable energy systems, Intelligent systems, Power systems optimisation; Environmental economics, Environmental modelling, Energy studies, Energy policy, Renewable energy, Environmental policy</p> <p>Sustainable Development and Corporate Governance: Corporate strategy, Business administration, Food security, Climate change mitigation, Climate change – Adaptation, Mining – Environment, human rights, innovation and sustainable development, Business ethics, Sustainable enterprise; Waste management, Biofuels, Life Cycle Assessment, Industrial ecology; Strategic management, Internationalisation, Cooperative governance, Innovation –</p>	<p>various initiatives focusing on renewable energy development)</p> <ul style="list-style-type: none"> - Business and sustainability - Environmental governance <p>UCT also has a number of research chairs</p> <ul style="list-style-type: none"> • SARCHI Chair of Security and Justice (Prof Clifford Shearing): focus on the governance of environmental security • SARCHI Chair in Climate Change (Prof Bruce Hewitson): linked to the Climate Systems Analysis Group – focus on climate modeling, variability, change and regional projections. Lead co-ordinator of the WCRP global CORDEX programme to develop regional climate projections. • SARCHI Chair in Marine Ecology and Fisheries (Prof Astrid Jarre: focus on interdisciplinary research into marine social-ecological systems under global change in the Benguela current • SARCHI Chair in Modeling of the coupled ocean-land-atmosphere phenomena related to climate change (position still being filled)

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<p>Management, Innovation and entrepreneurship</p> <p>Biotechnology: Wastewater treatment, Biohydrometallurgy, Algal biotechnology</p> <p>Environmental History: Semi-arid rangelands, Desertification, Resource management</p> <p>Development Finance: Finance, Economics, Forecasting and time series, Development finance, Development economics, Financial economics</p> <p>Cultural studies, sustainable design / architecture, and urbanisation / social change studies: African studies, Educational policy, Sociology, Young people in Africa, Spatial planning, Planning theory, City planning; Architectural design, Design innovation, Design at times of social change, Design of roof lights that can separate light and heat, Self-built rentable housing, Environmentally responsive and responsible design in architecture</p>	
<p>University of Fort Hare</p>	<p>The University of Fort Hare has 18 NRF rated researchers. Not all of the researchers listed below are NRF rated, but they are all engaged with CCD related research:</p> <ul style="list-style-type: none"> ■ Plant and Animal Sciences & Climate Smart Agriculture: Ethnobotany, bioprospecting, phytomedicine; Ethopharmacology, Ethnovetinary, Animal Health; Animal breeding, Animal welfare; resilient Nguni varieties. Effects of CC on cereal stress responses; Agro-meteorology, resilient pest tolerant food plant varieties – stress tolerant Maize PVCs and farmer tolerance to open pollinated maize varieties; effects of 	<p>Fort Hare Institute of Technology (FHIT) (Director: Prof Meyer): Renewable energy technologies, energy efficiency, energy efficient building integrated photovoltaics (EEBIPV) systems and building materials. Renewable Energy Centre of Excellence (RECoE). Research areas: photovoltaic modules and systems, photochemical dye-sensitised solar cells and modules, gassification of biomass.</p> <p>Agricultural and Rural Development Research Institute (Director: Prof Masika): Generates social, economic and technical information relating to livelihood systems and support services with a focus on agriculture, and then disseminates this information to facilitate</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<p>CC on livestock production</p> <ul style="list-style-type: none"> ■ Renewable Energy: Solar energy, photovoltaics, solar physics ■ Climatology, Geomorphology: Impacts of CC on smallholder farming and productivity ■ Water Resources Management, Water Quality, Agricultural Water: Physico-chemical, bacteriological and virological qualities of water; Research on agricultural water, reduce the water footprint of crops; Hydrological cycle; Water harvesting for small scale farming ■ Agricultural economics; climate vulnerability and adaptation options for smallholder farmers, barriers and incentives to adoption of biofuel crops ■ Conservation agriculture, vermicomposting, climate mitigation; small-scale irrigation cropping productivity ■ Social Science Studies on CC risk perception 	<p>change</p> <p>The University of Fort Hare also hosts a DST Risk and Vulnerability Science Centre (RVSC) linked to the Global Change National Research Plan (Director: Dr Zhou): Generates and disseminates knowledge on risk and vulnerability on global change challenges focusing on food and water security, waste management, and environmental management in the face of climate change</p> <p>It also has a Centre for Transdisciplinary Studies (Director: Dr Mahlangu) that teaches an undergraduate transdisciplinary module on 'Life, Knowledge and Action' to all first-year undergraduate students using an innovative campus-wide model. It includes aspects of environment and climate change.</p> <p>SARCHI Chair in Social Change (Prof Minkley)</p>
<p>University of Johannesburg</p>	<p>The University of Johannesburg has 112 NRF rated researchers, with the following overall areas of expertise related to CCD (details of all the researchers are included in Volume 2):</p> <ul style="list-style-type: none"> ■ Ethno botany, medical plant chemistry, taxonomy, indigenous knowledge ■ Biodiversity: Plant and Fish Sciences; Aquatic Health: Fish parasitology, aquatic health ■ Renewable Energy Production, Energy Systems, Life Cycle Engineering: Environmental management, atmospheric environment ■ Biotechnology, Nanotechnology and Environmental and Water Analysis ■ Water demand side modeling 	<p>It has the following research centres:</p> <ul style="list-style-type: none"> ■ Sustainable energy Technology and Research Centre (SeTAR) focusing on Sustainable Energy and Geo-Informatics (Prof Annegarn): flagship programme ENERKEY, which is an international mega-cities research programme focusing on sustainable energy for cities. Also includes residential thermal energy research, schools energy efficiency project retrofitting schools, solar water heating project focusing on roll out of solar water heaters for the domestic sector. ■ The Centre for Nanomaterials Research undertakes research on nanomaterials for sensors and photovoltaic applications, and water analysis and treatment

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<ul style="list-style-type: none"> ■ Environmental / analytical chemistry, wood, soil and water sciences ■ Sustainable Construction and Construction Management with a focus on gender concerns ■ Land Use, Forests and Forestry Management, including vegetation mapping, applied environmental science ■ International Environmental Law ■ Rural Livelihoods and Vulnerability 	<ul style="list-style-type: none"> ■ The Centre for Social Development in Africa (Prof Leila Patel) (in the Faculty of Humanities) conducts research into corporate social and environmental responsibility as a sustainable development strategy ■ SARCHI Chair in Indigenous Plant Use (Prof BE van Wyk) ■ It also hosts a Centre for Aquatic research (Prof Avenant-Oldewage): freshwater biology – focusing on Fish health, molecular and systematics, phylogeography, landscape genetics and population genetics; Comparative respiratory functional morphology and developmental biology (in extreme environmental conditions); Ecotoxicology and impacts of pollutants on fish species; Fish parasitology
University of KwaZulu-Natal	<p>The University of KwaZulu-Natal has 209 rated researchers, most in the category of established researcher, with the following areas of expertise related to CCD</p> <ul style="list-style-type: none"> ■ Renewable Energy, smart materials and structures ■ Biodiversity Conservation, Ecology: Plant based biodiversity management and ecological studies; Marine and coral reproductive ecology, coral reef health and anthropogenic stressors, coral reef biology; Ecological modeling; Plankton and phytoplankton ecology; Zooplankton ecology; Pollination ecology; Estuarine and mangrove ecology; Spatial planning, ecosystem services; Conservation planning; Ecosystem ecology ■ Plant and Animal Sciences: including plant breeding, crop diversification, natural products processing, biological evaluation, ethnobotany, seed physiology, forest science ■ Soil Sciences, system change: Climate modeling, climate change impacts, crop modeling 	<p>Key research themes that have been defined as university-based areas of excellence of relevance to CCD at UKZN include:</p> <ul style="list-style-type: none"> ■ Agriculture and Food Security ■ Energy and Technology for Sustainable Development ■ Indigenous African Knowledge Systems ■ Maritime Studies ■ Water, Environment and Biodiversity (UKZN has a strong research programme on water, environment and biodiversity)

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<ul style="list-style-type: none"> ■ Water Sciences: Stochastic modeling, hydrometeorology, environmental engineering; Water engineering, IWRM, engineering hydrology, floods ■ Sustainability Science and Environmental Governance: Sociocultural space and time, spatial planning, environmental governance; International environmental law ■ Gender economics, poverty, household well-being, labour economics, economic demography ■ Environmental biotechnology and rehabilitation, agriculture, applied mineralogy; Environmental Biotechnology and bioremediation; Agricultural biotechnology, water and effluent management ■ Environmental history ■ African ethics ■ Biochemistry, Molecular biology; Biomedical sciences, including focus on malaria; Environmental epidemiology; Health promotion; Child health; Health communication ■ Food processing, food engineering; agricultural engineering, post-harvest systems, drying of foodstuffs, renewable energy use in Agriculture, energy efficiency in the food industry ■ Science Communication ■ Development Studies, Development Economics, Social Movements, Labour 	
University of Limpopo	<p>The University of Limpopo has eight NRF rated researchers with expertise in the following areas related to CCD:</p> <ul style="list-style-type: none"> ■ Agricultural Sciences: Animal sciences, animal breeding and management; Animal nutrition; Crop production, horticulture, plant pathology, phytochemistry 	<p>The SAES Geography and Environmental Studies department has a focus on water and sanitation, water resources management, public health, and hosts a Centre for Rural Community Empowerment (Head: Prof Mollei)</p> <p>The University of Limpopo also hosts a DST Risk and Vulnerability</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<ul style="list-style-type: none"> ■ Biodiversity: Taxonomy, biodiversity, biosystematics ■ Social change: Psychopathology, psychology, indigenous knowledge systems, public health 	<p>Assessment Centre (RVAC), which is linked to the Global Change National Research Plan (Director: Ms Geldenhuys)</p>
<p>University of Pretoria</p>	<p>The University of Pretoria has 334 NRF rated researchers, most of whom are in the established researcher category, with the following areas of expertise and research centres that are engaged in CCD research:</p> <ul style="list-style-type: none"> ■ Veterinary Sciences, including veterinary epidemiology, wildlife veterinary research; Wildlife population dynamics and monitoring; Veterinary toxicology; animal nutrition; Veterinary parasitology; Mycobacterial diseases, zoonosis, zoonotic diseases (on the increase due to CC); Veterinary epidemiology, veterinary public health, agricultural development ■ Sustainable Agriculture, Soil, Forestry and Water sciences: Modeling, crop water use, irrigation management, irrigation water, smallholder sustainable agriculture, plant disease control, indigenous plant beneficiation, Agroforestry, community forestry, social aspects of forests and forestry, soil fertility, soil-water relations; pasture sciences, animal nutrition; post-harvest pathology, food safety, Microbial ecology; Ethnobotany; Forest pathology; Fungal population biology; Cereal sciences; Engineering geology, hydrogeology; Seed science ■ Environmental Law and Governance: IWRM, water policy, water resources governance; Governance of rural livelihoods, climate change governance; linked to Technology and food security policy; Climate change and insurance law ■ Human Settlements and Energy Studies: Conservation and 	<p>The UP has the following centres / departments that are involved in CCD:</p> <ul style="list-style-type: none"> ■ Centre for Environmental Studies: extensive climate change research including mapping, livelihoods, adaptation and health (Dr Olwoch – holds a Global Change Grand Challenge Award) ■ Construction Economics (Prof Chrisna du Plessis): holds a Global Change Grand Challenge Award for research on climate resilient and sustainable human settlements ■ Geo-informatics and Meteorology (Prof Engelbrecht, Prof Vogel) ■ Agricultural Economics, Extension and Rural Development (Prof Hassan): climate change and agricultural adaptation

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<p>restoration architecture, urban conservation architecture; Appropriate technology, building science, heritage, affordable housing, sustainable development policy and housing systems, human security, housing development</p> <ul style="list-style-type: none"> ■ Innovation Studies and Business: Innovation and technological change; Technology management; Mitigation investment and financing; Corporate involvement in mitigation ■ Renewable energy and energy efficiency: Thermal energy systems efficiency, energy modeling; energy management and energy technology management; carbon materials; Energy modeling, energy efficiency, energy management ■ Biodiversity, Conservation and Wildlife Management: Marine and coastal ecology, population ecology; Veld management, wildlife management, vegetation science; Apoidea (bees) behavioural ecology; Evolutionary ecology; Pollination biology ■ Health Sciences: Antimalarial drug discovery, antimalarial compounds etc.; Public health, malaria control; Nutrition and health, nutritional epidemiology, micronutrients, children's nutrition; Air quality monitoring networks, exposure assessment, environmental epidemiology ■ Environmental Resource Economics, development economics; Climate change economics; Macroeconomics; Transdisciplinary approaches to research in accounting and finance; Critical perspectives on accounting and finance; Ecological economics, agricultural economics ■ Biotechnology: Environmental / water biotechnology, plant biotechnology – fungal-plant interactions; ■ Humanities: Utopian studies, African modernism, New media and art, public art practice. ■ Climate Change Meteorology; CC Adaptation, impact and 	

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
University of South Africa	<p>mitigation: Climate variability modeling; geo-informatics</p> <p>The University of South Africa have 130 NRF rated researchers, mostly in the established researcher category, with the following areas of expertise related to CCD as identified in this mapping study. The university has 263 470 students enrolled and is the largest distance learning institution on the African continent.</p> <ul style="list-style-type: none"> ■ Renewable Energy: Fuel cells, composite materials, environmental engineering and science; Carbon nanomaterial ■ Environmental Science and Environmental Management: Ecotoxicology, bioremediation, environmental microbiology ■ Environmental History, Heritage ■ Human Settlements: Urban geography, social transformation, land reform, spatial planning and environmental management ■ African Studies: African development, power and politics, social theory, Agrarian land questions, global movements ■ Indigenous Knowledge Systems: IKS and Environmental Education / Education for Sustainable Development ■ Environmental Education 	<p>Exxaro Chair in Business and Climate Change Institute for Corporate Citizenship: Research on green economy transitions, climate mitigation, climate change in Africa (Prof Nhamo)</p> <p>SARCHI Chair in Development Education, includes a focus on sustainable development (Prof Hoppers)</p> <p>Research Niche Area (NRF approved) on Ecotoxicology (Prof Mphahlele)</p> <p>Institute for Social and Health Studies, includes epidemiology research (Prof Seedat)</p> <p>Institute for Science and Technology Education (Prof Atagana)</p> <p>Institute for African Renaissance Studies (IARS), focusing on the comprehensive development of Africa(ns) in the 21st century; includes a focus on ESD and sustainable development issues, including climate change (Prof Gutto)</p> <p>Research Flagship Projects relevant to CCD:</p> <ul style="list-style-type: none"> ■ Fog Harvesting Project in the College of Agricultural and Environmental Sciences (harvesting of clean water for rural water security) ■ College of Science, Engineering and Technology has several research projects focusing on climate change, poverty and pollution of soil and water, as well as a flagship project ‘fuel cell and nanotechnology’

