climate change counts

STRENGTHENING UNIVERSITY CONTRIBUTIONS TO CLIMATE COMPATIBLE DEVELOPMENT IN SOUTHERN AFRICA

Botswana Country Report

sarua
southern african regional universities association

SARUA CLIMATE CHANGE COUNTS MAPPING STUDY

VOLUME 2 COUNTRY REPORT 2 2014

STRENGTHENING UNIVERSITY CONTRIBUTIONS TO CLIMATE COMPATIBLE DEVELOPMENT IN SOUTHERN AFRICA

Botswana Country Report

Series Editor: Piyushi Kotecha

Authors: Penny Urquhart and Heila Lotz-Sisitka

sarua
southern african regional universities association

Note

This is the Botswana Country Report of the Southern African Regional Universities Association (SARUA) ***Climate Change Counts*** *mapping study. It brings together background documentation on climate change in Botswana, insights into knowledge and research needs and capacity gaps (individual and institutional), a mapping of existing university roles and contributions to climate compatible development (CCD); as well as a discussion on possibilities for CCD learning pathways and future collaborative knowledge co-production and use in Botswana.*

This report is one of a set of 12 Country Reports in Volume 2, which inform Volume 1: the integrated regional Knowledge Co-production Framework of the ***Climate Change Counts*** *mapping study, and which includes comparative regional analysis using the outputs of the other SADC countries, as well as the proposed regional framework for collaborative research on climate compatible development.*

Southern African Regional Universities Association (SARUA)
PO Box 662
WITS
2050
SOUTH AFRICA

ISBN: 978-0-9922354-4-4

Series Editor: Piyushi Kotecha

Authors: Penny Urquhart and Heila Lotz-Sisitka

Project Management and Coordination: Botha Kruger, Johan Naudé, Ziyanda Cele

Research and Workshop Facilitation: M.J. Ketlhoilwe, Dick Kachilonda, Dylan McGarry

Project Steering Committee: Professor Xikombiso Mbhenyane, University of Venda; Professor Raymond Mande Mutombo, University of Lubumbashi; Professor Mark New, University of Cape Town; Professor Samson Sibanda, National University of Science & Technology; Professor Pius Zebhe Yanda, University of Dar es Salaam

Copy-editing: Kim Ward

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 **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).*

Core mapping study Partners

Programme Owner

Implementation Partner

Supplementary Study Sponsors

SADC Regional Environmental Education Programme

University Sponsors and Hosts

Rhodes University

Tshwane University of Technology

Universidade Agostinho Neto

Université des Mascareignes

University of Cape Town

University of Dar Es Salaam

University of Fort Hare

University of Malawi

University of Namibia

University of Pretoria

University of Seychelles

University of Swaziland

University of Zambia

Vaal University of Technology

Zimbabwe Open University

Contents

Tables

Figures

Acronyms

BCA	Botswana College of Agriculture
BGCC	Botswana Global Change Committee
BID	Background Information Document
BIH	Botswana Innovation Hub
BIOKAVANGO	Building Local Capacity for the Conservation and Sustainable Use of Biodiversity in the Okavango Delta
BIUST	Botswana International University of Science and Technology
BOCONGO	Botswana Council of Non-governmental Organisations
BoTec	Botswana Technology Centre
CBM	Coal Bed Methane
CBO	Community Based Organisation
CCAM	Conformal-Cubic Atmospheric Model
CCD	Climate Compatible Development
CDKN	Climate and Development Knowledge Network
CESRIKI	Centre for Scientific Research, Indigenous Knowledge and Innovation
CGCMs	Coupled Global Climate Models
CLIP	Climate, Land-use, Institutions and People
CSIR	Council for Scientific and Industrial Research
DELPHE	Development Partnerships in Higher Education
DoES	Department of Environmental Science
EAD	Energy Affairs Division
EIA	Environmental Impact Assessment
FFEWS	Famine and Flood Early Warning System
GEF	Global Environmental Facility
GIS	Geographical Information System
GNI	Gross National Income
HEI	Higher Education Institution
HEMA	Higher Education Management Africa consortium
IHDP	International Human Dimensions Programme on Global Environmental Change
IKS	Indigenous Knowledge Systems
IPCC	Intergovernmental Panel on Climate Change
IVP	Indigenous Vegetation Project
MEAs	Multilateral Environmental Agreements
MEWT	Ministry of Environment, Wildlife and Tourism
NCCC	National Committee on Climate Change
NCCS&AP	National Climate Change Strategy and Action Plan
NDMO	National Risk and Disaster Management Office
NGO	Non-Governmental Organisation

ODMP	Okavango Delta Management Plan
ORI	Okavango Research Institute
PMS	Performance Management System
REDD+	Reducing Emissions from Deforestation and forest Degradation
SASSCAL	Southern African Science Service Centre for Climate Change and Adaptive Land Use
SNC	Second National Communication (to the UNFCCC)
UB	University of Botswana
UBLS	University of Botswana, Lesotho and Swaziland
UBS	University of Botswana and Swaziland
UNDP	United Nations Development Programme
UNFCCC	UN Framework Convention on Climate Change
YEA	Youth Environment Association