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
University of the Free State	<p>The University of the Free State has 106 NRF rated researchers, mostly in the established research category, with the following areas of expertise related to CCD as identified in this mapping study</p> <ul style="list-style-type: none"> ■ Microbial biotechnology and microbiology, mycology, forest pathology, microbiology and plant pathology ■ Agriculture, Soil, Animal and Plant Sciences; soil degradation, soil fertility, soil chemistry, plant nutrition, animal disease control, veterinary biotechnology; plant breeding; soil assessment for land suitability; soil hydrology; soil survey; soil classification; hydopedology; animal production and breeding; soil hydraulic properties; veterinary parasitology; genetic engineering; biotransformation; agricultural biotechnology; crop modeling, cropping systems; sustainable agriculture, agricultural extension, irrigation scheduling, agricultural information systems ■ Ecology and Biodiversity (aquatic and terrestrial), including conservation and wildlife management: Taxonomy, fish diseases, fish parasitology; Wildlife forensics, conservation biology, wildlife management, evolutionary ecology, systematics (biology), entomology; Integrated pest management, biogeography, soil ecology; Bioinformatics, epigenetics; Conservation ecology; Savanna ecology; Grassland science; Restoration ecology; Wetlands ■ Solar Energy: photovoltaic ■ Water: Water conservation, constrained optimisation, irrigation farming, risk analysis ■ Food sciences: Food microbiology, food safety, bacterial taxonomy, food chemistry; Food safety; Food processing ■ Health sciences: Indigenous healing systems, social aspects of 	<p>Faculty of Natural and Agricultural Sciences hosts the following Centres:</p> <p>Disaster Management Training Centre for Africa (Prof A Jordaan): DDR, disaster risk assessment, disaster management planning, agricultural development planning, business planning, drought risk assessments, disaster risk analyses, also at municipal levels</p> <p>Centre for Sustainable Agriculture (Prof Groenewald): semi-arid sustainable agriculture systems, farming systems research and extension research, natural resources management in agriculture</p> <p>Centre for Environmental Management (Prof Seaman): Focus on water conservation and water management (especially groundwater), and water management in water scarce areas Research areas include: management of water aquatic ecosystems in water scarce areas, managing water scarcity in agriculture, optimal water-use for development in water-scarce areas</p> <p>Department of Agricultural Economics is focusing on the economics of climate change adaptation research in agricultural commodity contexts</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<p>health care, health systems research, medical sociology</p> <ul style="list-style-type: none"> ■ History and Global Change: Palynology, global change, African prehistory ■ Department of Anthropology is focusing on social adoption of rain water harvesting technologies 	
<p>University of the Western Cape</p>	<p>The University of the Western Cape has 94 NRF rated researchers, most in the established research category.</p> <p>It conducts research into:</p> <ul style="list-style-type: none"> ■ Renewable Energy, Solar Energy (photovoltaic) and Hydrogen Production and Utilisation, nanostructures, nanophysics; Solar cells; Applied chemistry, hydrogen economy, fuel cells, hydrogen production and utilisation; Hydrogen storage, hydrogen economy, electro catalysis, electrochemistry ■ Land and Agrarian Studies ■ Marine Biology and Marine Sciences: Biogeography and marine microbiology, biological evaluation of natural products; Biological oceanography, taxonomy ■ Rural Development, Coastal and Fisheries Co-management, fisheries management, integrated coastal management, small-scale fisheries development, gender and development ■ Biodiversity Conservation, Plant Molecular Biology, plant biotechnology, plant genetic transformation; Animal biology ■ Science Education and Indigenous Knowledge Systems ■ Nutrition and Public Health, including health policy, including epidemiology; Environmental health; Health systems, health systems strengthening, health policy ■ Environmental Law and Governance: AU law, environmental 	<p>It has the following Centres that are engaging with aspects of CCD:</p> <p>PLAAS: The Institute of Poverty and Land Agrarian Studies (Prof Cousins): SARHCI Chair in Poverty, Land and Agrarian Studies – it was not clear to what extent PLAAS is engaging with CCD issues, but many of the core issues that PLAAS deals with are core to CCD in southern Africa, as pointed out in this mapping study</p> <p>Institute of Water Studies in the Department of Earth Sciences (Prof Mazvimavi): involved in climate change, water availability and supply research at regional level</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<p>law, SADC law, international law (especially international environmental law); Intergovernmental relations</p> <ul style="list-style-type: none"> ■ Biotechnology, bacterial biotechnology, bio mining micro-organisms, marine biotechnology ■ Agricultural Economics: research on change in agricultural seasons due to climate change, with focus on food security for smallholder farmers 	
<p>University of the Witwatersrand</p>	<p>The University of the Witwatersrand has 248 NRF rated researchers.</p> <p>Relevant areas / nodes of expertise identified:</p> <ul style="list-style-type: none"> - Forestry: Forest hydrology, forest growth modelling, land use hydrology, plant water use efficiency - Water and Hydrology: Hydrological modeling, water resources management, stochastic hydrology, water risk and uncertainty; Groundwater hydrology, water engineering; Hydrogeology - Migration Studies: Human mobility, governance, migration - Health: Bio inorganics and antimalarial - Geo-physical changes: Climate change, sedimentology, geomorphology and landscape; Geo and environmental sciences - Environmental Engineering and clean technology development; Clean coal technology - Biological and Plant Sciences, entomology, plant biochemistry, biological control; population ecology; Pollination ecology, bird migration, behavioural ecology, ornithology - Biotechnology - Health Sociology and Public Health: Health promotion; Urban health; Popular culture and new media 	<p>It has the following Centres involved in CCD research:</p> <p>Global Change and Sustainability Research Institute (GCSRI) (Prof Hans-Peter Plag): A multidisciplinary research centre focusing on global change adaptation and mitigation; Biodiversity, human health and nutritional status of rural communities, sustainable urban living through improved water, waste and energy management; Pollution, extraction and ecosystem health; Action research on environmental policies to improve collaboration between environmental, science and technological agencies. The GCSRI also hosts a climate leadership programme.</p> <p>School of Architecture and Planning (Prof Irurah): focuses on the built environmental and climate change in South Africa, and strategic implications for architecture; as well as the implications of CC on information settlements in urban areas (Dr Nenweli)</p> <p>School of Animal, Plant and Environmental Science is also doing CC research related to CC and changes in tick-borne diseases (East coast fever); adapting conservation strategies to climate change (Prof Erasmus); and research on urban ecology and climate change focusing on social-ecological theory; multiple strategies for resilient</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
	<ul style="list-style-type: none"> - Innovation and entrepreneurship; Social innovation; Human ecology resilience - Complexity sciences, conservation, adaptive management, river and wetland sciences; Natural resources management; Sustainable development; Restoration ecology; Savanna ecology - Environmental biogeochemistry - Human Settlements: Urban development, regional development, environmental design 	<p>livelihoods in communal areas; rural outmigration and livelihoods (Dr Twine)</p> <p>The School of Electrical and Information Engineering conducts renewable energy research focusing on renewable energy sources such as solar and wave energy, and they are exploring development of linear synchronous generators for ocean wave-energy harvesting; photovoltaic systems conversion and cost efficacy; wind energy generation; intelligent energy systems involving micro-grids for sub-urban and rural application with renewable sources, which includes a focus on control and metering systems; load identification, and energy use monitoring</p> <p>The Centre for Applied Legal Studies also has an environmental law programme (Prof Meyersfeld)</p>
<p>University of Venda</p>	<p>The university of Venda has 15 NRF rated researchers, with some of these researchers particularly associated with the following areas of expertise relevant to CCD:</p> <ul style="list-style-type: none"> ■ Soil Sciences and Environmental Health; applied clay mineralogy, environmental geology, soil pollution ■ Health Promotion and Disease Prevention; nutrition and health, cross-cultural studies in health care, child malnutrition, epidemiology ■ Health related Water Microbiology Research; environmental health impact assessment ■ Biodiversity Conservation, small mammal ecology; Invertebrate diversity, spider systematics ■ Plant breeding (genetics) 	<p>The university has a core research focus on poverty alleviation and sustainable rural development. It has the following key research themes that are relevant to CCD:</p> <ul style="list-style-type: none"> ■ Food Security: sustainable farming and agro-forestry farming systems for improved livelihoods and food security ■ Integrated environmental management, settlement and energy for sustainable development ■ Indigenous knowledge systems ■ Water research for improved quality of life ■ Enterprise development, micro-finance and innovation ■ Public health, youth development and women's health, including gender issues <p>It has an Institute for Rural Development (Dr Francis) which is</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
		<p>involved in research for developing a household vulnerability index in southern Africa, which is implemented in partnership with the Food, Agriculture and Natural Resources Policy Analysis Network and World Vision (FANRPAN)</p> <p>The School of Environmental Sciences (Prof Odiyo) conducts research into ecology and resource management. It also has an Institute for semi-arid environment and disaster management.</p>
University of Zululand	<p>University of Zululand has 11 NRF rated researchers, with the following areas of expertise:</p> <ul style="list-style-type: none"> ■ Fish biology, environmental impacts assessment, aquatic ecology ■ Indigenous Knowledge Systems ■ Savanna ecology, plant-herbivore interactions, rangeland systems, plant ecology ■ Nano toxicology, focusing on malarial research 	<p>UniZul has a Centre for Integrated Rural Development, and a Department of Geography and Environmental Studies but it is not clear if and how they are involved in CCD research.</p>
Vaal University of Technology	<p>Vaal University of Technology has six NRF rated researchers with expertise in the following areas relevant to CCD:</p> <ul style="list-style-type: none"> ■ Waste water treatment and integrated water resources management: Physical water treatment, adsorption ■ Renewable energy and fuels: composite materials, alternative fuels, renewable energy resources, casting technology, polymer nanocomposites ■ Community health and food security, including nutrition /malnutrition 	<p>The University has:</p> <p>A Centre for Sustainable Livelihoods (CSL) (Prof Oldwage-Theron)</p> <p>An Institute of Applied Electronics that is currently developing a sustainable solar-driven hydrogen plant, using fuel cells – to supply power to rural communities and off grid telecommunication sites (Prof Pienaar)</p> <p>Water and Wastewater research group (Prof Aoyi)</p> <p>Environmental Pollution Group (focusing on biological contaminants,</p>

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
		and have investigated the use of biomass for removal of heavy metals from industrial effluent; complements membrane technology and can remove both high and low metal concentrations from water. (Ms Christa van Wyk; Biotechnology Department)
Walter Sisulu University	<ul style="list-style-type: none"> ■ Walter Sisulu University has seven NRF rated researchers with expertise in the following areas relevant to CCD: ■ Plant biology – linked to livelihoods generation: natural products from plants 	Walter Sisulu University has a Centre for Rural Development (Head: Prof Luswazi); and a School of Applied Environmental Science (Dr Jumbam) but it is not clear to what extent they are engaged in CCD issues. Walter Sisulu University has a SARCHI research chair in Indigenous Knowledge Systems .
Other large South African research organisations / centres with CCD research expertise, that provide important research networks for the university-based researchers are:		
The Agricultural Research Council	The ARC conducts the following research related to CCD: remote sensing, geographic information systems research, conservation research, rural geography, agricultural biotechnology, applied animal breeding, and climate change mitigation and adaptation research. They conduct research on renewable energy, biological control, agro-processing, and animal and plant genetics. The ARC has 31 NRF rated researchers, four being internationally acclaimed researchers, one of which specialises in plant genetics and plant breeding.	
The Centre for Scientific and Industrial research	The CSIR has 31 NRF rated researchers. It is involved in global change and Earth Systems Science / observation research in its Natural Resources Directorate (where the ACCESS Centre of Excellence is housed – see below); and is also involved in energy, water, waste and clean technology research. It co-operates with university researchers, the DST and the NRF. The CSIR assisted the DST to develop the Global Change Grand Challenge National Research Plan for South Africa.	

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
The Human Sciences Research Council	<p>The HSRC has 11 NRF rated researchers. Research areas relevant to CCD include: Health: health care, health sciences, health services, health systems research, child health, environmental factors impacting on nutritional status, health promotion and disease prevention</p> <p>Sociology and Urban geography: Regional development, urbanisation, migration, sociology of youth, youth development etc. These are not currently engaged with CCD, but could be important research partners for CCD in future.</p> <p>The HSRC area is also undertaking some studies on the Green Economy, and labour market intelligence, which is important for building the national system of skills development for green economies.</p>	
The National Institute for Water and Atmospheric Research	<p>NIWAR has one NRF rated researcher in the category of 'promising young researcher' specialising in climatology.</p>	
South African Environmental Observation Network	<p>SAEON has two NRF rated researchers, but works with a wide range of researchers situated in different Nodes. All of their research is focused on environmental observation and monitoring, including oceanographic modeling and observation; wildlife monitoring; monitoring of aquatic biodiversity; monitoring of biomes etc.</p>	
South African Institute for Aquatic Biodiversity	<p>SAIAB has six NRF rated researchers; it collaborates with a wide range of established researchers. Its key focus areas are fish behaviour, fish monitoring and tracking, taxonomy, population genetics, systematics, estuarine biology, coastal ecology, biodiversity conservation, ichthyology, fisheries management, invasion biology. It is involved in ACCESS and contributes to global change research.</p>	
South African National Biodiversity Institute	<p>SANBI has seven NRF rated researchers with expertise in climate change, biodiversity, modeling, earth system sciences, molecular biology, biogeography, invasion biology, conservation and conservation management, ornithology, environmental observation, population ecology. SANBI co-ordinates the Long Term Adaptation Strategy Research and works with national climate change researchers on climate change research. The CEO of SANBI serves on the Future Earth Board / Steering Committee.</p>	

University	Nodes of Expertise	Centres of Expertise and Centres of Excellence (where these were identified)
Applied Centre for Climate and Earth System Sciences (Centre of Excellence)		ACCESS Centre of Excellence (which has been established for a while now, and which works across a number of universities), using a number of research themes, each of which is led by leading research/ers from the participating institutions in ACCESS. ACCESS also runs an innovative student summer school programme named the 'Habitable Planet' which crosses universities and involves students offering training to other students, supported by core staff at ACCESS, and using a curriculum that has been developing over time to be more inclusive of different disciplines, making the programme more interdisciplinary. The ACCESS CoE has the following research themes which bring together researchers from the CSIR, and universities across the country: Biogeochemistry and Earth System Modeling; Seasonal / inter-annual climate predictability; Long term climate and impacts; Water Resources; Marine and Coastal Estuarine Systems; Urban and Rural Land cover and Land use; Ecosystem Services and Livelihoods. (Dr Sweijd, Director ACCESS)

NOTE: Only relevant contact details for researchers associated with the research centres, institutes and/or centres of excellence – as established with best available information at the time of the mapping study (2013) are included in the South African mapping study Country Report (see Volume 2). Further contact details relevant to specific expertise areas in each university can be found on the NRF rated researchers database (www.nrf.ac.za) which is updated annually and published online.

South Africa has a relatively well-developed institutional framework for research overall, and for CCD research. However, this system is still in development, and has only really been functioning for the past five years under the National Energy Grand Challenge and the Global Change National Grand Challenge research frameworks. As noted in the National Climate Change Response White Paper, further impetus is needed to strengthen the Science and Technology infrastructure for climate change and CCD research. The proposal for a foresight study, and the possible establishment of a Climate Change Science Council are promising in this regard, as are current funding commitments to developing Centres of Excellence (such as the Applied Centre for Climate and Earth System Sciences), the African Environmental Observation Network (AEON), the South African Environmental Observation Network (SAEON) and a number of SARCHI Chairs that focus on global change / CCD related research themes.

The South African institutional assessment also revealed that there are a number of new and emerging Centres of Expertise (normally around research chairs) in institutions and new Centres of Excellence emerging (normally around expansive university and other stakeholder partnerships) that can potentially provide strong platforms for CCD knowledge co-production in future.

The institutional assessment revealed that the 23 South African universities are almost all engaged with some form of research that is relevant to CCD (see Table 14). However, the institutional assessment also revealed that research capacity across the South African university system is *highly unequal*, with some universities such as the University of Cape Town, the University of Pretoria, the University of Stellenbosch, the University of Johannesburg, the University of KwaZulu-Natal, the University of the Witwatersrand and Rhodes University having more capacity for CCD related research than others. This inequality mirrors historical inequalities in the South African university system. There is, however, a concerted effort at government level to support historically disadvantaged universities to become more involved in CCD research and three Risk and Vulnerability Assessment Centres have been placed at the University of Fort Hare, the University of Limpopo and the University of Venda. The University of the Western Cape is also actively developing its Life Sciences research capability and has recently opened a new Life Sciences building with state of the art facilities, and in the recent round of bidding for SARCHI research chairs UWC was awarded seven research chairs.

The institutional assessment was not able to probe the full range of courses being offered in CCD related fields in South African universities due to the scope of the task. However, the Department of Environmental Affairs Environmental Sector Skills Plan for South Africa (DEA, 2010) showed a 'groundswell' of new environmental courses being developed in and across all of South Africa's universities with almost every university having a Department of Environmental Sciences (which would not have been the case 20 years ago). Interesting however, is that CCD related courses are not only confined to the Departments of Environmental Sciences, and are instead emerging across a range of disciplinary contexts. There are also examples of courses that are explicitly multi- and transdisciplinary in their construction, especially at Masters level.

Questionnaire data, although limited to 40 respondents, showed that there were some interesting curriculum innovations occurring in response to sustainability and CCD related issues most notable amongst these are the University of Stellenbosch's Tsama Hub Transdisciplinary PhD programme, the University of Stellenbosch MPhil in Sustainable Development (which is multidisciplinary); the University of Cape Town's MSc/MPhil specialising in Climate Change and Sustainable Development, the RU Environmental Learning Research Centre's MEd and PhD programmes that specialise in Environment and Sustainability Education and Social Learning (which includes a CCD focus); UNISA's Exxarco Chair's teaching programmes in climate change, business and the green economy; the University of Free State Masters degree in Integrated Water Resources Management (focus on groundwater); and Disaster Risk Management and the University of KwaZulu-Natal's MSc programmes in conservation, agriculture and water resources management. The University of Fort Hare's Agricultural Degrees, and the University of Limpopo also have programmes on offer that address CCD related concerns notably the Agricultural, Environmental and Geographical Sciences. The University of the North West has strong environmental law and governance programmes in place which includes climate law, while the University of Pretoria has conservation, environmental management and sustainable development and built environment degree and post-degree programmes.