1 INTRODUCTION

1.1 Regional climate risks and climate compatible development in southern Africa

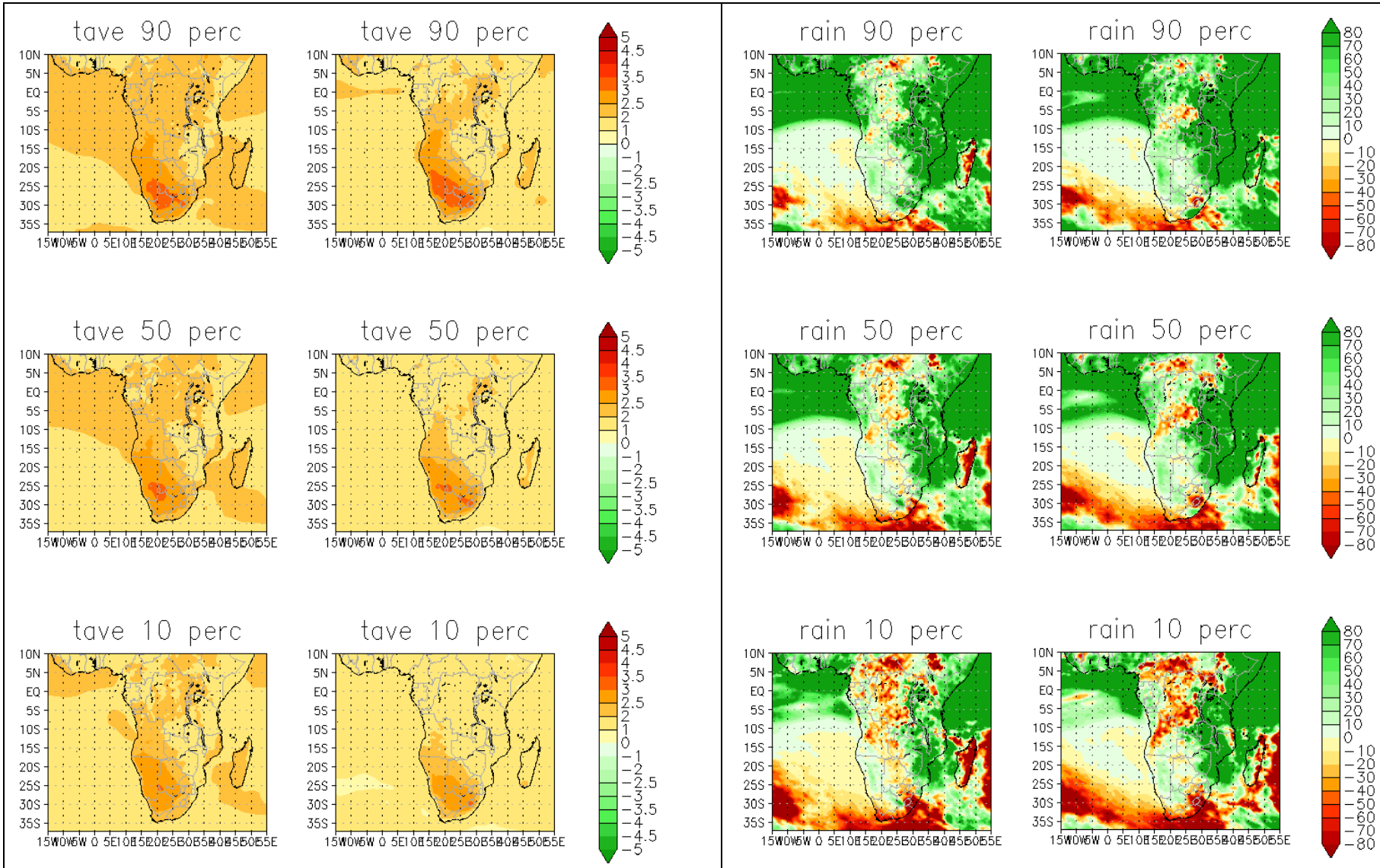
Globally, southern Africa is one of the most vulnerable regions to the impacts of climate change. Current climate variability and vulnerability to extreme events such as floods and droughts is high, and a range of existing stressors, including water availability, land degradation, desertification and 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, which heightens both exposure and sensitivity to the impacts.

In addition to its role as a risk multiplier, climate change introduces new climate risks. 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.[1] 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. [See Figure 1.[2]] 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.

---

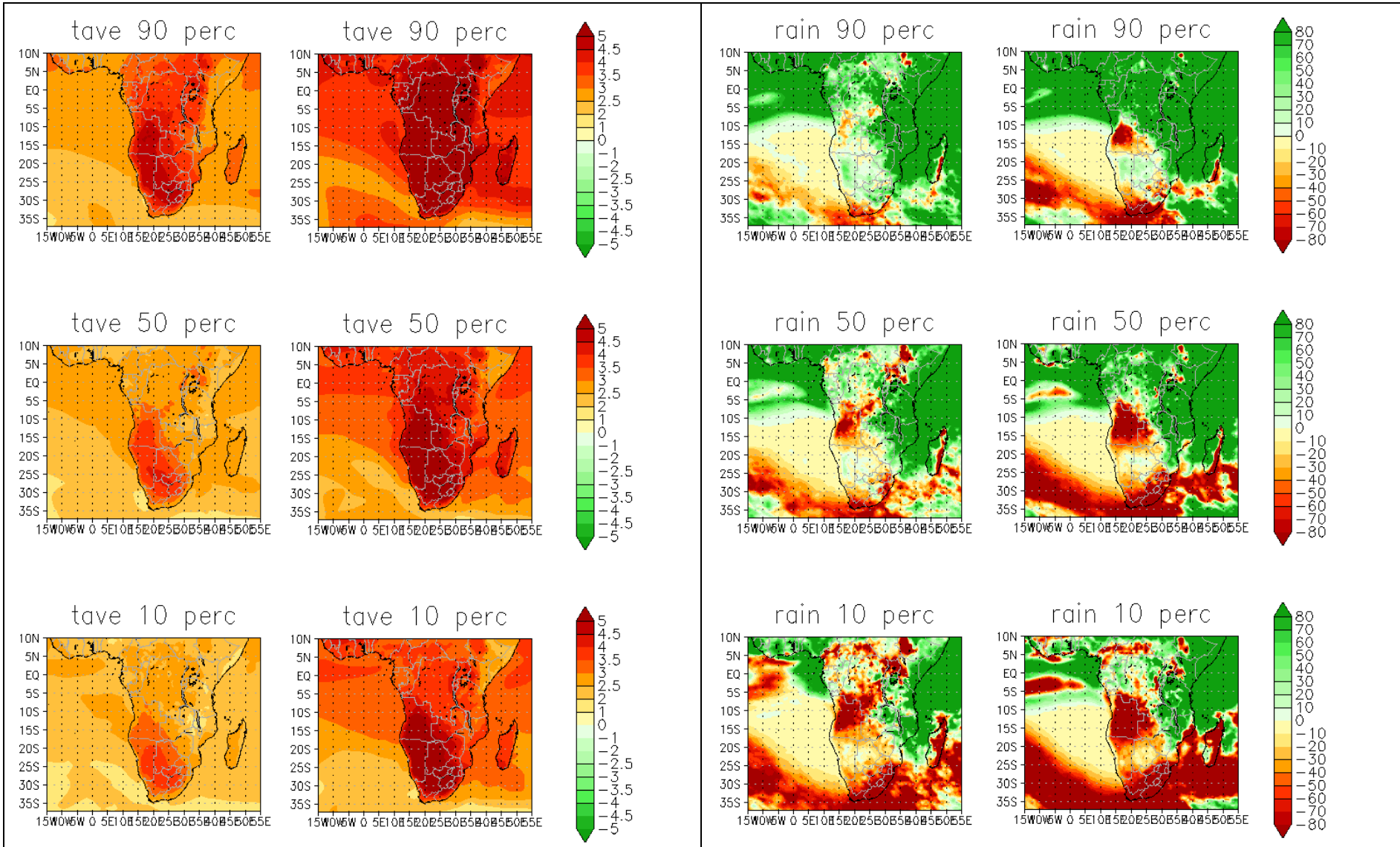
[1] IPCC. 2013. *Impacts, Vulnerability and Adaptation: Africa*. IPCC Fifth Assessment Report, draft for Final Government Review, Chapter 22.