Overall this shows that there is a vibrant context of academic innovation for sustainability and CCD is 'alive and well' in South Africa. However, workshop data showed that although academics were engaged in this kind of curriculum innovation, and were obviously able to 'push through' their innovations at systemic level, there was still a tendency to privilege the 'traditional course' or 'disciplinary specialisation' route. It was said that HEI leadership institutions such as the Council of Higher Education (who performed quality assurance functions) and HESA should be encouraged to take an interest in CCD related concerns and that they should actively promote new societal directions and agendas, as they did with the HIV/AIDs issue.

Questionnaire data also revealed that there were a number of student societies actively engaging with environment and sustainability issues in South African universities, and that they were 'networked' with each other via a network called the 'BlueBuck network' (referring to the first antelope to go extinct in SA). The Africa Green Campus initiative was also mobilising cross-institution student engagement and campus management initiatives.

The institutional analysis showed there is an active and emerging engagement with transdisciplinarity, and a number of examples of transdisciplinary research were identified, although these were in various stages of development and the contours of transdisciplinarity in the various projects were still being worked out, theorised and monitored. The NRF's Global Change Society and Sustainability research programme funding actively encouraged transdisciplinary proposals, but they report that only two strong transdisciplinary proposals were presented and approved for funding. Other organisations such as the Water Research Commission and international funding organisations are also beginning to call for transdisciplinary research programme proposals, such as the most recent IDRC Climate Adaptation (CARIA) research programme call, which was awarded to UCT. This is generating interest in transdisciplinary research, also amongst university management involved in the

promotion of research. South African researchers, especially at the research intensive and research led universities are also 'well networked' into international research environments, and are partnering with both regional universities in southern Africa and elsewhere on the African continent, and with international research partners.

The institutional assessment has also highlighted that while an active research community and a relatively strong research infrastructure for CCD research exists in South Africa, it is still inadequate for the scope of demand. The research environment also continues to be affected by ongoing inequalities that exist between institutions, and one of the key priorities in research infrastructure development is to develop a more equitable research environment that benefits all students in all South African universities, and to upscale the research infrastructure for climate change. As shown in the institutional assessment, there is capacity for curriculum innovation, but this is also unevenly spread, and institutions like the CHE and HESA need to take a stronger leadership role in enabling all universities to engage with new societal priorities such as climate change. Research funding, while available, was also said to be inadequate for the *type* of interdisciplinary, multi-sector and multi-scale research that is required for CCD problems. Technical skills shortages, and lack of adequate supervision capacity (as pointed out in the needs analysis) also hamper knowledge co-production possibilities for CCD.

15 SWAZILAND

15.1 Swaziland needs analysis

15.1.1 Context that frames the needs

Swaziland's observed annual mean temperature has already increased by more than 3°C in the period from 1961 to 2000 in all agro-ecological zones¹⁵⁰, which is considerably above the regional average for southern Africa (which is itself above the global average). The country is already feeling the impacts of climate change, and urgent action is needed on many fronts. As workshop participants noted, "This concerns our survival!"

Within this context, the mapping study needs analysis for Swaziland revealed that despite progress on identifying research and capacity needs in broad terms, the status of CCD knowledge and research will need to be enhanced significantly in both specific and cross-cutting ways to address the considerable observed and projected impacts. In this regard, findings of the Needs Analysis could be helpful in the development of Swaziland's Climate Change Strategy and Action Plan. Consistent with the socio-economic context, overarching barriers to adaptation indicated in all three data sources include low levels of awareness of the threats and opportunities of climate change; limited human resources in a small country; low technological capacity; and availability of the financial resources to address climate adaptation. The workshop and questionnaire responses further identified a range of cross-cutting needs for responding better to CCD, amongst which capacity development, training, enhanced and better resourced research, technology development and innovation, and mainstreaming climate change into policy and ensuring implementation through awareness raising and enforcement, were key.

15.1.2 Broad adaptation and mitigation needs

There is broad agreement amongst the three data sources (policy, workshop, questionnaires) on the *broad priority focus areas for adaptation* – namely, agriculture and food security, terrestrial ecosystems, biodiversity and forestry, and water resources; with some additional emphasis in the questionnaire responses on health and on infrastructure.¹⁵¹ This is not surprising given that Swaziland's key climate vulnerabilities lie in these areas. The data sources also agree on *broad mitigation priorities and needs*, which encompass industry and energy, and Land Use, Land Use Change and Forestry (LULUCF). Concerning the latter, policy notes the need for mitigation measures such as conservation farming, reforestation, regeneration, and bio-electricity, while a few questionnaire responses noted the need for industrial policy and

¹⁵⁰ Swaziland Second National Communication. 2011. p.34.

¹⁵¹ It is assumed that this refers to climate-proofing infrastructure against climate risks such as more intense rainfall and increased flooding.

development to reduce greenhouse gas emissions, without specifically noting desired technologies to achieve this. Both policy documents and workshop data emphasise the need to strengthen and promote renewable energy sources. While the policy documents note the need for mitigation to gradually contribute to moving Swaziland from a carbon source to a carbon sink after 2030, this issue was not mentioned in other data sources.

15.1.3 Specific knowledge and research gaps

In the Second National Communication, research capacity gaps were mainly focused on agricultural adaptation, while workshop discussions and questionnaires raised a broader range of specific knowledge and research gaps related to Swaziland's projected key impacts. While no significant change in the total precipitation is projected for Swaziland, distributional changes will be key drivers of risk and vulnerability; thus there will be more flooding and drought events, and increased trends in impacts that have already been observed: wild fires, dry weather, storms, floods and strong winds. Thus, consistent with these projected impacts, workshop and questionnaire data highlighted the need for observational data to underpin climate assessments of impacts and vulnerability on water resources, agriculture, biodiversity and the health sector; as well as data to underpin such assessments in the energy, industry and waste sectors. Local-level vulnerability mapping is a key knowledge/research gap; as is testing of relevant technologies for climate adaptation and mitigation. Specific research gaps highlighted in the areas of agriculture and forestry included the development of drought-resistant crops, exploration of agricultural technology for climate change adaptation, afforestation technologies and sustainable forest management. Other prioritised research gaps included tropical disease control and the effects of climate change on this; and climate change compatible building technology and town planning methods, as well as the use of indigenous knowledge systems in addressing climate change challenges.

Key further points concern the need for urgent action on the ground to enhance the climate resilience of many marginal livelihoods, in which indigenous knowledge systems (IKS) are felt to have an important role to play. Also important are integrated adaptation/ mitigation approaches – e.g. conservation agriculture, which are already being tested and implemented in Swaziland, with some research, teaching and outreach activity in this regard.

15.1.4 Cross-cutting needs

Key cross-cutting needs are the need for better coordination, knowledge management, flow of and access to information, and packaging information appropriately. Cross-cutting educational priorities included addressing the lack of research programmes and curricula specifically targeted to climate change, leading to superficial treatment in courses and concerns over the few climate change-related Masters or PhDs available. Inhibiting factors affecting climate change and CCD-related research included a lack of collaboration within and between sectors and disciplines. Specific points included developing adequate data capture, storage and information on climate change in Swaziland, and methods for using data to establish baselines, that could be developed through observational data and linked to indigenous knowledge.

15.1.5 Notable themes

Emerging from the Swaziland workshop and questionnaire data was the importance of exploring the *potential contribution of indigenous knowledge*, integrated with scientific methods, for responding to climate change. It was also felt that the response to climate change should be demand driven, location specific and participative – thus there is a need for *localisation of data and research*. In addition, there is a need not only for awareness raising and capacity development but also for *empowerment* of Swazis to become more resilient to current and future climatic changes.

15.1.6 Individual capacity gaps

The Needs Analysis has shown that while the SNC focused largely on the needs of the Meteorological Department as National Focal Point for Climate Change, an overall point in workshop and questionnaire data was the need for a broadened understanding of climate change and its impacts, with concerns about the insufficient number of suitably trained and skilled people. More detailed individual capacity gaps included the need to develop skills for systematic observation and modelling of climate change; the technical competence of key officials involved in assembling and interpreting climate data; the capacity to translate and transmit expert knowledge to local communities; and project preparation skills and the ability to mobilise financial support. Gaps clustered around the area of community outreach and education included targeted training of extension officers and building capacity at the community level, especially of community leaders who are the land allocators. Improved collaborative capacities are required at different levels, as is improved leadership and management skills across institutions, and enhanced political will to address the scale of the challenges.

15.1.7 Institutional capacity gaps

Specific institutional capacity gaps emerging from documentation, the workshops and questionnaire responses show an overall lack of institutional capacity on climate change issues, which is not surprising for a small country with a limited skills base. There is consensus across the data sources on the need to *consolidate and reinforce adaptation and mitigation research* in general, and to develop active *information sharing mechanisms* for accessing existing information technologies. Lack of postgraduate research and an ill-equipped National Research Foundation, together with insufficient research funding, may contribute to the situation noted in which policy development does not seem to be informed by research. *Financial resourcing* was a priority gap highlighted, specifically to improve the distribution of the country's weather observation station network. In addition to this *policy and legislative frameworks*, operationalised under a single framework, are needed to coordinate and consolidate climate change activities in the country. A lack of *clearly defined mandates and responsibilities* has been noted as well as the need for a *consolidated framework for coordination of education, training and public awareness activities* in different sectors on climate change. Overall participants felt that a *mainstreaming of allied CCD elements across all government systems and departments* is needed, which should include *CCD integration in curricula* across all educational levels, as well as other *training and outreach*.

“We need specialists trained on climate change issues, adaptation and mitigation in each and every Ministry or organisation. Universities need to introduce programmes on climate change long term or short term in order to capacitate communities. Communities must be well informed on issues of climate change and survival skills.”

Ministry of Agriculture spokesperson

15.2 Swaziland institutional assessment

This mapping study has identified existing initiatives amongst the higher education institutions (HEIs) in Swaziland and their partners where activities such as research, teaching, policy engagement and community outreach are addressing climate change-related needs. The institutional assessment has shown that HEIs in Swaziland do have expertise and capacity for responding to climate change and moving towards CCD, as do other stakeholders. University-based expertise is summarised in Table 15. However, these areas of capacity for work on CCD will need to be supported through strategic and sustained programmes to enhance, deepen and expand this capacity and expertise. The institutional assessment has identified the need for collaborative research, increased networking, innovative approaches to climate change, and relevant capacity development of academic staff and other stakeholders to unlock these approaches. A critical point highlighted in the study is that knowledge does not necessarily translate into action – we need to understand what unlocks this at different levels – for example, political commitment at the policy level, and empowerment at the community level. Key areas are policy response, behavioural changes, and better interactions such as between communities and researchers, and between policy and praxis.

Table 15: Identified sources of expertise for CCD in Swaziland

University	Nodes of expertise	Centres of expertise	Centres of excellence ¹⁵²	Active CCD related research networks
UNISWA	<p><i>Faculty of Science:</i> Staff associated with the multidisciplinary MSc in Environment Resources Management, which includes a dedicated climate change component Geography, Environmental Science and Planning: research on various CCD-related matters, including management of forest fires</p> <p><i>Faculty of Agriculture:</i> organic farming and vegetable production in horticulture programme; investigating and incorporating conservation agriculture and local indigenous knowledge systems that could inform new mitigation solutions</p> <p><i>Faculty of Social Science, Sociology Department:</i> doing commissioned research on crop diversification and climate change for UNDP; broader interest in range of CC-related issues</p>	<p>RCE Swaziland: Regional Centre of Expertise (RCE) in Education for Sustainable Development Coordinating ESD activities and processes in the country; ESD training and capacity building; Developing innovative methods of education in all sectors and levels of education; Reviewing and reorienting curricula towards ESD; Developing a resource facility for storage and retrieval of information on ESD; and Providing a forum for the sharing of ideas, expertise and experiences on ESD implementation. Working with SADC Regional Environmental Education Programme (SADC REEP)</p>		<ul style="list-style-type: none"> ■ Renewable Energy Association of Swaziland (REASWA) ■ EEASA (Environmental Education Association of Southern Africa) ■ OSSREA (Organisation of Social Science Research in Eastern and Southern Africa) ■ CGIAR (Consultative Group on International Agricultural Research) ■ ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) ■ African Technology Policy Studies Network (ATPSN)
William Pitcher College	Geography Department: teaching and research on sustainable development and climate change			

¹⁵² No relevant formal SADC Centres of Excellence located in Swaziland could be identified via web searches.

University	Nodes of expertise	Centres of expertise	Centres of excellence ¹⁵²	Active CCD related research networks
Southern African Nazarene University (SANU)	Curriculum development – currently integrating ESD and CC issues; at the consultative stage of introducing a degree on sustainable development			

Note: This analysis is based on best available evidence. With further information and evidence, it can be expanded, and also used for monitoring and updating of CCD expertise in Swaziland. Relevant contact details for researchers associated with this table – as established with best available information at the time of the mapping study (2013) are included in the Swaziland mapping study Country Report (see Volume 2).

Student-based centres with potential for enhancing knowledge and awareness of climate change and CCD in Swaziland were identified as being:

UNIGEP (University of Swaziland Geography Environmental Science and Planning Society): is an environmental organisation for University of Swaziland students (both current and former) in the Department of Geography, Environmental Science and Planning.

UNISWA's Green team: Student initiated organisation aimed at educating, improving knowledge and understanding sustainability through diverse programmes with the aim of increasing awareness about the space we live in and general health

Stakeholders in Swaziland firmly located climate compatible development (CCD) within the umbrella of sustainable development. They identified a critical role for transdisciplinary research, and other forms of knowledge co-production, in mediating between scientific and other knowledge systems, such as IKS. Universities and training colleges classified CCD-related activities according to areas of teaching, research and service. UNISWA has a stand-alone graduate course on climate change titled "*Climate Change and Environment*" in its multidisciplinary MSc Environment and Resources Management (ERM) programme. Moreover, UNISWA, its affiliated training colleges and SANU (Southern Africa Nazarene University) have several undergraduate and graduate courses in which, while climate change is embedded in the course, the specific focus of teaching is not climate change.

The institutional assessment has revealed that capacity development of the wider CCD related research community in Swaziland is needed. Although useful starts have been made in integrating climate change into a number of university course, a wider more transdisciplinary and collaborative capacity development programme is needed, that addresses the social process capacity needs in response to climate change among other needs specifically in curriculum development, food security, water and energy infrastructure, and cross-cutting issues between biodiversity, agriculture, water resources, forestry and health. Key areas identified for UNISWA include curriculum development and innovation, research, and community engagement.

The institutional assessment highlighted that it was extremely important for universities to go beyond standard teaching, so that they could be located within key climate change dialogues. Modalities identified included short courses for climate change professionals, as well as capacity development interventions that target youth and communities. This could include technical skills and translation of CCD knowledge into tangible and meaningful information for communities.

16 TANZANIA

16.1 Tanzania needs analysis

16.1.1 Context that frames the needs

Tanzania has observed increasing frequency and severity of droughts, as well as increased flooding and tropical storms in recent decades. Despite projections for an overall increase in rainfall, the country has detected a statistically significant decrease in rainfall, as well as increasing inter-annual variability. Observed average temperature has increased by 1°C since 1960, with projections of up to 4.5°C increases, or higher, by the end of the century, should global emissions rates not decrease radically. The country is highly vulnerable to increasing climate variability and climate change, given the high dependence on natural resources of the economy and of most people's livelihoods, and its high levels of poverty. Shortages of food and increase malnutrition could hit the country hard. As participants in the mapping study stated, "Climate change concerns survival". The study has revealed that while understandings of CCD differ amongst and between stakeholders and university staff involved in the field, there is generally a close conceptual association between climate compatible development and adaptation and mitigation, and climate compatible development and sustainable development.

Within this context, the needs analysis for Tanzania revealed that despite some significant existing expertise, as well as good prospects for emerging expertise in the field, CCD knowledge and research will need to be greatly enhanced in both specific and cross-cutting ways to address the considerable observed and projected impacts. In this regard, findings of this study could be helpful in the future implementation of the 2012 National Climate Change Strategy (NCCS), as well as related policy development and implementation for mainstreaming climate change.