[2] The projections of future climate change displayed in Figures 1 and 2 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 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 1: 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 2: 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 1 and 2[3] showed 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 1 CGCM projections are for RCP4.5 and Figure 2 projections are for RCP8.5.

Shifting perspective from 'development' to 'climate compatible development' requires significant scientific and social innovation. New forms of learning, leadership, planning, policy making and knowledge production are needed. New collaboration platforms will be needed within and between countries and their universities. Universities have a key role to play in supporting societal innovation and change for CCD. Not only do they develop the knowledge and competence of future leaders in government, business and civil society, but they also provide immediate societal responses given their pivotal role as centres of research, teaching, knowledge sharing and social empowerment. Given the risk multiplier effect of climate change, coupled with the multiple stressor context, it is clear that the impacts of climate change will be far-ranging, acting upon diverse sectors such as transportation, agriculture, health, industry and tourism. This necessitates a wide-ranging and cross-sector response, which will call upon non-climate-related knowledge fields.

Universities need to develop a strong understanding of the knowledge, teaching, research and outreach implications of the external climate change development context in which they operate. This calls for:

- New scientific directions and practices;
- New teaching and learning content and approaches;
- Stronger forms of community outreach and policy outreach activities; and
- Enhanced collaboration between universities and other knowledge producers and users in society.

In recognition of the above issues and their longer-term implications for society and universities, the Southern African Regional Universities Association (SARUA) hosted a Leadership Dialogue in 2011, which resulted in a vision for a collaborative programme on climate change capacity development, with a defined set of outcomes. This programme is highly relevant for Botswana, given the country's vulnerability to the impacts of climate change.

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

1.2 The SARUA Climate Change initiative: History and Objectives

Arising from the 2011 Leadership Dialogue, SARUA designed a five-year 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 region. The five-year programme is endorsed by a majority of Vice Chancellors within SARUA's 62 public university members (as at August 2013). The programme aims to build capacity for *climate compatible development* (CCD), which is emerging as a platform for significant collaboration across the academic sector. The objectives identified are as follows:

- **Collaborative network development** (establishment of six interesting collaborative networks);
- **Policy and community outreach;**
- **Research** (140 PhD students (average 10 per country) in two themed research programmes);
- **Teaching and learning** (integration of CCD into undergraduate and Masters degree programmes);
- **Knowledge management** (regional database and knowledge management systems); and
- **Institutional learning and support** (ongoing reflexive development of programme).[4]

The programme started with an extensive **mapping study** of current climate-related priorities and university capabilities for CCD of countries in the region, supported by funding from the UK and Dutch-funded Climate and Development Knowledge Network (CDKN). The Higher Education Management Africa consortium (HEMA) is coordinating the study on behalf of SARUA. This Botswana Country Report forms part of the mapping study.

The initiative is diagrammatically illustrated below.

[4] Butler-Adam, J. 2012. *The Southern African Regional Universities Association (SARUA). Seven Years of Regional Higher Education Advancement. 2006-2012*. Johannesburg: SARUA.

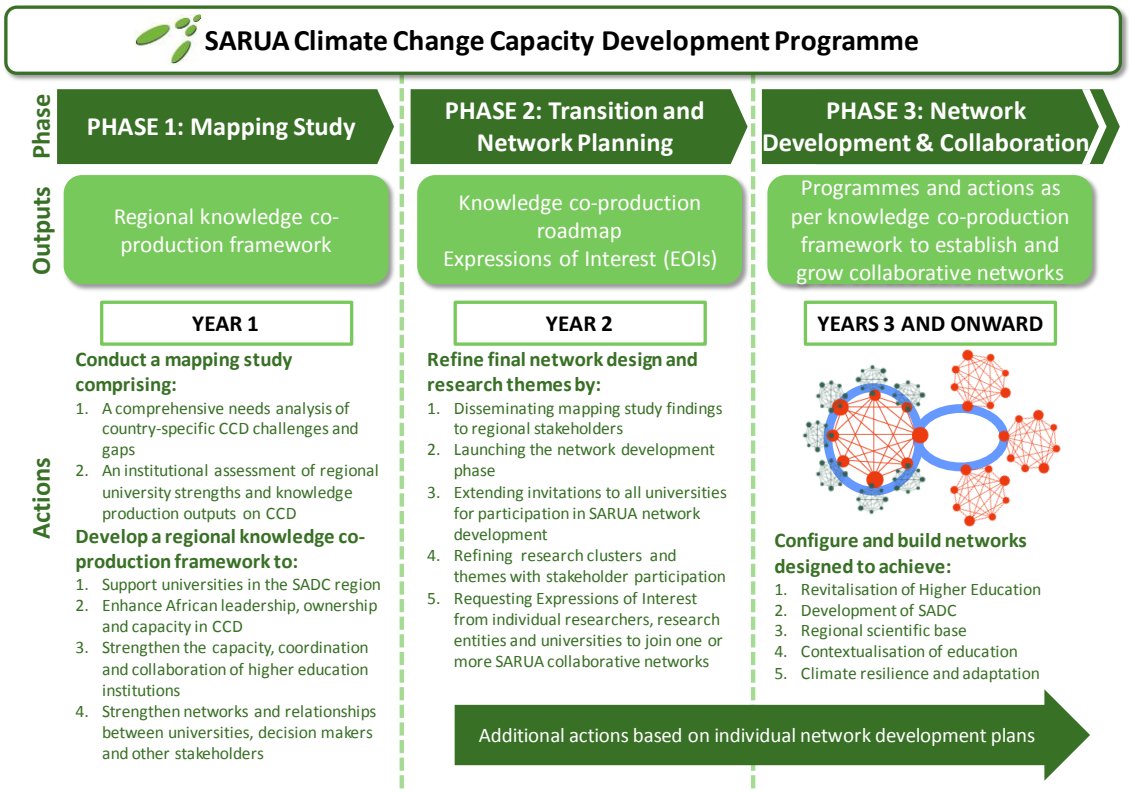


Figure 3: The SARUA Climate Change Capacity Development Programme, showing the mapping study

The intended outcome of the SARUA **mapping study** will be a collaborative research framework to enhance co-production of knowledge on CCD. It will include strategies to strengthen networks for climate compatible development research, teaching, community and policy outreach involving knowledge co-production processes between participating universities and policy and community stakeholders. This framework will form the basis for the realisation of the longer term objectives of the SARUA programme outlined above, as well as for a SADC-level research programme and various country-based partnership agreements. It will provide a 'knowledge platform' 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 Regional Knowledge co-production Framework for Climate Compatible Development can be obtained from the SARUA website www.sarua.org.

1.3 The SARUA CCD mapping study: Mapping existing capacity and future possible knowledge co-production possibilities

Climate compatible development (CCD) is low carbon, climate resilient development. While the concept clearly requires integration of development, adaptation and mitigation (see definitions below), specific framing of the concept of CCD may vary between countries, universities and disciplines, according to differing national, institutional and disciplinary goals, needs and values. The scope and strength of existing expertise, networks and capacity for

climate compatible development research and knowledge production in SADC is largely unknown or unconsolidated. Despite the emerging knowledge infrastructure for CCD in the region, opportunities for collaboration involving higher education institutions within and between countries are yet to be fully explored.

To address these factors, the mapping study aimed to:

- Explore diverse understandings of CCD on a country-by-country basis;
- Scope CCD knowledge and capacity needs on a country-by-country basis (a 'needs analysis'); and
- Identify and map research, teaching and outreach capabilities for CCD that exist in southern African countries (an 'institutional analysis' of SARUA member universities); and
- Produce an up-to-date picture of the extent of knowledge co-production and trans-disciplinary research practices across the SARUA network and identify opportunities for future collaboration.

While the mapping process has used a country-by-country approach, this is supplemented by a regional perspective generated through analysis across countries, to provide a platform for regional collaboration and knowledge co-production. This document contains the country analysis from Botswana.

The mapping process was designed to be scientifically informed, participatory and multidisciplinary. Through the workshop process new collaborative possibilities will emerge, and a stronger engagement and participation in the SARUA five-year programme on Capacity Development for Climate Change will be established.

1.4 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 4. 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.[5] Thus climate compatible development opens up new opportunities for interdisciplinary and transdisciplinary research, teaching and engagement with communities, policy makers and practitioners.

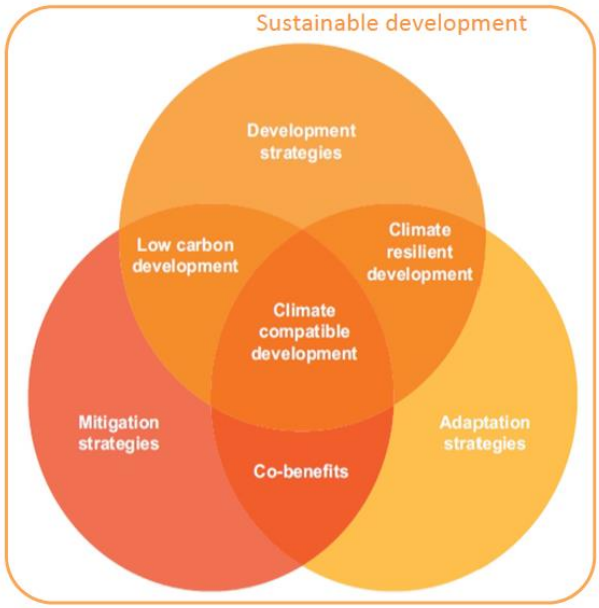


Figure 4: Conceptual framework for Climate Compatible Development (adapted from Mitchell and Maxwell, 2010)

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)[6]:

[5] Mitchell, T. and S. Maxwell. 2010. *Defining climate compatible development.* CDKN Policy Brief, November 2010.

[6] IPCC. 2013. *Fifth Assessment Report: Impacts, Vulnerability and Adaptation*. Currently in draft form.

> *"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."[7]

Sustainable Development

The most widely accepted definition of sustainable development, as formulated in the Bruntland 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 interrelated, 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.

In 2002 South Africa hosted the World Summit on Sustainable Development, and the Johannesburg Plan of Implementation re-affirmed commitment to Agenda 21, and the Millennium Development Goals. These are currently under review and will be expanded through Sustainable Development Goals. In 2012 the Rio+20 Conference was held in Rio de Janeiro, and 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,

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

accompanied and partly implemented by Green Economies. These international commitments, together with ongoing assessment of national sustainable development concerns and goals, have driven the development of sustainable development policy and practice. 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.

2 METHODOLOGY, DATA SOURCES AND ANALYSIS LOGIC

2.1 Research design

This country-based study has been informed by an interactive and dialogical research design that included document analysis of key national and regional documents focusing on climate change in Botswana 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 Report for Botswana, within an overall interpretive, participatory and consultative and social realist methodology[8]:

2.1.1 Document analysis

The country Background Information Document (BID) provides 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. This was 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. The following documents were analysed through rapid desk review, to develop the Botswana Country Report:

- Vision 2016: Towards Prosperity for us all, Botswana, 1996;
- National Policy on Disaster Management, Botswana, August 1996;
- Implementation strategy for Multilateral Environmental Agreements (MEAs), 2007;
- National Disaster Risk Management Plan, 2009;
- Climate Change and Sustainable Development Programme, 2009;
- Botswana's Tenth National Development Plan (2010-2016), 2010; and
- Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), December 2011.

[8] 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.