16.1.2 Broad adaptation and mitigation needs

The mapping study revealed support across all data sources for the broad adaptation strategies prioritised in the NCCS, namely water resources, coastal and marine environment, forestry, wildlife, agriculture and food security, human health, tourism, energy, industry, livestock, fisheries, infrastructure, human settlements and land use. Workshop and questionnaire responses highlighted additional broad priority areas in the important role of ecosystems services, as well as education and communication. The mapping study found consensus between all three sources of data that while the focus should be on adaptation, given its negligible GHG emissions, Tanzania can participate in mitigation activities to contribute to its sustainable national development. Mitigation priority areas include land use, agriculture and forestry, energy, transportation systems, and waste disposal activities.

16.1.3 Specific knowledge and research gaps

The mapping study data shows that key **knowledge gaps** focus on improving the curricula, baseline information, long term, developing a climate change database; improving the balance

between conservation and tourism development; decreasing the rate of GHG emissions due to deforestation and forest degradation; improving agronomy practices and improving technological knowledge. The **research gaps** highlighted in this study focus on biodiversity, agriculture, food security, modelling, and water resource management primarily, but also concern issues of sea level rise, coastal development, tourism, disaster risk management and specific energy related mitigation.

16.1.4 Cross-cutting needs

Information and data-related gaps include inadequate baseline information, lack of long-term data and time series data, inadequate climate projections and weather prediction, the need to digitise data that does exist, and lack of a climate change database to house relevant information. Overall the need to harmonise and consolidate research efforts in Tanzania was highlighted, as well as raising awareness, improving the curricula content relating to climate change and CCD, and research in this regard.

16.1.5 Notable themes

Participants in the Tanzanian mapping study placed emphasis on the role of indigenous knowledge in climate proofing agriculture and food security, as well as the critical role of ecosystem services for enabling both adaptation and mitigation, and in underpinning the important tourism industry. There was also a focus on the need to design CCD research so that it addresses the needs of poor and marginalised communities; this was also specifically related to the need for integrated adaptation-mitigation approaches, so that mitigation initiatives such as REDD+ do not impact negatively on access rights and livelihoods of people.

16.1.6 Individual capacity gaps

The mapping study shows that in order to further enhance co-production possibilities in Tanzania, a wide range of individual capacities need attention. These include more specific, technical or disciplinary gaps, such as climate change observation and climate modelling, GIS skills, EIA competencies, biotechnology, environmental regulations enforcement, climate change expertise in the tourism sector, fire modelling experts in forest ecosystem management, and a range of individual capacities in the area of climate change and agriculture. More cross-cutting individual capacities required are financial and resource mobilisation, monitoring and evaluation competencies, technology management competencies, conflict resolution skills, information sharing and database management capacities. In general, more climate change and CCD-informed managers, researchers, service providers and modellers are required.

16.1.7 Institutional capacity gaps

The mapping study found that knowledge co-production for CCD requires developing institutional capacities for improved multi-sectoral coordination and collaboration, policy harmonisation and enforcement, and integrated approaches to development. An effective research-policy interface would be critical for science-based and evidence-based decision

making. To address the identified needs, teaching facilities and curricula need to be extended and better institutional repositories information centres developed. In addition, conflicting institutional mandates were identified as a key institutional capacity gaps.

16.2 Tanzania institutional assessment

This mapping study has identified existing initiatives amongst the HEIs in Tanzania and their partners where activities such as research, teaching, policy engagement and community outreach are addressing climate change-related needs. The study has shown that HEIs in Tanzania do have relatively good expertise and capacity for responding to climate change and moving towards CCD, as do other stakeholders. Active researchers identified in this mapping study are listed in Volume 2 and CCD areas of expertise in Tanzania, mainly with respect to universities, are summarised in Table 16.

Critical issues to address in Tanzania in a broad sense are the need to create an effective research-policy interface, to enable science-based and evidence-based decision making, as well as the need to design research on CCD to address needs of poor and marginalised communities. The need for greater collaboration and integration was highlighted, both in research and implementation. For example, participants in the mapping study stressed that an integrated approach to adaptation and mitigation was required to ensure that mitigation interventions (e.g. REDD+) do not impact negatively on access rights and livelihoods of people – i.e. to avoid maladaptation. A critical issue is the establishment and strengthening of linkages between R&D institutions, academia and the productive sectors' activities.

Specific enablers for knowledge co-production per sector provided some key insights into enabling more collaborative research in Tanzania. Governments were suggested to make environmental education mandatory in the education system, provide regulatory frameworks to deliberately integrate policy and research; encourage stakeholder collaboration; harmonise the policy into national climate change response strategy; approach policy implantation from the bottom up and empower communities to run their own projects in CCD. Governments were also suggested to involve universities and the private sector in policy making and also embrace traditional and indigenous knowledge systems in these activities. Participants felt the donors could encourage knowledge co-production by providing financial support through grants rather than loans; collaborate with NGOs, universities and government; should have a clear agenda and interest in CCD projects and should try to be more flexible and accommodate the researched needs and development in this area. Despite these suggested enabling conditions, universities were seen to hold the most important responsibility in enabling knowledge co-production, particularly in creating environments for multi-, inter-, and transdisciplinary research.

National stakeholders and university stakeholders seemed to have a strong understanding of the need for CCD and the needs and potential gaps in future CCD responses. Of interest are their interpretations of the priorities and needs, which are diverse and cover a range of areas, that relate somewhat to their disciplines or mandates, but also extend further beyond their specific interests, revealing the interdisciplinary and multi-sectoral nature of climate change. The combination of an engaged growing legislative movement and a broadening

understanding of the particular needs for climate change and CCD in Tanzania makes a fertile environment for the development of co-production possibilities. Even with the growing engagement of government, participants felt this was not enough and a more attentive, motivated and well-resourced approach was required from government. Alongside this, improved transfer of knowledge and dissemination of research and more dedicated funding and resourcing of CCD in Tanzania were highlighted. In further developing knowledge co-production opportunities, two key priority areas were established. These included curriculum development/ awareness raising and improved involvement of government and policy makers in revising and expanding legislation for CCD.

The need for improved institutional support seemed to be the greatest area of concern among participants in the mapping study, as also supported by policy documents such as the 2003 Initial National Communication to the UNFCCC. Mechanisms are particularly needed for institutions to fully support, nurture and enable collative forms of inquiry, and knowledge co-production projects, particularly in curriculum development. This will require improving the information management systems available in the country; enforcement/ implementation of policies and strategies as well as promoting and supporting inter-institutional cooperation.

Generally, then, an integrated approach to knowledge, research, individual and institutional capacity development is needed in Tanzania where improved resourcing, and more active and attentive government and legislative support is offered. This will allow appropriate research agendas and curriculum development to occur, further enabling the wider climate change and CCD related research community in Tanzania, and ensuring that positive relevant developments are enabled through climate change projects, such as the creation of a climate change observatory for Tanzania, which is an outcome of the 2012 – 2017 Adaptation Fund programme.¹⁵³ A key initial step could be to develop a clear set of national research priorities for CCD in the country, as well as strategies to enable research on these. A potential sectoral model for this lies in the Tanzania National Health Research Priorities for the period 2013 – 2018, as developed in 2013 by the National Institute for Medical Research.

¹⁵³ The programme is entitled 'Implementation of Concrete Adaptation Measures to Reduce Vulnerability of Livelihoods and Economy of Coastal and Lakeshore Communities in Tanzania'.

Table 16: Identified sources of expertise for CCD in Tanzania

University/ organisation	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
University of Dar Es Salaam (UDSM)	<p><i>Faculty of Science:</i> Department of Geography: several researchers working on local knowledge and CC</p> <p><i>Faculty of Education</i></p> <p><i>Faculty of Agriculture</i></p>	<p><i>UDSM Institute of Resource Assessment:</i> Wider experience on CCD related research projects; housing Centre for Climate Change; Masters Programme; Secretariat for REDD</p> <p><i>UDSM Institute of Marine Science (Zanzibar),</i> also houses Tanzania National Oceanographic Data Centre</p> <p><i>Sokoine University of Agriculture Centre for Ecosystem Analysis and Climate Change</i></p> <p><i>Tanzania Meteorological Agency (TMA):</i> has two departments dealing with climate change, with more than six PhDs, more than 30 people with Masters degrees; range of CC skills including dynamical downscaling</p>	University of Dar es Salaam: Mwalimu Julius Nyerere Professorial Chair: Environment and Climate Change, held by Prof. Pius Yanda	<ul style="list-style-type: none"> ■ Forum CC Tanzania ■ Zanzibar Climatic Change Alliance ■ OSSREA Tanzania chapter (Organisation for Social Science and Research in East Africa) ■ START ■ Tanzania Natural Resource Forum ■ Institute for Environment and Sustainable Development ■ Lawyers Environmental Action Team-LEAT

University/ organisation	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
Sokoine University of Agriculture	<i>Department of Forest Biology,</i> other departments: group of active and experienced researchers working on ecosystems and CC, IK on CC, vulnerability assessments, management of natural resources for sustainable agriculture	<i>Prospective: Tropical Research Centre for Oceanography, Environmental and Natural Resources (TROCEN), located in State University of Zanzibar, School of Natural and Social Sciences. Newly established, will have multidisciplinary focus; training hub</i>		

Note: This analysis is based on best available evidence, within the constraints of the mapping study. With further information and evidence, it can be expanded, and also used for monitoring and updating of CCD expertise in Tanzania. Relevant contact details for researchers associated with this table – as established with best available information at the time of the mapping study (2013) are included in the Tanzania mapping study Country Report (see Volume 2).

17 ZAMBIA

17.1 Zambia needs analysis

17.1.1 Context that frames the needs

Climate change has multiple impacts at diverse scales on both the economy and on people's livelihoods. Zambia has already observed a 2°C rise in temperature over the past 50 years, which is significantly higher than the global average, and has further experienced flooding and decreased potential for hydropower. Projections are for up to a 6°C increase by 2100, substantial increases in the frequency of hot days and nights, and increased rainfall intensity.¹⁵⁴ Workshop participants emphasised that climate change is a major threat to sustainable development in Zambia. Attaining CCD will require coordination of all of the pillars of sustainable development, as well as integration of current and future climate risks, necessitating actions across sectors and disciplines. Existing mechanisms and capacity are insufficient to deal with the complex and diverse climate issues, which will require a strategic, coordinated and harmonised approach to increase the effectiveness of actions. The identified general mismatch between the existing supply of skills and the demand in the labour market exacerbates this situation. As noted in the 2010 National Climate Change Response Strategy (NCCRS) and upheld by the mapping study findings, the critical overarching shortfall is the lack of a coherent approach to tackle the climate change challenge in the development context.

Within this context, the mapping study needs analysis for Zambia revealed that despite progress on identifying research and capacity needs in broad terms, the status of CCD knowledge and research will need to be enhanced significantly in both specific and cross-cutting ways to address the considerable observed and projected impacts. In this regard, findings of the Needs Analysis could be helpful in future policy development and implementation in Zambia.

While Zambian participants in the mapping study were in agreement broadly with the concept of CCD, and strongly exemplified an approach that prioritised both adaptation and mitigation, or framing this often as resilient and low carbon development, several people did highlight that adaptation should be the main priority in the country's development goals, while at the same time embracing the opportunities of cleaner energy and other low carbon technologies.

17.1.2 Broad adaptation and mitigation needs

There is consensus amongst the three data sources (policy, workshop, questionnaires) on the *broad priority focus areas for responding to climate change*, namely integrating adaptation and disaster risk reduction; land use, forestry and wildlife, which includes reducing deforestation and sustainable forest management; water management; health and social infrastructure;

¹⁵⁴ See full Zambia Country Mapping Study in Volume 2 for reference sources for the climate projections.

climate-proofing smallholder agricultural production and diversifying livelihoods; climate-proofing physical infrastructure and transportation systems; and making the economy resilient through low-carbon growth. Mitigation-related priorities centre around ensuring that mitigation actions are implemented in the most greenhouse gas-intensive sectors of land-use (agriculture and forestry), energy, transport and mining, and ensuring that development proceeds using low carbon pathways, including switching to cleaner energy sources such as solar power.

17.1.3 Specific knowledge and research gaps

Knowledge gaps of concern mainly involve mainstreaming climate change adaptation and disaster risk reduction into relevant policy, and programmatic priorities, most noticeably in local development planning. Information sharing was also a significant knowledge gap in Zambia. Significant research gaps focused mainly on resource management research, contextualising research for Zambia and curriculum development. With regard to natural resource management, knowledge and research gaps for Zambian GHG emissions remain a key issue, as there are various forms of land use practices potentially contributing to these emissions. Of particular concern is in the forestry and mining sector, where little research in mining's effect on deforestation, as well as limited research on the role of deforestation on Zambia's GHG emissions. Connected to the Natural Resource Management knowledge, research, capacity and institutional gaps was the role of women in CCD.

17.1.4 Cross-cutting needs

The mapping study found the most significant needs were for training and capacity development in various CCD related fields, including both adaptation- and mitigation-oriented research. Capacity building, networking, collaboration and partnerships (between sectors and stakeholders as well as international and national) were constantly referred to as key priorities, as was the need to strengthen policy and institutional frameworks, as well as decision making processes, even though compared to many other SADC countries Zambia has a variety of relatively well-developed action plans and policies. Policy implementation was also a key concern area, and translating policy implementation from existing policies was discussed regularly in both the workshops and questionnaires. Improvement of research and development regarding forms of sustainable development, particularly energy development was highlighted. Finally curriculum development and integration within schools and higher learning institutions, was a key area explored in both the workshops and the questionnaires.

17.1.5 Notable themes

Emerging from the Zambia workshop and questionnaire data were the importance of contextualising and localising CCD research and technology development to Zambia, which could improve policy development and implementation. Related to the significant youth presence at the workshop, but also supported by the country's demographics, there was considerable emphasis on youth participation in all CCD related actions, particularly in decision processes and policy development. Furthermore, priorities expressed throughout the workshop and questionnaires were not aligned along institutional or disciplinary mandates and

interests, but rather seemed to be well related to the particular needs of Zambia, with regard to youth, energy, the need for increased awareness, education, capacity development, information sharing and partnerships, and development and policy challenges. Valuing, recording, studying and applying indigenous knowledge was a further notable theme.

17.1.6 Individual capacity gaps

The most significant of these were lack of training and capacity development in various CCD related fields, including climate modelling, research, renewable energy technology, carbon marketing, monitoring, reporting, verification, mapping, natural resource management, economic diversification, gender related issues and fundraising. Limited skills to translate strategies into action at the community level constitute a cross-cutting individual capacity gap. Other individual capacity gaps lie in risk assessment and risk management; climate change and adaptation specialists; atmospheric scientists; environmental lawyers and economists; environmental educators; predictive skills and integration.

17.1.7 Institutional capacity gaps

While there appears to be a growing supportive institutional foundation for CCD in Zambia, with new policies, units and networks emerging that support climate change and CCD related research and project action, significant hurdles remain with regard to collaboration, information sharing and partnership development. Specific institutional capacity gaps relate to the need to improve the national weather observation system, for enhanced climate services; and to strengthen disaster risk reduction and management systems. The mapping study data sources consistently highlighted the need for improved financial resources to implement adaptation measures, as well as a well-funded human resource development and comprehensive CCD capacity development strategy.

17.2 Zambia institutional assessment

This mapping study has identified existing initiatives amongst the HEIs in Zambia and their partners where activities such as research, teaching, policy engagement and community outreach are addressing climate change-related needs. The study has shown that HEIs in Zambia do have some expertise and capacity for responding to climate change and moving towards CCD, as do other stakeholders. Active researchers identified in this mapping study are listed in Volume 2, and CCD areas of expertise in Zambia, mainly with respect to universities, are summarised in Table 17. Zambian universities have been central in defining best practices in the area of climate change and CCD, for example through the EERG at UNZA, the DMTC at Mulungushi University and the Biological Sciences department at Copperbelt University. However, as highlighted also by the NCSA, there is in general limited research capacity and expertise on climate change within the country and an insufficient level of contemporary, up-to-date knowledge in certain specialised areas. There is arguably more capacity within the NGO sector. Thus, in order to respond better to new challenges arising in the climate area, and to enhance and deepen the country's implementation of CCD, existing areas of capacity for work on CCD will need to be supported through a range of mechanisms, and broader areas of relevant capacity developed. The various knowledge, research, individual and institutional

capacity gaps offer a substantial route map for the specific needs for higher education institutional CCD development in Zambia. The institutional assessment has highlighted a number of mechanisms for this route map: these include the need for scholarship support for PhD outputs, to enhance, widen and deepen CCD coverage across the disciplines, as well as for making climate change and CCD a compulsory subject in the school curriculum, building on the recent curriculum review. Positive curriculum innovations on CCD identified in this study will need to be built on by mainstreaming climate change and CCD across the range of undergraduate courses, developing new focused postgraduate courses, and ensuring a good match between graduates and the demands of the labour market, including through extra attention to practical aspects of training. This will assist with addressing a fundamental, non-climate change related issue of ensuring greater investment in quality education that leads to decent job creation for Zambian youth, as prioritised in the 2013 national consultations on the Post-2015 Development Agenda in Zambia.