2.1.2 Stakeholder and university staff consultations (national workshop)

As part of the SARUA mapping study Initiative *Climate Change Counts*, the second round of country consultations was held in Botswana on 18 and 19 April 2013 in Gaborone. The consultations were structured as a 1.5 day programme, with a combined group of participants, which included university, government, private sector and NGO stakeholders. See Appendix A for the list of participants. A summary of the content of the different sessions is provided below in Table 1. 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 this Country Report, combined with document analysis and questionnaire data.

Table 1: Workshop programme outline

SESSION	DAY 1: 18 APRIL 2013	DAY 2: 19 APRIL 2013
INTRODUCTION	▪ SARUA Initiative Overview	▪ Recap day and Agenda for day 2
SESSION 1	▪ Framing Climate Compatible Development	▪ Breakaway groups and plenary ▪ Who is doing what, where and why in universities in climate compatible development? (Research, Teaching, Community Engagement) ▪ Who is doing what and where amongst stakeholder groups? ▪ How does this respond to the identified needs and priorities? ▪ What are existing university plans? What are the gaps?
SESSION 2	▪ Botswana priorities and needs ▪ Knowledge and institutional gaps and capacity	▪ Plenary discussion ▪ Knowledge co-production introduction and example of trans-disciplinary research programme ▪ Gaps in enabling environment, and needs for policy and practice support
SESSION 3	▪ Group discussion (Breakaway) ▪ Botswana priorities and needs, knowledge and institutional gaps and capacity ▪ Plenary report-backs from group work	▪ Opportunities for collaboration ▪ Policy implications for government, universities and donors
SESSION 4	▪ What is the role of the university sector? ▪ Identifying other knowledge partners	▪ Way forward and closure
SESSION 5	▪ Framing Climate Compatible Development	

2.1.3 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 Appendices 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. For Botswana, a total of 39 questionnaires were answered, which included 17 stakeholders and 22 university professionals. Questions covered the following areas:

2.1.3.1 University staff questionnaire

A. **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)
B. **Understandings of Climate Change and Climate Compatible Development** and views on critical CCD issues and responses from universities (staff and university leaders)
C. **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)
D. **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)
E. **Policy, community engagement and student involvement**
F. **University collaboration** (inside the university; between universities in country; with partners; regional and international involvement)
G. **University policy and campus management**

2.1.3.2 Stakeholder questionnaire

The stakeholder questionnaire covered items A-C above, with an additional:

H. **Interests, policies, networks and Centres of Excellence or Expertise**

2.2 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 Botswana, 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 workshop relates to the number of participants, their expertise and the number of different sectors and institutions present. Further, while every

effort was made to obtain questionnaire responses from as wide a range of stakeholders as possible, 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 mapping study Country Report. Overall, the mapping study was further constrained by a budget cut imposed mid-way through the study.

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 Country Report therefore presents as a useful 'initial document' and it is hoped that Botswana, and in particular, the University of Botswana (UB), Botswana College of Agriculture (BCA), Botswana International University of Science and Technology (BIUST) and the Ministry of Environment, Wildlife and Tourism and other national stakeholders can take this analysis forward in ongoing mapping and planning activities related to CCD research and knowledge co-production.

2.3 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 every academic at universities in Botswana, and in a way that would allow for aggregate data within and across Faculties and Departments. 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 national and local stakeholders (Appendix D) involved in environment and development initiatives in Botswana to understand the full scope of climate change and CCD responsiveness in Botswana, and to further develop the knowledge co-production capacity for CCD in Botswana. In many ways therefore the SARUA study, as reported in the Country Report, maps out the pathway forward for more detailed and ongoing reflexive analysis of CCD knowledge co-production capacity in Botswana, 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 Botswana. Ministries who could take this study forward could include the Ministry of Education and Skills Development; the Ministry of Environment, Wildlife and Tourism, and the Ministry of Minerals, Energy and Water Resources, together with other relevant partners and stakeholders.

2.4 Analysis logic

The analysis logic informing this Country Report is threefold. 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 Botswana, but also on knowledge co-production possibilities, based on information gathered during the mapping study. It provides a knowledge base for producing knowledge co-production pathways in Botswana, which may also assist Botswana **to co-operate with other SADC countries in regional knowledge co-production processes.**

3 NEEDS ANALYSIS

3.1 Introducing the needs analysis

The needs analysis starts with a brief overview of Botswana's socio-economic context, which provides the baseline for addressing the climate change-related needs and priorities in the country (section 3.2), and a summary of the observed and projected climatic changes for the country (section 3.3). This is followed by an overview of the broader priorities for addressing climate change as identified by policy (section 3.4.1), in workshops (section 3.4.2) and via the questionnaires (section 3.4.3). A summative discussion is then provided of the broader climate change-related priorities and needs from these three sources of data in section 3.4.4. The needs analysis then moves on to describe more specific priorities and needs, and their associated knowledge, research and capacity gaps (section 3.5). The following differentiation of knowledge, research and capacity gaps is 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).

It is possible that this analysis can 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 mapping study outlined above), rather than definitive.

3.2 Socio-economic context

Botswana is a largely arid and semi-arid country that lies between 20 and 30° east and between 18 and 27° south. It covers an area of 600 370 km² and is landlocked, sharing borders with Zimbabwe, South Africa, Namibia and Zambia. Most of the country is hot and dry, rainfall is generally low and historically droughts have occurred once every three to five years. It experiences warm winters, hot summers and highly erratic rainfall. Mean maximum temperatures range from 29.5 to 35°C in summer and 19.8 to 28.9°C in winter. Mean minimum temperatures range from 14.6 to 20.8°C in summer, to 2.9 to 11.6°C in winter. The mean annual rainfall in the northeast is 650 mm, while in the southeast it is less than 250 mm, resulting in a national mean annual rainfall of 475 mm. The rainfall is seasonal, and mostly occurring from October to April. The high temperatures result in high evapotranspiration, which ranges from three to five times the mean annual rainfall and largely explains why most rivers in the country are ephemeral. Two-thirds of the country entirely depends on

groundwater. According to the 2009 Botswana Country Strategy Paper, in 2008 the population had a life expectancy of 51 years. The Gross National Income (GNI) per capita was US$3 166 in 2002 (SNC 2012), and US$5 840 in 2007.[9] Although Botswana is a middle income country, 36.7 percent of its population was living under the poverty datum line in 2002. Botswana's mismatch between skills needs and supply has been worsened by the impact of HIV/AIDS through reduced productivity and high staff turnover; shortage of skills and knowledge due to deaths; higher training costs to replace and re-skill personnel; and delays in implementation of climate compatible development projects and programmes.

3.3 Observed and projected climatic changes, impacts and vulnerabilities

3.3.1 Observed and projected climatic changes

Climate variability and extreme events have increased since 1931, with drought conditions of different severity occurring once every 3–5 years over the last 65 years. All the 11 natural disasters that occurred in Botswana between 1974 and 2003 were hydro-meteorological – seven droughts, three floods and one windstorm. More than one out of 10 people are affected by natural disasters, mostly droughts (93 percent of the affected).[10] Temperatures are projected to increase by 2°C in 2030, with desert areas experiencing the highest changes. Projections are that rainfall will decrease by 5 percent in northern and western regions, while it will increase by the same percentage in the southern and eastern regions. The rainy season will be shorter and more variable. The incidence of both droughts and floods is expected to increase. The severity and frequency of drought is particularly expected to increase between 2080 and 2100, especially in western and northern Botswana. The country is expected to have severe water shortages in 2075, ranging from 24 percent in the Shashe River Catchment area to 332% in the south-eastern area of the country, to 1 043 percent in the Metsemotlhaba-Ngotwane catchment (Gaborone and surrounding villages).

3.3.2 Impacts and vulnerabilities

Climate change is likely to double the population living in malaria prone areas by 2021 because during the high rainfall years, outbreaks of malaria extend from the northern parts of Botswana where rainfall is high, to the southern parts where it is generally low. The other diseases that are likely to increase as a result of climate change are dengue fever, cholera, yellow fever and bilharzia. Based on 'normal' population growth projections, climate change is projected to have differential impacts on crops in Botswana. For example, a 2°C increase in mean annual temperature will result in yield reductions of 21.6 percent yield for maize and 16.1 percent for sorghum; while a 3°C increase will result in yield reductions of 35.8 percent

[9] African Development Bank. 2009. "Botswana country strategy paper 2009–2013". Gaborone: African Development Bank.

[10] Wingqvist, G.Ö. and E. Dahlberg. 2008. *Botswana's environmental and climate change analysis*. Gothenburg: University of Gothenburg.

for maize and 25.6 percent for sorghum. The impact will also be determined by soil type, with sandy soils being worse affected. Seventy percent (70 percent) of the population is partly dependent on agriculture for its livelihoods and livestock is the base for 49 percent of household livelihoods. Livestock, which is dependent on natural rangelands, is sensitive to climate change as illustrated by the loss of 33 percent of the country's livestock during the severe droughts of the late 1980s and early 1990s. The cost of drought to the GDP has ranged from 0.39 percent in 1997 to 6 percent in 1983. The climate sensitive sectors have also been identified as critical for greening the economy.[11]

3.4 Identified needs: Short to medium term national priorities for CCD in Botswana

Section 3.4 focuses on the broad priorities and needs for addressing climate change and moving towards CCD in Botswana. Section 3.4.1 highlights key priorities and needs articulated in policy and strategy, after which some of the broader priorities articulated by workshop participants are discussed in section 3.4.2. This is followed by a presentation of the broader needs for CCD as specified in the questionnaire responses (section 3.4.3). A summative perspective on both broad priorities and specific identified needs (see section 3.5) for adaptation, mitigation and, ultimately, for CCD, is provided in section 6.1.

3.4.1 Identified adaptation and mitigation priorities articulated in policy and strategy

Botswana has identified key needs and priorities, related to the abovementioned observed and projected climatic changes, impacts and vulnerabilities. Currently the only recent and substantial climate policy relating to CCD in Botswana is the 2011 Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), referred to in this report as the SNC (2011). This communication identifies adaptation priority sectors as water, health, rangeland and livestock, and forests. These priorities resonate with those identified by a climate change analysis study conducted in 2008, which identified climate change adaptation priorities related to water transfer, purchase, recycling and conservation; sustainable community-based natural resources management of woodlands and grazing lands; minimum soil tillage for soil and water conservation; early drought warning systems; tapping into traditional coping mechanisms; and policy incentives and regulatory controls.[12]

Botswana's mitigation priorities focus on transformation of the agricultural, mining, transport, tourism and energy sectors. Mitigation strategies for reducing emissions from livestock include reducing livestock numbers, feed conversion and livestock methane vaccine. Solar, biomass and coal energy technologies have also been identified for mitigation. Biomass options include collecting methane from landfills, sewerage systems and slaughterhouses, and biofuels. Coal-

[11] http://www.greeneconomycoalition.org/know-how/national-vision-green-economy-emerges-botswana

[12] Wingqvist and Dahlberg. *Botswana's environmental and climate change analysis*.

related options are improving the quality of coal and using highly efficient coal combustion technology, which is high in ash and sulphur; and tapping into coal bed methane (CBM), which can provide fuel for transport and domestic use. The country has vast solar energy resources, which provides the potential for solar heating, pumping, and cooling, as well as for passive solar designs. It also has significant waste water, which could be made available for use through sludge treatment for irrigation.

The identified potential adaptation solutions, with embedded possible research needs, include:

- **Water:** water conservation; water recycling, rainwater harvesting, desalination of ground water, incorporation of water demand in all national development projects, increased investment in water infrastructure development, improved water use efficiency, review of existing national and sectoral policies, importing water, and inter-basin transfers;
- **Agriculture/crops:** minimum soil tillage for soil and water conservation, early drought warning systems, developing capacities of the drought early warning units, importing cereals, wider use of early maturity varieties, use of greenhouses/nets, development of agricultural infrastructure, and seed and fertiliser provision;
- **Rangeland and livestock:** the raising of small livestock that is adapted to arid environments, provision of feeds, and diversification of farm produce;
- **Health:** malaria control programme, control of diarrhoeal disease programme, and integrated management of childhood infections; and
- **Forestry:** planting trees, use of alternatives to trees, community-based forest and woodland management, and enforcement of conservation policies.

The SNC (2011) identifies the following **mitigation measures**:

- Energy efficiency in residential areas;
- Replacing fuel wood with biogas;
- Rural electrification and increased use of solar energy;
- Landfill gas recovery;
- Aerobic manure composting and biogas capture;
- Reforestation;
- Industrial energy efficiency in electric furnaces;
- Space heating and general lighting purposes and motors; and
- Shift in the mode of transport, and use of biodiesel buses.