The institutional analysis shows that there is limited experience in knowledge co-production partnerships, while numerous knowledge partners exist for CCD knowledge co-production in Zambia. The mapping study on the whole found the need in Zambia for a collaborative approach to set and implement the research agenda. There is clearly scope for enhanced collaboration on the part of HEIs for CCD knowledge co-production within the country, and with other universities in the SADC region, as well as further afield in Africa. This will require actions to remove the barriers identified in section 5, including through university policy and strategy reform. When discussing the need for efforts from all sectors of society, workshop participants stated that religious organisations should be included too, to partner with HEIs to raise issues of moral and value-based environmental protection, as should traditional leaders, to raise the profile of indigenous knowledge and cultural practices.

Table 17: Identified sources of expertise for CCD in Zambia

University/ organisation	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
University of Zambia	<p><i>Faculty of Science:</i></p> <ul style="list-style-type: none"> Department of Physics – see next column <p><i>Faculty of Education:</i></p> <ul style="list-style-type: none"> Department of Language and Social Sciences Education (LSSE), UNZA – 2nd year Gender and CC course; teaching, research and community outreach on CCD and gender <p><i>Faculty of Agriculture:</i></p> <ul style="list-style-type: none"> Department of Soil Science – adaptive land and water management 	<ul style="list-style-type: none"> University of Zambia, <i>UNESCO Chair in Renewable Energy and Environment</i>; chair is held by Prof Prem Jain; Energy and Environment Research Group (EERG), research and consultancy group in Department of Physics; over 20 years experience. EERG has 3 sub-groups: Solar Energy Materials and Photovoltaic Systems, the Climate Group, and Distance learning in Sustainable Energy Engineering Group EERG leads in integrating CC into undergraduate and postgraduate curricula and institutional mainstreaming of CC. The Climate Group conducts inter alia climate modelling, statistical and dynamical down-scaling, detection and attribution of CC, CC impacts <i>SADC MESA Chair in Teacher Education</i> (mainstreaming environment and sustainability into African universities) <i>Lusaka Regional Centre of Expertise (LRCE)</i> on Education for Sustainable Development, School of Education, Department LSSE (UNZA): multi-stakeholder /institutional; research, community engagement, training and capacity building on ESD 		<ul style="list-style-type: none"> Zambia Climate Change Network (ZCCN) Lusaka Regional Centre of Expertise The UN-REDD Programme–Zambia Quick Start Initiative Environmental Council of Zambia, which plays a key role in coordinating the National Communications to the UNFCCC Southern Africa Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL)

University/ organisation	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related research networks
Copperbelt University		Vulnerability and other climate-related research in the Biological Sciences department; progress in integrating climate change into the environmental engineering and biological studies curricula		
		<i>Ministry of Science and Technology - National Remote Sensing Centre</i> : involved in SASSCAL climate change adaptive land use programme with many components. Remote sensing for UN REDD+ programme through forestry dept. provides internships for undergraduate students, providing technical support to MSc and PHD students		
Mulungushi University		<i>Disaster Management Training Centre</i> of Mulungushi University – established centre of excellence in disaster studies in the sub-region; long history of association with the Disaster Management and Mitigation Unit (DMMU)		
	<i>Youth-related initiatives</i> : Several groups involved in increasing engagement of youth in CC and CCD-related activities, e.g. ZEN and Unicef Climate Ambassadors; require additional support			

Note: This analysis is based on best available evidence, within the constraints of the mapping study. With further information and evidence, it can be expanded, and also used for monitoring and updating of CCD expertise in Zambia. Relevant contact details for researchers associated with this table – as established with best available information at the time of the mapping study (2013) are included in the Zambia mapping study Country Report (see Volume 2).

18 ZIMBABWE

18.1 Zimbabwe needs analysis

18.1.1 Context that frames the needs

Zimbabwe is experiencing increases in temperature, recurrent droughts and unpredictable rainfall patterns, according to the Southern African Risk and Vulnerability Assessment report (2012). The warming trend is already established, with an increase of at 0.4°C since 1900, with the last decade of that century as the warmest. Rainfall declined by 5 percent during the twentieth century, with the driest years experiencing in the 1990s. The country is experiencing more hot and fewer cold days than before as a result of climate change and variability. The projected rates of warming range from 0.15 - 0.55°C per decade, with higher temperature changes in the dry seasons compared to the wet seasons. Increasing temperatures of around 2.5°C by 2050 have been projected. Rainfall is predicted to decrease in all seasons; this is more conclusive for the early and late rains than for the main rainy season months of December to February.

Within this context, the mapping study needs analysis for Zimbabwe revealed that despite progress on identifying research and capacity needs in broad terms, the status of CCD knowledge and research will need to be enhanced significantly in both specific and cross-cutting ways to address the considerable observed and projected impacts. In this regard, findings of the Needs Analysis could be helpful in the further development and implementation of Zimbabwe's National Climate Change Policy which is currently in draft form. Consistent with the socio-economic context, overarching barriers to adaptation indicated in all three data sources include informational barriers: brain drain, inadequate research and development facilities, low levels of awareness about climate change. There are also political and institutional barriers which include inadequate planning capacity and weak institutions; socio-cultural barriers which include resistance to adoption of biogas cooking technologies; and financial barriers which emerge from the recent economic crisis in Zimbabwe.

18.1.2 Broad adaptation and mitigation needs

There is broad agreement amongst the three data sources (policy, workshop, questionnaires) on the *broad priority focus areas for adaptation* – namely, agriculture and food security, biodiversity and forestry, rangelands, water resources, human settlements and tourism, and economic planning (infrastructure). This is not surprising given that Zimbabwe's key climate vulnerabilities lie in these areas. The data sources also agree on *broad mitigation priorities and needs*, which encompass industry and energy, waste, and land use and forestry (reforestation and afforestation). Concerning the latter, policy notes the need for mitigation measures such as conservation farming, reforestation, regeneration, and bio-electricity, while a few questionnaire responses noted the need for clean technology and improved industrial policy and development to reduce greenhouse gas emissions. Both policy documents and workshop data emphasise the need to strengthen and promote renewable energy sources. A number of cross-cutting policy issues are also identified for adaptation and mitigation – especially

capacity building, research and technology transfer, education and awareness raising, and governance.

18.1.3 Specific knowledge and research gaps

Research capacity gaps were mainly focused on climate sciences, observation and modelling, water, land use and forestry and agriculture, biodiversity and forestry, mining and health. Knowledge needs associated with these issues include for example risk analyses and modelling to predict the various climate change scenarios on water availability and on the various use sectors; yield assessments for surface and groundwater systems; exploration and analysis of ground water resources; development of information systems to capture and manage land use changes, development of instruments for accounting for carbon stock changes; modelling and prediction for timescales between weather forecasts and seasonal forecasts; establishment of a strong national monitoring system and network; and improved early warning systems. From an Agriculture perspective the following knowledge and research gaps were identified: research gaps on varietal and breed adaptation to drought and heat resistance; poor information on stress physiology; limited knowledge of choice of water harvesting technologies and relationships between these choices and soil types.

Overall there was a strong view that Zimbabwe had limited knowledge of indigenous knowledge systems and what they could potentially offer to improved natural resources management and change adaptation. Workshop participants also noted a lack of adequate knowledge on disaster management, and health related concerns. There was also a strong feeling that more research was needed on the efficacy of the education and training system, and how it is dealing with CCD issues.

18.1.4 Cross-cutting needs

Key cross-cutting needs are the need for better coordination, knowledge management, flow of and access to information, and packaging information appropriately. Cross-cutting educational priorities included addressing the lack of research programmes and curricula specifically targeted to climate change, leading to superficial treatment in courses; and concerns over the few climate change-related Masters or PhDs available. Inhibiting factors affecting climate change and CCD-related research included a lack of collaboration within and between sectors and disciplines. Overall there was a clear need for improving education and training processes, curriculum development and curriculum innovation, and working more effectively with indigenous knowledge.

18.1.5 Individual capacity gaps

The Needs Analysis has shown that there is concern about the insufficient number of suitably trained and skilled people. More detailed individual capacity gaps included the need to develop skills for systematic observation and modelling of climate change; the technical competence of key officials involved in assembling and interpreting climate data; the capacity to translate and transmit expert knowledge to local communities; and project preparation skills and the ability to mobilise financial support. There were also a number of gaps clustered

around the area of community outreach and education, which included targeted training of teacher education, training of extension officers and building capacity at the community level, especially of community leaders. Improved collaborative capacities are required at different levels, as is improved leadership and management skills across institutions, and enhanced political will to address the scale of the challenges. Other specific individual capacity gaps identified include: Community health workers with CCD expertise, experts in disaster management and preparedness, Nutritional scientists, Soil Scientists and Biological Scientists, Skin problem dermatologists, Renewable Energy experts, Zoology and Botany specialists, Siviculturalists, Foresters, experts with breeding biotechnology expertise (amongst others).

18.1.6 Institutional capacity gaps

Specific institutional capacity gaps emerging from documentation, the workshops and questionnaire responses show an overall lack of institutional capacity on climate change issues, which is not surprising given the recent economic issues facing Zimbabwe. There is consensus across the data sources on the need to *consolidate and reinforce adaptation and mitigation research* in general, and to develop active *information sharing mechanisms* for accessing existing information technologies, and for making meteorological data more available to researchers. Lack of adequate research facilities and funding was a key institutional issue identified, as well as a loss of capacity due to movement of skilled academics during the economic crisis. In addition to this *policy and legislative frameworks*, operationalised under a single framework, are needed to coordinate and consolidate climate change activities in the country, and it was felt that there was a need for stronger impetus for policy implementation. Overall participants felt that a *mainstreaming and consolidated co-ordinated approach of allied CCD elements across all government systems and departments* is needed, which should include *CCD integration in curricula* across all educational levels, as well as other training and outreach programmes, especially into the extension services.

18.2 Zimbabwe institutional assessment

The aims of the Science and Technology Policy, which provides an important relevant research framework for CCD, include the promotion of rapid and sustainable development, and environmentally sound development programmes. The Ministry of Science and Technology, the Research Council of Zimbabwe (RCZ), and the Zimbabwe Scientific, Industrial Research and Development Centre (SIRDC) provide leadership on research matters in Zimbabwe, but it seems that there is still a need to strengthen CCD related policy and practice interventions in these institutions, and workshop participants were hopeful that the new climate change policy (currently in draft form) would have an influence on the uptake and prioritisation of CCD research via these structures.

This mapping study identified existing initiatives amongst the HEIs in Zimbabwe and their partners where activities such as research, teaching, policy engagement and community outreach are addressing climate change-related needs. The institutional assessment has shown that higher education institutions (HEIs) in Zimbabwe do have expertise and capacity for responding to climate change and moving towards CCD, as do other stakeholders. Best available knowledge of university-based expertise as identified in this mapping study is

summarised in Table 18. The institutional assessment also showed that Zimbabwean researchers are publishing their CCD research in the international literature which shows a 'strong research presence' from Zimbabwe on climate change which is feeding into regional and international knowledge on climate change responses, especially in the agriculture and fisheries sectors. There are also strong clusters of researchers working on community-based adaptation; social-ecological system and wildlife management related CC issues; and biomedical research; but agricultural adaptation research stands out as a key research strength in Zimbabwe. NGO organisations such as ZERO (Zimbabwe Regional Environmental Organisation) and a number of development research organisations (that are also linked to and associated with the University) such as the Centre for Applied Social Sciences (CASS-Trust; affiliated to the Social Science and Humanities Faculty) also undertake climate change research. The Institute of Environmental Studies at the University of Zimbabwe was appointed to lead the development of a National Climate Change Response Policy and Strategy.

While this is the case, there was still a strong agreement in the workshop that the existing areas of capacity for work on CCD will need to be substantially expanded and supported through strategic and sustained programmes to enhance, deepen and expand this capacity and expertise, especially in the light of the severity of the climate related issues facing Zimbabwe, as reported in the Needs Assessment. The institutional assessment has identified the need for collaborative research, increased networking, innovative approaches to climate change, and relevant capacity development of academic staff and other stakeholders to unlock these approaches; as well as greater access to meteorological data. A critical point highlighted in the study is that there is a need to consider how CCD research can contribute to economic development and employment opportunities, especially for youth, and that knowledge does not necessarily translate into action – we need to understand what unlocks this at different levels – for example political commitment at the policy level, and empowerment at the community level. There was a strong sense that greater use should be made of indigenous knowledge as a means to bridge university and community knowledge, policy and practice.

Key areas are policy response, behavioural and social changes, and better interactions such as between communities and researchers, and between policy and praxis. Workshop participants felt that, even with growing engagement of government, government could further enhance improvement of CCD, especially in enabling cross-sectorial collaboration and knowledge exchange. More dedicated funding and resourcing of CCD research were also highlighted as important enabling factors, as was the need to develop a 'new generation' of academics as many experienced academics had left the country during the economic downturn.

Workshop data showed that there was strong support for developing more PhD scholars, and there may be the need to encourage further PhD research in climate change and CCD related fields in Zimbabwe, especially since workshop participants reflected that many experienced academics from Zimbabwe had left the country due to the economic downturn. A number of academic researchers have also joined consultancy companies as the remuneration is potentially higher than in universities, and there is a fluid relationship between university academics and consultancy organisations. Zimbabwean researchers also tend to be active regionally and contribute to a number of regional programmes, which in turn benefits national knowledge production.

Table 18: Identified sources of expertise for CCD in Zimbabwe

University	Nodes of expertise	Centres of expertise	Centres of excellence ¹⁵⁵	Active CCD related research networks
Harare Institute of Technology (HIT)	<i>Department of Chemical and Process Systems Engineering:</i> Vermiculture technology, coal methane gas extraction and use in power generation; Waste management and disposal site technologies; Sewage waste degradation; Waste to energy		No specific CCD Centres of Excellence were identified, but two Centres of Excellence that are undertaking CC related research in Zimbabwe were identified: ICRISAT, the International Crops Research Institute for Semi-Arid Tropics has a research station in Bulawayo (Matopo Research Station). It is affiliated to ICRAF and other ICRISAT 'hubs' in Africa and in Asia, including those in Mozambique and Malawi. The focus is on drought resistant crop varieties and community-based adaptation. (Director: Andre van Rooyen)	Department of Meteorological Services SADC Drought Monitoring Early warning units – Climate forecast unit level rests in Zimbabwe SADC Regional Environmental Education Programme SARDC – Southern African Research Documentation Centre (linked to Zambia) SWEDESD (Swedish Centre for Education for Sustainable Development) WATERNET / CAPNET Scientific and Industrial Research Centre (SIRDC) – Zimbabwe ZIMVAC – Zimbabwe Vulnerability Assessment
Chinoin University of Technology	<i>School of Agricultural Sciences and Technology:</i> Crop Science and Post-Harvest technology research, focussing on the impact of conservation agriculture on greenhouse gas emissions and carbon sequestration in various soil types. Also studies underway focussing on effect of plant manipulation on water use efficiency in maize; and predicting climate change impacts on fruit growing			
Zimbabwe Open University	<i>Nursing Science:</i> Health threats of climate change <i>Centre for Open and Distance Learning</i>		The Biomedical Research Training	

¹⁵⁵ No relevant formal SADC Centres of Excellence located in Zimbabwe could be identified via web searches.