Botswana's National Risk and Disaster Management Office (NDMO) identified the following barriers to climate change adaptation:

- Lack of funding;
- Lack of co-ordination;
- Lack of supportive policies and legislation;
- Lack of community participation; and
- Inadequate political will and support.

Botswana's strengths in relation to disaster management and climate change adaptation include availability of capacity building institutions, good infrastructure and high economic

performance; transparent development processes; and prudent and good governance systems. Mitigation barriers in relation to solar energy adoption include high investment costs, limited government support and lack of financial sponsors. Barriers to biomass used include inadequate feasibility information and financial constraints, while barriers to CBM exploitation include under-developed markets, lack of financial resources and infrastructure for the exploitation, distribution and use of the gas.

The SNC (2011) also highlights the following technical and financial needs to urgently support capacity building and to establish research programmes within universities and research institutes. In this respect, support is needed for:

- Research capacity to generate data and information needed to derive locally, regionally and continentally applicable solutions;
- Development of *data and information management systems* that allow sharing, integrated analysis and synthesis for local, regional and continental application;
- Developing a *networked critical mass of scientists and other expertise* that could provide needed services in the entire spectrum of emerging climate change-related challenges;
- Harnessing *technology transfer*, particularly where advantages are emerging, as in the area of *bio-energy and other energy source developments t*hat are geared to explore potential of African resources;
- Building *capacities for modelling and early warning* of extreme events and disasters such as flash floods, dust storms and droughts;
- Developing *appropriate policies and institutions* that are geared to address climate change-related challenges, including the participation of the private sector, particularly in the provision of specialised services;
- Developing capacity to negotiate effectively from informed positions in international forums, to *attract meaningful resources* to address emerging climate change challenges, including reparations where due or assistance in lieu; and
- Re-training of *local experts in cross-cutting issues.*

3.4.2 Identified needs associated with CCD articulated in workshop interactions

Participants provided a range of responses during the workshop session dedicated to identifying climate change- and CCD-related needs, which indicated a strong level of engagement with the issue. Participants provided practical examples of the impacts on food security that should not be compromised and emphasised sustainable development to build resilience to the impact of climate change. They highlighted the following interventions:

- Accurate climate projections to address *not only* the "long term" but also the "solutions for now". One participant raised a concern that "we should be addressing the current situation, as climate change is impacting us now".
- We need data to make accurate predictions. What do we therefore tell the farmers? Do we have the data? Some of this requires remote sensing data. As African countries we are lacking data, the more reason for us to consult with or work in collaboration with local people to tap into traditional ecological knowledge, because right now there are many uncertainties.

- We need to look at the response and what we are responding to, since climate change has so many uncertainties. Some of us are experiencing climate variability, others are experiencing human-induced climate change. We should think of the need for adaptive management systems.
- We should take into consideration human-induced causes of climate variability in our interventions and initiatives.

3.4.3 Identified needs for CCD articulated in questionnaire data

Questionnaire data showed that there is a relationship between institutional interest/mandate and/or disciplinary interest / mandate and the definition of priority needs (see Table 2).

Table 2: Needs identified by different stakeholders / disciplinary specialists (from questionnaire data)

Need identified	Institutional interest / mandate and/or disciplinary interest / mandate
The nation must do what research recommends would do less harm on climate	Languages and Social Sciences Education
To have a robust land cover change maps which will give us a baseline of the indication of the climatic change effects throughout time	Science
Educating the communities on climate change effects – so that they reduce acts that add to degradation of the ecosystem	Primary and Secondary Education
Outreach, or adaptation strategies / Research on CCD	Earth and Environmental Science
Industry pollution such as mining / Create clean energy such as wind, biogas and solar etc. / Create clean farming systems such as zero tillage and sustainable feeding of livestock / water conservation and harvesting / Conservation of flora and fauna / Recycling and waste management	Animal Science and Production
Strengthen policies and institutions / Take advantage e.g. international funding sources to strengthen capacity and appropriate technology / more research and awareness raising	Environmental Science
We need adaptive strategies / programmes in place - low carbon development strategies e.g. energy sources, low tillage farming are critical	Forestry Unit / Section – Crop Science
National Development Plans, District plans, village plans / Household knowledge, attitudes, perceptions / Policy enablers / Funding / Human Capital	Environmental Science
Knowledge sector development / Climate proof investment / Climate resilient social / livelihoods	Environmental Science
Reduce burning of materials, reduce the number of cars that emit unwanted fumes	Health Policy, Development, Monitoring and Evaluation – Ministry of Health
Climate Change Education with special emphasis on values and ethics education in dealing with all climate change related issues that are critical such as water and agriculture and poverty	Primary and Secondary Education

Table 2 above shows that different institutions / disciplines and levels of interdisciplinary management shape the perceptions of what the most important climate compatible development 'needs' are. A number of cross-cutting priority areas are also identified, such as the need for strengthening polices and institutions, for generating better data and using evidence from research to inform decision making, for building the knowledge sector, for developing human capital in the area of climate change, and for funding to enable all of these activities. It is important to identify and recognise these different perspectives in knowledge co-production processes and approaches. Such perspectives also show the interdisciplinary and multi-sectoral nature of climate change. *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.*

3.5 Specific knowledge and capacity needs: CCD knowledge, research, and individual and institutional capacity gaps

A second important part of the Needs Analysis undertaken in the context of the SARUA mapping study involved more detailed analysis of CCD knowledge, research and capacity gaps, related to the broad CCD priorities discussed above, with a focus on those identified in key national documents, and as articulated by stakeholders and university staff attending the workshops and completing questionnaires. These specific knowledge, research and capacity gaps, distilled from all three data sources, are discussed in this section.

3.5.1 Needs analysis – Specific research needs and knowledge gaps

Botswana's Second National Communication (2011) notes that technical and financial support is urgently needed for capacity building and to establish research programmes within universities and research institutes. It further highlights the need to develop a networked critical mass of scientists and other expertise that could provide needed services in the entire spectrum of emerging climate change-related challenges.