University	Nodes of expertise	Centres of expertise	Centres of excellence ¹⁵⁵	Active CCD related research networks
	<i>Research and Scholarship:</i> climate compatible waste management research Department of Development Studies		Institute (BRTI) at University of Zimbabwe (www.brti.co.zw), together with the African Institute of Biomedical Science and Technology (AiBST) (www.aibst.com) and other affiliated Centres of Expertise such as the John Hopkins Centre of Expertise in Malaria Research and an international network of centres of expertise in malaria research are focusing on some climate related malaria research. Malaria research is only one focus of the work of these Centres of Excellence, but nevertheless they present a formidable research force with potential to engage with health related CCD concerns.	Committee Research Council of Zimbabwe Zimbabwe Environmental Regional Organisation (ZERO) Matopo and Mokolodi Research Stations (agricultural research stations of government) ZINWA Collaboration of government departments e.g. AGRITEX, Environmental Management Agency (EMA), police World Food Programme ICRISAT (International Crops Research Institute for Semi-Arid Tropics) SADC Vulnerability Assessment Committee SADC Early Warning Unit Zambezi Early Warning Systems SARCOF (Southern African Regional Climate Forecasting) FEWSNET (Famine Early Warning Systems)
Lupane State University	<i>Agricultural Sciences:</i> Animal Science and Rangeland Management; crop science research focussing on improving quality of drought tolerant sorghum varieties			
Midlands State University	<i>Faculty of Natural Resources Management and Agriculture, Department of Agronomy:</i> Capacity building for adaptation to climate variability and climate change			
University of Zimbabwe	<i>University of Zimbabwe and Soil Fertility Consortium for Southern Africa:</i> Measures to enhance the adaptive capacity of local communities to respond to pressures of climate change. <i>Department of Agricultural Economics:</i> Studies on climate change adaptation amongst small holder farmers in districts affected by climate change (e.g. Chiredzi district). <i>Faculty of Education:</i> Education for Sustainable Development and Climate Change Education research and outreach. Climate Change courses also taught and interventions are taking place	<i>Institute of Environmental Studies,</i> established in 1994 as an independent, non-faculty unit. Involved in development of Zimbabwe's National Climate Change Response Strategy and various research projects related to environmental science, sustainable development, rural livelihoods, soil fertility, indigenous soil and water conservation and climate change adaptation. (Director: Prof S.B Feresu)	(Dr S Mharakurwa, BRTI; Dr Coleen Masimirembwa; AiBST).	

University	Nodes of expertise	Centres of expertise	Centres of excellence ¹⁵⁵	Active CCD related research networks
	<p>in teacher education and with schools.</p> <p><i>Faculty of Humanities and Social Studies:</i> Sociological and multidisciplinary research and teaching on human-environment / natural resources concerns, including climate change. Affiliated Centre for Applied Social Science (CASS)</p>	<p>Institute of Development Studies, established in 1982; currently undertaking some research on the economics of climate change, and agricultural adaptations to climate change. (Lead CC researcher: Dr Medicine Masiwa)</p> <p><i>Centre for Applied Social Science (CASS)</i>, located in the Faculty of Social Studies. It is a multidisciplinary research centre undertaking various human-environment related research; including climate change adaptation research focusing on human settlements, infrastructure, community-based natural resource management and indigenous knowledge. (Chairperson: Dr B. Mukamuri)</p>		

Note: This analysis is based on best available evidence. With further information and evidence, it we can be expanded, and also used for monitoring and updating of CCD expertise in Zimbabwe. Relevant contact details for researchers associated with this table – as established with best available information at the time of the mapping study (2013) are included in the Zimbabwe mapping study Country Report (see Volume 2).

Student outreach, campus management and community outreach activities that are seeking to contribute to CCD objectives were found at the Chinhoyi University of Technology, where students were involved in a tree planting and carbon sequestration community outreach project where they worked with local councils and communities to address deforestation problems. The University of Zimbabwe is providing in-service training for teachers in partnership with the SADC REEP, and Zimbabwe Open University are engaged in campus management activities mainly related to waste management. The Harare Institute of Technology has a student organisation called HIT ENVIRO that is involved in various student outreach activities.

Stakeholders in Zimbabwe firmly located climate compatible development (CCD) within the umbrella of sustainable development. They identified a critical role for indigenous knowledge research and more inter- and transdisciplinary approaches to research as ways of bridging the gap between universities and communities, a point that was also strongly emphasised by the Minister who opened the workshop. Universities and training colleges classified CCD-related activities according to areas of teaching, research and service. A number of courses on climate change were being offered in the universities, and it was noted that these were generally integrated into other courses such as a climate change component in Molecular Biology (first-year course), plant breeding methods (fourth-year course), simulation and modelling (third-year course at the Chinhoyi University of Technology in Zimbabwe's Agricultural Sciences and Technology Department. At the Zimbabwean Open University, a second-year course on environmental hazards and human responses was taught in the Geography and Environmental Studies programme, and the University of Zimbabwe was teaching climate change at BEd and Masters level via a Climatology course. Agroclimatology was a specialist area at Lupane State University at both undergraduate and postgraduate levels, and at Midlands State University Agricultural Meteorology was being taught at both undergraduate and postgraduate levels. There was, however, no mainstreaming of CC taking place, and courses were inserted by those who had developed an interest in CCD research. It was felt that much more could be done to improve the scope of CCD courses, and that this should be done in a clearly structured way to ensure progression of learning.

The institutional assessment has revealed that capacity development of the wider CCD related research community in Zimbabwe is needed, and Zimbabwean researchers emphasised the need for expanding their capacity as they felt that whilst they were doing good research, the institutional support was not adequate. Although useful starts have been made in integrating climate change into a number of university courses, a wider more transdisciplinary and collaborative capacity development programme is needed, that addresses the social process capacity needs in response to climate change among other needs specifically in curriculum development, food security, water and energy infrastructure, and cross-cutting issues between biodiversity, agriculture, water resources, forestry and health. Key areas identified for universities in Zimbabwe included curriculum development and innovation, strengthening of research infrastructure, and community engagement.

The institutional assessment highlighted that it was extremely important for universities to go beyond standard teaching, so that they could be located within key climate change dialogues. Modalities identified included short courses for climate change professionals, as well as capacity development interventions that target youth and communities. This could include technical skills and translation of CCD knowledge into tangible and meaningful information for communities.

Appendix B: Methodology description

For a detailed analysis of the research process, workshop participants and findings in each country, please refer to Volume 2 of this series, which comprises 12 individual Country Reports.

19 RESEARCH DESIGN

The country-based Mapping Studies were informed by an interactive and dialogical research design that included document analysis of key national and regional documents focusing on climate change in each country and in the SADC region. This produced an initial analysis which was used to plan for and engage university participants and national organisations involved in the climate change and development arenas in a consultation to discuss a) the validity of the analysis, and b) expanded views and perspectives on the analysis, and to generate further insight into knowledge co-production practice and possibilities for climate compatible development.

The following methods were used to compile the mapping study Country Reports for each country, within an overall interpretive, participatory and consultative and social realist methodology¹⁵⁶:

19.1 Document analysis

A country Background Information Document (BID) was developed to provide a summary of needs, priorities and capacity gaps already identified within key country documents (see below) for climate change, adaptation and mitigation, and in some cases, where this was available, climate compatible development. The BID was developed for each country and used as a source of background information for the stakeholder and institutional consultations held in each country. While the scope of CCD is necessarily wide, the document analysis did not focus on sectoral policy and institutions, but concentrated on overarching policy dealing with mainstreaming climate change into planning and development. The initial document analysis was presented to stakeholders during the workshops, and was revised based on outcomes of the consultations held in the country. While documents reviewed differed in each country, based on availability, in general the following key policy and programme documents were analysed through rapid desk review:

¹⁵⁶ A social realist methodology takes account of knowledge that has previously been established via scientific methods before engaging in consultative and participatory knowledge production processes.

- Initial and/or Second National Communications to the United Nations Framework Convention on Climate Change (UNFCCC);
- National Adaptation Programmes of Action (NAPA);
- UNDP Country Climate Change Profiles on the specific countries;
- National Climate Change Policies (where these existed);
- National Climate Change Strategy and Action Plans (where these existed);
- Any other major documents on Climate Change produced with relevant national level data; and
- Any national level research reports or development programme documents with relevance to the focus of the mapping study (where these existed).

19.2 Stakeholder and University Staff Consultations (National Workshop)

As part of the SARUA mapping study Initiative *Climate Change Counts*, a country consultation was held in each of the participating countries. In most countries, the consultations were structured as a 1.5 day programme, with a combined group of participants that included university, government, private sector and NGO stakeholders. Participant lists were generated from this and circulated as part of the workshop reporting. From detailed workshop proceedings captured by a team of three rapporteurs a workshop report was produced, which was circulated to all who participated in the workshop for verification and accuracy. Data produced in the workshops was also verified and added to during plenary sessions. The workshop report forms a substantive basis of the data used for the mapping study Country Reports, combined with document analysis and questionnaire data.

19.3 Questionnaires

Two different questionnaires were prepared to obtain more in-depth data on climate change and CCD knowledge co-production practice and possibilities, and to enable people who were unable to attend the country workshops to participate in the mapping study (see Appendix C and D). One was designed for university professionals and the other for national and regional stakeholders who are involved in climate change and CCD. Questions covered the following areas:

University staff questionnaire

- **General demographic and professional information** (name, gender, highest qualification, job title, years of experience, years of experience with CC, name of university, country, faculty, department, programme, contact details)
- **Understandings of Climate Change and Climate Compatible Development** and views on critical CCD issues and responses from universities (staff and university leaders)
- **Capacity, knowledge and research gaps** (levels of involvement in CC and CCD research – local, national and international; levels of single, inter- and transdisciplinary involvement in CCD research; stakeholder involvement; funding and fundraising for CCD research; policy contributions; major research programmes / projects; active researchers; research knowledge networks)
- **Curriculum, teaching and learning** (specialist courses; integration of CCD issues into courses; cross-faculty teaching; inter- or transdisciplinary teaching approaches; service learning approaches; critical thinking and problem solving approaches; social or technical innovation courses; assessment and examination of CCD issues; staff willingness and staff ability; actual courses and teaching methods)

- Policy, community engagement and student involvement
- **University collaboration** (inside the university; between universities in country; with partners; regional and international involvement)
- University policy and campus management

Stakeholder questionnaire

The stakeholder questionnaire covered items A-C above, with an additional:

- Interests, policies, networks and Centres of Excellence or Expertise

20 ANALYSIS LOGIC

The analysis logic informing the development of the mapping study Country Reports and the Knowledge Co-Production Framework is three-fold. It firstly maps out a ‘needs analysis’ which identifies country based knowledge, research and capacity gaps for key CCD priorities as articulated in documents, workshop and questionnaire responses. Secondly, it provides an ‘institutional analysis’ providing insight into existing institutional capacity for CCD knowledge co-production. Thirdly, it provides a perspective not only on existing knowledge co-production practice for CCD in each country, but also on knowledge co-production possibilities, based on information gathered during the mapping study. It identifies research themes, curriculum innovation actions, policy engagement actions and some suggested strategies for enhancing community engagement, all of which together provide ways of improving ‘knowledge co-production pathways’ for CCD knowledge co-production. It outlines a framework in which different countries could **co-operate with other SADC countries in regional CCD knowledge co-production processes**, via a mix of research thematic engagements for which ‘start up’ centres and nodes of expertise have been defined from across the SADC countries; curriculum innovation possibilities and proposed directions for policy and community outreach. The Knowledge Co-Production Framework captures these possibilities in a set of research thematic areas, strategies for curriculum policy and community outreach, and recommendations that can inform the next four years of the SARUA Climate Change and Development Programme.

The mapping study, implemented in the first year of the SARUA programme, was designed to constitute the ‘knowledge base’ to inform the further development of the SARUA programme. While providing strategic direction, it does not over-prescribe, as there is a need for the university community in SADC to engage with the suggested research themes and Knowledge Co-Production Framework overall, and to further refine and constitute the research programmes via actualised research programmes in which further detail will be required in terms of objectives, actualised partnerships, research questions and so forth.

Appendix C: Institutional questionnaire

QUESTIONNAIRE FOR UNIVERSITY MANAGERS, TEACHING AND RESEARCH STAFF: Status of Climate Compatible Development Research, Teaching and Policy / Community Engagement

A: GENERAL INFORMATION

A1: NAME	
A2: GENDER	
A3: HIGHEST QUALIFICATION	
A4: JOB TITLE	
A5: YEARS OF EXPERIENCE	
A6: YEARS OF EXPERIENCE WITH CLIMATE CHANGE / COMPATIBLE DEVELOPMENT RELATED ISSUES	
A7: NAME OF UNIVERSITY	
A8: COUNTRY	
A9: NAME OF FACULTY	
A10: NAME OF DEPARTMENT	
A 11: NAME OF PROGRAMME/ CENTRE / UNIT / INSTITUTE	
A12: E-MAIL CONTACT	
A13: WEBSITE ADDRESS:	

B: GENERAL VIEWS

B1: Give a short description of **how you understand** 'climate change'.

B2: Give a short description of **how you understand** 'climate compatible development' in your context.

B3: What, in your view, are the most **critical aspects** to deal with in your country if 'climate compatible development' is to be achieved?

B4: In your view, what is **the role of universities** in contributing to the achievement of climate compatible development?

B5: In your view, what is the **role of university managers** in contributing to achievement of climate compatible development?

C: CAPACITY, KNOWLEDGE AND RESEARCH GAPS

Please indicate if you are answering these questions on behalf of a:

University	
Faculty	
Department	
Programme / Centre / Institute	

Rate the contributions of your university / faculty / department / programme using 1-5 with 1 being non-existent, and 5 being very active or well developed

		1	2	3	4	5
C1	Involvement in research in the area of climate change and/or climate compatible development					
C2	Involvement in local climate change and/or climate compatible development research					
C3	Involvement in national climate change and/or climate compatible development research					
C4	Involvement in international climate change and/or climate compatible development research					
C5	Involvement in single discipline approaches to climate change and/or climate compatible development research					
C6	Involvement in interdisciplinary approaches to climate change and/or climate compatible development research					
C7	Involvement in transdisciplinary approaches to climate change and/or climate compatible development research					
C8	Involvement of multiple stakeholders in climate change and/or climate compatible development research					
C9	Record of raising funding for climate change and/or climate compatible development research					
C10	Contributions of the research to local climate compatible development pathways					
C11	Contributions of the research to national climate compatible development pathways					

C12: Would you describe your university / faculty / department / programme's research primarily as being focused on:

Climate Change	
Climate Compatible Development	
Other (please specify)	

C13: List major research projects / programmes focusing on climate compatible development in your university / faculty / department / programme:

C 14: List the most active researchers involved in climate change and/or climate compatible development research in your university / faculty / department / programme, and their 'specialist' areas of research and if possible give an email contact address.

C 15: List any major practices and research initiatives you or others regard as innovative in your university / faculty / department / programme, and their 'specialist' areas of research, and if possible provide a contact name and email of a person responsible.

C16: List any major research or knowledge production networks that you may be involved in that focus on or support knowledge production and / or use that is relevant to climate compatible development in your context? If possible, provide a contact name and email address for the person responsible for the network.

D: CURRICULUM, TEACHING AND LEARNING

Rate the contributions of your university / faculty / department / programme using 1-5 with 1 being non-existent, and 5 being very active or well developed

		1	2	3	4	5
D1	Specialist courses offered on climate change / climate compatible development					
D2	Climate change / climate compatible development issues and opportunities integrated into existing courses					
D3	Cross-faculty teaching on climate change / climate compatible development					
D4	Inter- and/or transdisciplinary teaching approaches used for climate change / climate compatible development courses					
D5	Service learning (accreditation of community engagement as part of formal curriculum) focusing on climate change / climate compatible development concerns					
D6	Courses develop critical thinking and integrated problem solving skills					
D7	Courses clearly focus on development of social and/or technical innovation and ethical actions					
D8	Climate change / climate compatible development aspects are included in assessment and examinations					
D9	Staff willingness to get involved in new issues such as climate change and/or climate compatible development					
D10	Staff ability to get involved in new issues such as climate change and/or climate compatible development					

D11: List any main courses in climate change / climate compatible development in your university / faculty / department / programme and indicate if they are undergraduate (1st, 2nd, 3rd year etc.) or postgraduate (Hons, Masters, PhD)

D 12: Give an example of one or two teaching methods that you would use for teaching climate change / climate compatible development in your courses

E: POLICY / COMMUNITY ENGAGEMENT AND STUDENT INVOLVEMENT

Rate the contributions of your university / faculty / department / programme using 1-5 with 1 being non-existent, and 5 being very active or well developed

		1	2	3	4	5
E1	Involvement in climate change / climate compatible development policy outreach / engagement activities					
E2	Involvement in climate change / climate compatible development community outreach / engagement activities					
E3	Student involvement (e.g. through societies, clubs etc.) in climate change / climate compatible development activities on campus and in the surrounding areas					

E4: List any major climate change / climate compatible development **policy** outreach / engagement activities and if possible, the person responsible for the programme.

E5: List any major climate change / climate compatible development **community** outreach / engagement activities and if possible, the person responsible for the programme.

E6: List any major student organisations / activities that are engaged with climate change / climate compatible development activities.

F: UNIVERSITY COLLABORATION

What opportunities exist for collaboration towards climate compatible development knowledge co-production?

F1: Inside the university

F2: Between universities in country

F3: With partners

F4: Regionally

F5: Internationally

G: UNIVERSITY POLICY AND CAMPUS MANAGEMENT

G1: Does the university have any policies that are aligned with climate compatible development objectives? If yes, then please list them.

G2: Does the university engage in any campus management activities that are aligned with climate compatible development objectives? If yes, then please list them.

G3: Are there major networks / research groups or programmes that the university is affiliated to that focus on climate compatible development? If yes, please list them.

Appendix D: Stakeholder questionnaire

SHORT QUESTIONNAIRE FOR STAKEHOLDERS on CLIMATE COMPATIBLE DEVELOPMENT KNOWLEDGE, RESEARCH AND CAPACITY NEEDS

A: GENERAL INFORMATION

A1: NAME	
A2: GENDER	
A3: HIGHEST QUALIFICATION	
A4: NAME OF ORGANISATION	
A5: NAME OF SECTION / DEPARTMENT IN ORGANISATION	
A6: JOB TITLE	
A7: YEARS OF EXPERIENCE	
A8: YEARS OF EXPERIENCE WITH CLIMATE CHANGE / COMPATIBLE DEVELOPMENT RELATED ISSUES	
A9: COUNTRY	
A10: EMAIL CONTACT DETAILS	
A11: WEBSITE ADDRESS	

B: GENERAL VIEWS

B1: Give a short description of **how you understand** 'climate change'.

B2: Give a short description of **how you understand** 'climate compatible development' in your context.

B3: What, in your view, are the most **critical aspects** to deal with in your country if 'climate compatible development' is to be achieved?

C: CAPACITY, KNOWLEDGE AND RESEARCH GAPS

C1: What, in your view, are the most critical **knowledge gaps** that need to be addressed for achievement of climate compatible development in your context?

C2: What are your most critical **specific research needs** for achieving climate compatible development in your context?

C3: What, in your view, are the most critical **capacity gaps** (individual skills and institutional capacity) that need to be addressed for achievement of climate compatible development in your context?

C 4: In your view, what is **the role of universities** in contributing to the achievement of climate compatible development?

C5: In your view, how could / should **your organisation** be collaborating with universities to strengthen climate compatible development in your country?

D: INTERESTS, POLICIES, NETWORKS AND CENTRES OF EXCELLENCE OR CENTRES OF EXPERTISE

D1: Briefly describe your organisation's main interest in climate change / climate compatible development.

D2: List any major policies and plans that have relevance to climate change / climate compatible development in your country and/or organisational context.

D3: Briefly describe any collaboration that you have had with universities and/or research, learning and innovation centres, etc. on mobilising knowledge and capacity for climate change / climate compatible development. List the specific initiative / collaboration, and if possible give details of a person responsible for this.

D4: Are there any national centres of excellence in climate change / climate compatible development research and innovation practices in your country? If yes, please list them and indicate their specialist competence areas.

D5: Is there any specialist expertise in your country / context for climate change / climate compatible development research and learning that you know of? If yes, please list who they are, and indicate their specialist competence areas.

D6: Are there any networks that are engaging with climate change / climate compatible development research and innovation practices in your country? If yes, please list them, and indicate what they focus on. If possible, list a responsible person (with contact details if possible).

Appendix E: Network development model

21 NETWORK FOCUS AREAS

21.1 SARUA long-term vision for collaborative network development

The long-term vision of the SARUA Climate Change Capacity Building programme is to significantly enhance the climate adaptive capacity and resilience of the SADC region through the development of a collaborative network of higher education institutions capable of pooling resources, maximising the value of its intellectual capital and attracting significant investment into the region.

21.2 Network focus areas

The network focus areas can be distinguished in terms of two inter-related broad thrusts, namely:

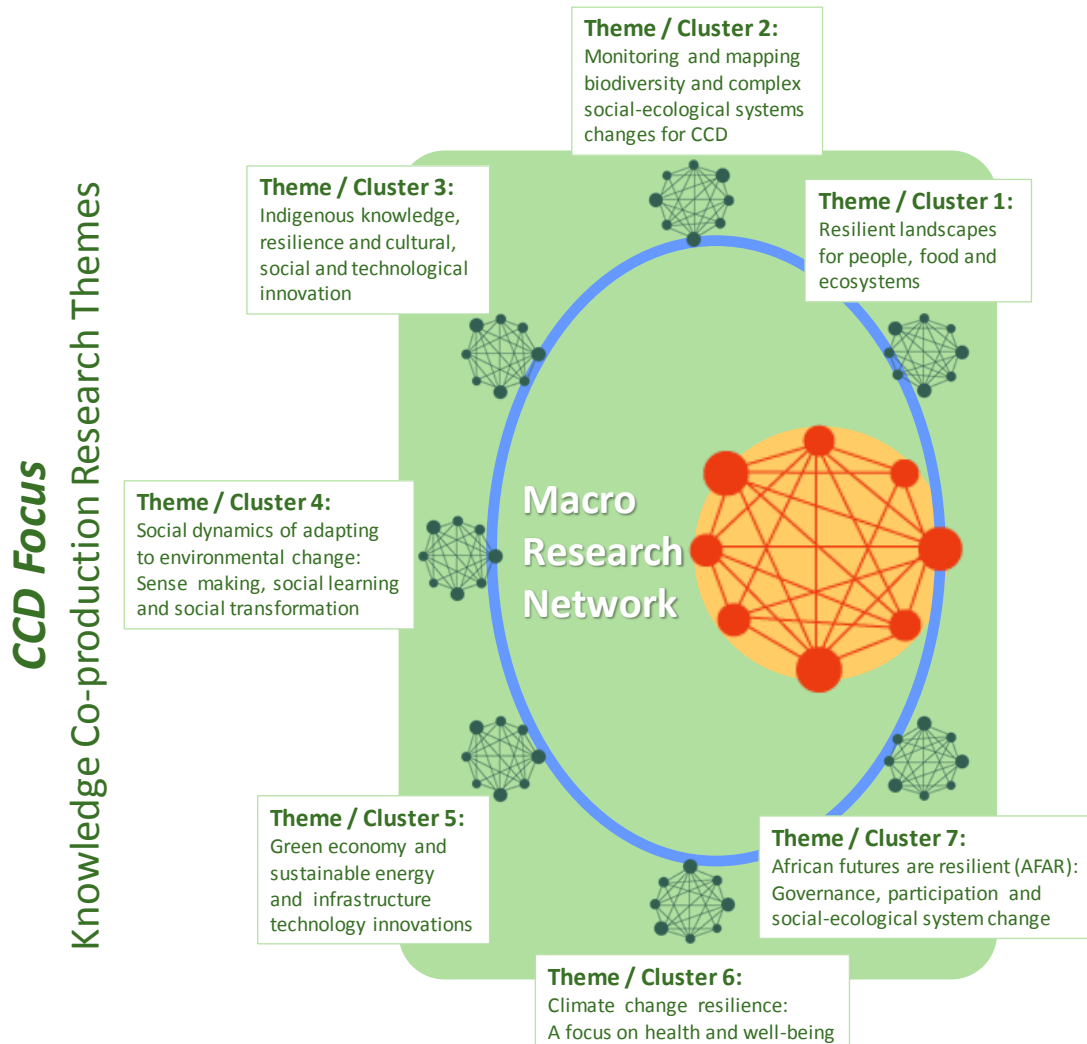
- The pursuit of research and innovation outputs through the identified research themes macro-research network – the *Climate Compatible Development focus*; and
- The implementation of the required support and enablement activities through three distinct networks to capacitate higher education institutions to produce meaningful climate change knowledge. This includes the strengthening of teaching and learning, and policy and community engagement and outreach activities – the *Higher Education Development focus*.

21.3 Climate compatible development focus

The research themes as outlined in section 4.4 provide the knowledge co-production focus for actions to be implemented. Seven research themes have been proposed in this Knowledge Co-Production Framework, which were derived from the mapping study findings. These may, however, still be revised and/or re-developed by participating research institutions and the SARUA research community in the next phases of the programme. However, either these, or a revised set of research themes are likely to form the basis of the Knowledge Co-Production framework. The initial research thematic areas for a proposed set of research clusters as identified from the mapping study are:

- Theme 1: Resilient landscapes for people, food and ecosystems;
- Theme 2: Monitoring and mapping biodiversity and complex social-ecological systems changes for CCD;
- Theme 3: Indigenous knowledge, resilience and cultural, social and technological innovation ;
- Theme 4: Social dynamics of adapting to environmental change: Sense making, social learning and social transformation;

- Theme 5: Green economy and sustainable energy and infrastructure technology innovations;
- Theme 6: Climate change resilience: A focus on health and well-being; and
- Theme 7: African futures are resilient (AFAR): Governance, participation and social-ecological system change.



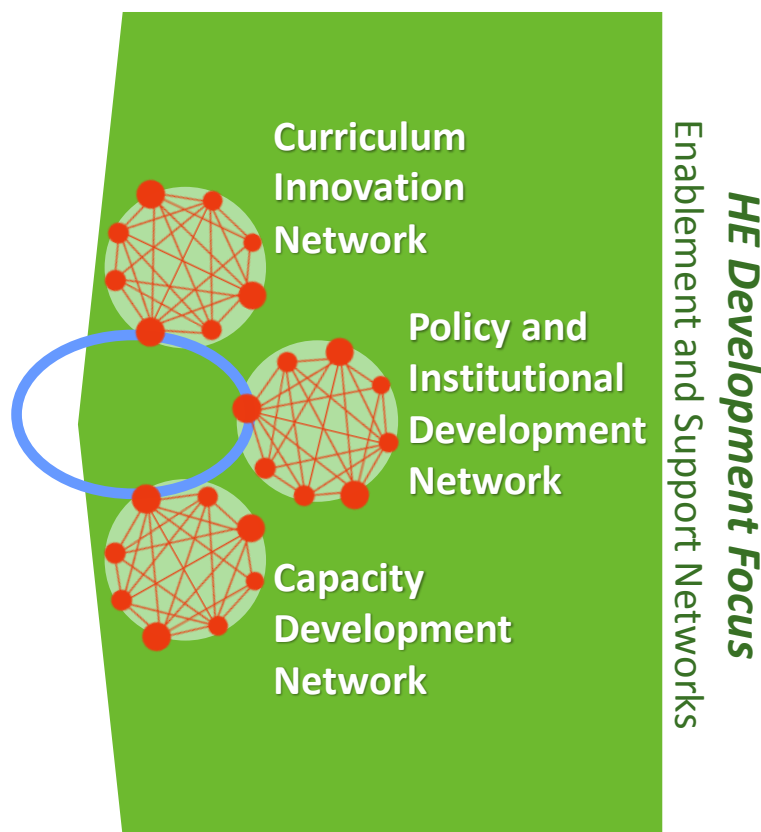
21.4 Higher education development focus

The Higher Education Development focus is inherent to the SARUA mandate and the emphasis of the three networks identified support the requirement for not only development of the institutional capacity, but also to strengthen collaboration between various stakeholders (government, universities, civil society, private sector) and to create a linkage between knowledge co-production and the development of policy.

The enabling networks that will support and interact with all the identified research clusters are:

Table 19: Objectives of Higher Education Development networks

Network	Core Objective
Curriculum Innovation network	To ensure CCD is mainstreamed into university curricula and to promote and design multidisciplinary teach and learning programmes
Policy and Institutional Development network	To engage in dedicated stakeholder relationships building activities on a country-by-country and regional level and to inform and influence policy thinking
Capacity Development network	To strengthen and support all networks through knowledge sharing, mentorship and development programmes.



The Higher Education Development networks are designed to address the key components of:

- Institutional development;
- Outreach and engagement; and
- Knowledge management.

21.4.1 Institutional development

The Policy and Institutional Development network in particular will be required to focus on:

- Sufficient attention to CCD needs and priorities in national policy and research plans;
- Building internal university policies on sustainable development and climate change issues, and mainstreaming into Strategic and Research Plans;

- Mainstreaming sustainable development and climate change into existing courses, and developing stand-alone courses;
- Strengthening CCD related offerings at Masters level;
- Putting in place dedicated programmes for increasing numbers of PhD graduates, especially among university permanent staff;
- Strengthening publishing and internationalisation of research;
- Strengthening community engagement as an important form of knowledge sharing, dissemination and co-learning;
- Reforming academic performance management systems so that they reward collaborative research: the conflict between knowledge production and performance is one that universities across the SADC region face, and is something that could fruitfully be addressed by SARUA and other university networks that encourage collaboration and collaborative publishing, through for example instituting a regional high-level dialogue on needed changes to university policy to incentivise knowledge co-production; and
- Introducing university management and leadership development interventions that aim to improve general management practices such as financial and human resources management and collaborating with existing programmes in this regard.

21.4.2 Outreach and engagement

All networks and cluster will be engaged in outreach activities, but the Policy and Institutional Development network in particular will ensure coordination and communication is facilitated with the following:

- Interaction with the SADC Climate Change Inter-sectoral Technical Working Group (CTWG);
- Establishing a working relationship with African institutions and networks for climate change and CCD within and beyond the SADC region (e.g. African Climate Policy Centre (ACPC), ENDA Energy, Environment and Development Programme);
- Collaborating with programmes and initiatives that support university engagement with sustainable development at global and regional levels e.g. Global Universities Environment and Sustainability Partnership Programme of UNEP and African Association of Universities (AAU); Mainstreaming Environment and Sustainability in African Universities Partnership Programme (MESA); African Teacher Education Network on Education for Sustainable Development (AFRITEIS); and
- Engaging with the post-2015 development agenda and the work of the IRF2015 group.

21.4.3 Knowledge management

The findings of this mapping study highlight the need for better all-round knowledge management and information flow on climate and development matters and for stronger decentralised collaboration amongst government, HEIs and non-government actors, and for stronger knowledge exchange approaches and strategies for knowledge sharing with major development programmes and universities. While many climate change projects are to be found in all countries, there are few countries that have established strong structures for interaction and knowledge sharing amongst the various stakeholders, and attempts to

synthesise findings and disseminate and use these in policy and programme development and design are poorly constituted. Individual agencies are all tending to attempt to do this in their own ways. It would seem therefore that there is a need for a more cohesive approach to knowledge management and information sharing at regional, as well as national levels. Research institutions that have capacity for continued synthesis of available data (e.g. national universities working with key national research institutes) could potentially play a much stronger role in strengthening knowledge management and information flows.

22 THE NETWORK DEVELOPMENT PROCESS

Each network within the SARUA programme will have a lifecycle. These might be synchronised according to one time frame, but in all probability will each have its own characteristics and time frame.

The typical network lifecycle is depicted below. This lifecycle can be applied to enabling networks, the macro network, as well as research clusters, as they would require the same type of coordination activities.

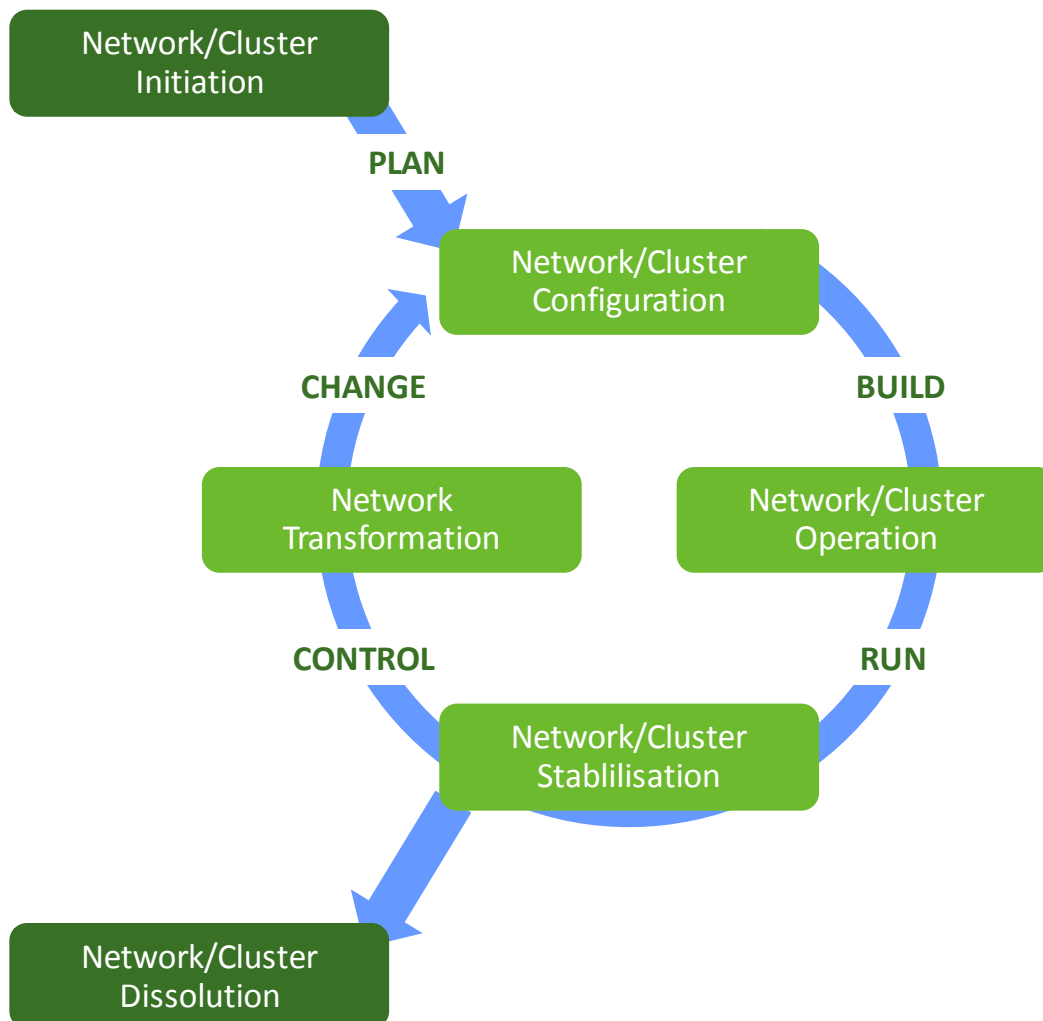


Figure 17: Network lifecycle

In terms of each major stage, specific roles will be assigned to SARUA as the overall network initiator, and stakeholders (whether university or government or other) will play different roles. These are depicted in the table below.

Table 20: Network lifecycle applied to the SARUA programme

Phase	Description	Questions	Roles
Initiation	The identification and agreement on the key themes and/or thrusts of the network, including partner institutions	<ul style="list-style-type: none"> ■ What are the core themes to address? ■ What is the network's vision and objectives? ■ What are the targeted outcomes to be achieved by when? ■ Who are the network stakeholders and institutions, how are they selected and what will their roles be? 	<ul style="list-style-type: none"> ■ Network Coordinator ■ Lead Research Chair ■ Additional research fellows ■ Emerging researchers
Configuration	Definition of key operating principles – communication, information and knowledge sharing, funding, governance	<ul style="list-style-type: none"> ■ How will the network be funded? ■ What IP rules are in place? ■ What is the governance model and who will perform which governance roles? (including how is institutional governance dealt with) ■ What are the shared values underpinning the collaboration within the network? ■ What are the incentives for network members (institutional and individual)? ■ What is the network's identity? ■ What information and knowledge sharing platforms and mechanisms will the network introduce? 	<ul style="list-style-type: none"> ■ Network Coordinator ■ Lead Research Chair ■ Additional research fellows ■ Host institutions ■ Emerging researchers ■ Other supporting roles

Phase	Description	Questions	Roles
Implementation and Operation	The roll-out and implementation of agreed actions and the coordination of activities to monitor progress and measure results	<ul style="list-style-type: none"> ■ Which network roles are established? ■ Which roles are not defined yet? ■ How are information systems / repositories / research results / shared resources linked and managed? ■ What communication is put in place, what is its purpose and frequency? (and measuring whether it is happening) ■ How are changes in network resources / budgets / plans dealt with and handled? ■ What are the monitoring and evaluation metrics and how is performance measured? 	<ul style="list-style-type: none"> ■ Network Coordinator ■ Lead Research Chair ■ Additional research fellows ■ Host institutions ■ Emerging researchers ■ Communications ■ Systems and infrastructure ■ Project management
Stabilisation	The further dissemination of network roles and outputs to broaden its reach	<ul style="list-style-type: none"> ■ What roles need to be established to grow the network and introduce it to more universities and stakeholders? ■ What social platforms and engagement opportunities are available to encourage more sharing? ■ How will collaborative capacity and capabilities of the network be enhanced? ■ How are conflicts managed and dealt with? ■ How is individual networking encouraged and incentivised to attract more participants and build capacity? ■ What is the network and identity and how does it begin to share and publish its outputs? 	<ul style="list-style-type: none"> ■ Network Coordinator ■ Lead Research Chair ■ Additional research fellows ■ Host institutions ■ Emerging researchers ■ Communications ■ Systems and infrastructure ■ Project management

Phase	Description	Questions	Roles
Transformation	Planning for a renewal / continuation / dissolution or further expansion of the network	<ul style="list-style-type: none"> ■ What needs to be done to continue / grow the network in SADC? ■ Is the network's initial vision and objectives still relevant / have these been achieved / what needs to be done? ■ How does the network scan its environment to determine its relevance and performance against its stated objectives? ■ How is learning facilitated / transferred / captured and disseminated? ■ What funding would a future network require? 	<ul style="list-style-type: none"> ■ Network Coordinator ■ Lead Research Chair ■ Additional research fellows ■ Host institutions ■ Emerging researchers ■ Communications ■ Systems and infrastructure ■ Project management
Dissolution	The termination (if necessary) of the network or the convergence into a different form	<ul style="list-style-type: none"> ■ What is the published legacy of the network? ■ What are the final dissolution IP-related actions to take? ■ How is the network dissolved? ■ Are there outputs or remaining activities that need to be taken over / handed over? 	<ul style="list-style-type: none"> ■ Network Coordinator ■ Lead Research Chair ■ Additional research fellows ■ Host institutions ■ Emerging researchers ■ Communications ■ Systems and infrastructure ■ Project management

22.1 Requirements for network development

Table 21: Network role descriptions

Role	Ideal entry point	Critical for establishment	Role description
Network Coordinator	Network Initiation	Yes – each cluster or network will require at least a coordinating entity or individual	Responsible for all project management and communication activities (even if delegated) to ensure network operates as effectively as possible
Lead Research Chair (in case of research clusters)	Network Initiation	Yes – the further development and definition of research dimensions need to happen early under the lead of a respected researcher	Provides academic leadership and is responsible for overall QA on research methodology, knowledge co-production approaches and outputs generated

Role	Ideal entry point	Critical for establishment	Role description
Additional research fellows	Network Configuration	No – once a research cluster gets traction, more research fellows can be recruited and asked to join through normal networking activities	Researchers with a specific role, task or interest who contribute in a clearly defined way
Host institutions	Network Operation	No – if a coordinator is in place, a network or cluster can begin to define its scope and collaborative approach virtually. Ideally, for operation of the network to commence, a host institution should be in place	A host institution could either provide a physical facility for research activities and meetings, or could provide a virtual workspace for information dissemination – it might require financial support
Emerging researchers	Network Operation	No – emerging researchers can become part of a research cluster or network until its stabilisation phase. Ideally, they should remain part as the network transforms into a more cohesive and developed group	Identified students and junior staff members who participate as part of a structure learning programme (in cooperation with Capacity Development Network)
Communications	Network Operation	No – formal communication would be required once research or support activities commence, but is not required for establishment if a coordinator is present	A communications task could be done by a coordinator, or by any delegated person as per the assigned roles and responsibilities
Systems and infrastructure	Network Operation	No – for a network to become effective in knowledge sharing, some form of common platform to share activities, outputs and results would be required. Ideally this should already be conceptually defined in the configuration phase	Could be provided by SARUA or another entity, and will need to be planned for both on a programme level and on a cluster and network level
Project management	Network Configuration	Yes – can be part of the Coordinator's responsibility	Coordinator to fulfil this role or delegate it – potentially to an emerging researcher as part of a personal development exercise

22.2 Key actions and issues to address in network development

Table 22 below provides a summary of key actions and issues to be addressed in the networks, delineated according to network phases.

Table 22: Outcomes and roadmap issues to address in network development

Outcome/objective	Network phase in which to address	Network/s responsible	Issue to address	Types of actions required	Immediate steps
To establish networks and clusters with a clear purpose, plan of activities and intended outcomes defined	Initiation and Configuration phase of all networks	Institutional Learning and Development network Network coordinating hub	The development of a knowledge management approach and framework, which addresses: <ul style="list-style-type: none"> Information and knowledge sharing principles Regional level and national level knowledge management systems and infrastructure ICT configuration, hosting and support Knowledge hubs coordination Infrastructure sponsorship 	Network coordinating hub, along with the Institutional learning and development network, to develop and implement an integrated network knowledge management framework and plan	<ul style="list-style-type: none"> SARUA to disseminate KCPF for institutions and stakeholders to identify potential network partners Call for registration and participation by SARUA Establishment of central information repository used for all programme documentation
To ensure targeted follow-up and commitment of universities, participating entities and individuals in joining in with themed clusters or networks	Configuration Phase Implementation and Operation Phase	Institutional Learning and Development network	A commitment to research and development (R&D) funding and support is made in almost all countries surveyed, but the implementation is varied. It is required that policy commitments are followed up in a focused approach to ensure CCD-related research activities are appropriately identified, recognised and funded.	A formal programme of active stakeholder engagement by the network members focusing on: <ul style="list-style-type: none"> Information dissemination on CCD gaps and challenges by the Policy and Outreach Network to universities and all stakeholders – government, civil society and private sector Communication of research priorities and their R&D requirements that respond to these challenges Preparation and presentation of funding proposals in line with SARUA CCD network priorities 	Establishment of a Policy and Institutional Development network to begin with preparation of communications material on results of mapping study

Outcome/objective	Network phase in which to address	Network/s responsible	Issue to address	Types of actions required	Immediate steps
To ensure where cluster and networks are established, their development needs are identified and captured in order to integrate capacity development into plans and individual roles	Implementation and Operation Phase Stabilisation Phase	Capacity building network	The emerging centres of expertise and excellence as documented require focused capacity building support around new forms of knowledge production and management, in line with the knowledge management framework developed	Targeted capacity development programmes – either on research team level, individual researcher level or management level – facilitated by SARUA and its members to assist emerging centres in new knowledge development approaches	Identify per emerging cluster or network team: <ul style="list-style-type: none"> Emerging researchers and their development goals Opportunities for PhD enrolment in network activities General project management skills and capacity gaps Specific knowledge/ expertise required within teams Institutional management gaps in order to coordinate activities
To introduce new approaches and ways to curriculum development in a structured fashion to address shortcomings within the region	Configuration Phase Implementation and Operation Phase	Curriculum Innovation Network Capacity Development Network	By utilising and further strengthening the existing network of Education for Sustainable Development (ESD) Centres of Expertise in the region, existing capacity can be focused on teaching and learning capacity development	A customised capacity building project around teaching and learning approaches and methodologies in support of curriculum development networking activities	Identify lead institutions in progressive and innovative curriculum development Engage individuals to establish a potential learning and development team Develop a programme for presentation and roll-out in other universities Engage, through SARUA, institutions to assess interest and schedule sessions

Outcome/objective	Network phase in which to address	Network/s responsible	Issue to address	Types of actions required	Immediate steps
To introduce research methodology standards and measures to ensure quality outputs from clusters and networks	Configuration Phase Implementation and Operation Phase	Research Clusters Institutional Learning and Development Network	For the successful roll-out of SARUA-facilitated research programmes, it is required to assess, develop and redevelop research methodologies that support a CCD focus and multi- and transdisciplinarity	<ul style="list-style-type: none"> Development of research guidelines, a research methodology and framework for engaging in multi- and transdisciplinary research Communication, dissemination and training in research methodologies Sharing existing experience of CCD related research especially more innovative approaches to research such as situated, multidisciplinary and transdisciplinary studies 	<ul style="list-style-type: none"> Identify potential lead partners (centres of excellence, individuals, universities) Commence a planning process to define needs and rollout plan and timeline
An increased number of PhD scholars in CCD-related disciplines enrolled	Configuration Phase Implementation and Operations Phase	Institutional Learning and Development Network Curriculum Innovation Network	There exists a need for improved institutional and academic support for developing more PhD scholars, particularly in climate change and CCD related fields	<ul style="list-style-type: none"> Development of a requirement specification for PhD scholar development – focusing on institutional requirements, support mechanisms and capacity needs Development of a SARUA-initiated programme for capacity development Roll-out of a programme to develop lagging institutions to become better capacitated to develop PhD programmes and enrol students 	<ul style="list-style-type: none"> Request and analyse statistics on a country-by-country basis Establish a working group and appoint a coordinator to analyse findings and develop a potential approach and timeline

Outcome/objective	Network phase in which to address	Network/s responsible	Issue to address	Types of actions required	Immediate steps
To ensure succession planning is in place for critical knowledge and expertise areas	Configuration Phase Implementation and Operations Phase Stabilisation Phase	Curriculum Innovation Network	With the limited resources and numbers of experts in the region, key areas of necessary expertise relating to CCD need to be strengthened and spread across the region. It is necessary to have professional development succession in mind and develop an appropriate response.	<ul style="list-style-type: none"> ■ Identification of “core”, “critical” and “necessary” elements of expertise to be able to engage in CCD-related research, teaching and learning ■ In the development of shared Masters programmes, a focus on these requirements to target the establishment of a regional baseline of expertise 	<ul style="list-style-type: none"> ■ Develop a skills and competency framework for CCD-related disciplines ■ Identify a coordinator and establish a working group to engage stakeholders to determine needs and possible approach
Ensure all existing partners are approached and formalised arrangements are in place to work against fragmentation	Configuration Phase Implementation and Operations Phase Stabilisation Phase	Curriculum Innovation Network Institutional Learning and Development Network Capacity Building Network	Existing programmes like SADC REEP and the Mainstreaming Environment and Sustainability in African (MESA) Universities Programme have shown they can positively bring about curriculum change and renewal in participating institutions and should be formalised as partner programmes to ensure a wider collaborative network at the start.	<ul style="list-style-type: none"> ■ Engage existing programmes to determine a collaborative approach and roll-out plan in line with CCD-related capacity issues identified ■ Source funding for rollout and target institutions for short to medium term interventions ■ Implement and adjust according to outcomes 	<ul style="list-style-type: none"> ■ Draft a MoU for partnership and cooperation ■ Engage potential partners and communicate intent ■ Sign agreements and initiate joint planning sessions

Outcome/objective	Network phase in which to address	Network/s responsible	Issue to address	Types of actions required	Immediate steps
To develop a fundraising approach for technology enhanced research system acquisitions.	Implementation and Operation Phase Stabilisation Phase Transformation Phase	Capacity Building Network Institutional Learning and Development Network Research Clusters	There is a region-wide need for high-end, technology enhanced research systems and the training of researchers to use them successfully. In all countries capacity for using modelling data and for producing downscaled models was noted as a critical capacity need.	<ul style="list-style-type: none"> Donor-focused fundraising for investment in technology-enabled research systems and equipment to support the research networks Training in research and advanced modelling techniques in line with system roll-out plan 	<ul style="list-style-type: none"> Identify coordinator and support team Put together funding brief and proposal Circulate for comment and submit based on identified priority projects / disciplines
To consolidate existing thinking around innovative learning practices and Masters programmes	Implementation and Operations Phase Stabilisation Phase	Curriculum Innovation Network Institutional Learning and Development Network	To ensure that the Masters programmes become regional “curriculum innovation points” it is necessary to build on existing expertise and configure platforms for shared courseware and e-learning across the region.	<ul style="list-style-type: none"> Request an existing centre of expertise to develop a framework for coursework sharing and integration on Masters level Raise funds as required for the implementation Implement according to time frame 	<ul style="list-style-type: none"> Identify a CoE and engage to assess interest Request the development of a framework and secure funding as required

Outcome/objective	Network phase in which to address	Network/s responsible	Issue to address	Types of actions required	Immediate steps
To develop a shared position of incentivisation of transdisciplinary research	Implementation and Operation Phase Stabilisation Phase Transformation Phase	Institutional Learning and Development Network Research Clusters Curriculum Innovation Network	The inter-university research approaches, structures and incentives do not support cross-boundary collaboration, transdisciplinary research and publication of multi- or transdisciplinary research results. Human resources management systems reward individual activities over collaborative activities.	<ul style="list-style-type: none"> ■ Structured benchmarking and global research study to determine new approaches to collaborative and transdisciplinary research promotion and incentivisation ■ Development of an initial position paper including guidelines and a framework for medium to long-term implementation ■ Targeted dissemination to university management and other stakeholders 	<ul style="list-style-type: none"> ■ Commission a research paper of research incentivisation to guide process and actions required

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