Regarding data from the workshop, the prioritised needs for CCD were developed through a combination of themes emergent in the workshop data. Workshop participants systematically identified knowledge, research and capacity (individual and institutional) gaps in relation to selected priorities under certain thematic areas. The thematic areas were developed based on the areas of interest and expertise of participants, and thus cannot necessarily be considered as rigorously developed priorities for the country. However, within these thematic areas, participants identified what they considered to be priority issues that needed to be addressed in order to respond better to the country's climate change challenges. The thematic areas focused on in the Botswana workshop were the following:

- Education, training and knowledge management;
- Agriculture and rural development
- Climate change strategy and cross-cutting issues; and
- Energy and Tourism (including biodiversity, water and forestry).

Table 3: Knowledge, research and individual and institutional capacity gaps identified by workshop participants

Prioritised needs for CCD	Knowledge gaps	Research gaps	Individual capacity gaps	Institutional capacity gaps
1. Education, training and knowledge management	▪ Lack of appropriate knowledge transfer strategies for different audiences ▪ Failure to recognise that every discipline can contribute towards issues of addressing climate change ▪ Lack of appreciation, recognition, and even lack of knowledge on Indigenous Knowledge Systems (IKS) ▪ Familiarity with international programmes, through which to source funding for climate change education ▪ Access to information on CC finance, regional and international protocols and conventions	▪ Appropriate strategies of packaging the information ▪ Research on appropriate strategies of harmonising the curriculum ▪ Limited research /inadequate research on the contribution of IKS to climate change adaptation and mitigation ▪ Desktop research and conduct annotated bibliography on protocols and conventions	▪ Educationists have individual shortcomings in understanding the strategies ▪ Not understanding research that informs curriculum development ▪ Looking down upon IKS ▪ Lack of skills to develop project proposals to access funds	▪ Policies that don't give room for innovation e.g. mainstreaming of climate change ▪ Lack of interdisciplinarity ▪ Lack of curriculum articulation or linkage through the various levels of education system, including within the university and between the university and the feeder institutions ▪ Failure to train teachers on implementation strategies ▪ Inadequate policies and structures for infusion of climate change education, and to guide CC research ▪ Lack of documentation of relevant IKS related to climate issues
2. Water, energy and infrastructure needs for climate compatible rural development	▪ Understanding future climate effects on, for example, ground water – we don't know how much ground water we have and how long it will last us under future climate scenarios ▪ Water conservation types of farming	▪ Low-cost, accessible, alternative water and energy systems and creative ways of generating energy and supplying water that is efficient and renewable	▪ Lack of climate modellers ▪ Innovators that will come up with resource efficient systems ▪ Biologists to teach climate resilient agro-ecosystems, conservation farming, water harvesting techniques, integrated pest management and biological control	▪ Lack of funding ▪ Lack of facilities and resources like laboratories ▪ Lack of knowledgeable manpower in rural areas to bring about innovation, due to brain drain to urban areas ▪ Complete lack of institutions in rural areas – rather concentrated around Gaborone ▪ Specific ministry focused on rural development

Prioritised needs for CCD	Knowledge gaps	Research gaps	Individual capacity gaps	Institutional capacity gaps
3. Information sharing and stakeholder engagement	▪ Better understanding of how to manage climate knowledge and information ▪ Inventory of the indigenous knowledge that is available	▪ Individual perceptions of risks	▪ Experts in knowledge management	▪ Limitations in generating , accessing, storing and disseminating information ▪ Institutional knowledge systems at community level lacking, such as libraries, ICT access
4. Sustainable rural livelihoods, poverty alleviation and community resilience enhancement	▪ How current livelihoods will be affected by climate change in specific instances e.g. effects of climate change on veld products like wild fruits, on which communities rely for nutrition ▪ How specific agricultural systems (crops, livestock, fruits, mechanisation like drip irrigation) are going to be impacted by climate change, and specific responses needed	▪ Research to explore climate change impacts on livelihoods ▪ Research on how specific crops will be impacted by climate change, and associated appropriate technological innovation	▪ Experts on climate change and how it affects agriculture and rural development and livelihoods ▪ Loss of traditional knowledge within rural communities, such as old knowledge on understanding which types of seeds to plant, when to grow, etc.	▪ Lack of funding of community based organisations and other organisations that operate in rural areas ▪ Lack of packaged information on climate change to rural Community Based Organisations (CBOs) ▪ Lack of national development plans and budgets to support CBOs
5. Food security	▪ Effects of climate impacts on food sources from other countries (e.g. South Africa) and potential outcomes for food security in Botswana, given country's over-reliance on food imports ▪ Lack of knowledge on how local breeds of animals will fare in changing climate versus imported breeds ▪ Understanding which traits in local breeds are responsible for resilience	▪ Selection of resilient genotypes	▪ Need for nutritionists	▪ Need greater regional cooperation around climate change and this issue in particular ▪ Need for government to build capacity in people to engage in horticulture

Table 3 contains a wealth of information on important knowledge and research gaps to address Botswana's climate change priorities. 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.

Knowledge gaps emerging from the participants include the future effects of temperature rise on ecosystems, biodiversity, water, agricultural systems and rural livelihoods. Coping with these changes meaningfully was a second priority raised. Rain-water harvesting and alternative energy sources were specifically mentioned as knowledge gaps for Botswana. Education, particular regarding politician's CCD literacy was mentioned, with emphasis also placed on public education (formal and Informal). Lack of funding, and the know-how to attract international funding for climate change research and projects was noted, including specific skills lacking such as writing funding proposals.

Research gaps raised concern regarding the capacities needed to generate relevant climate change data and information, and how these are articulated into locally appropriate solutions. Participants went into detail with regard to focusing on technology transfer, of which the most needed technologies included solar, biomass, biogas, coal washing and dealing with coal bed methane, water treatment technologies, rainwater harvesting, technologies to reduce emissions from livestock, and conservation tillage. Alongside this, research into improving the current research capacity for climate modelling and early warning of extreme events was called for.

Unfortunately these research needs currently remain somewhat isolated from policy development in Botswana, save for the current drafting of the National Development Plan (10), to which University of Botswana, and a key professor in the Environmental Science Department are contributing. As Botswana is currently (in the course of 2013/2014) developing a National Climate Change Strategy and Action Plan, we can expect that this document will provide a clearer anchor for research and capacity development needs related to climate change. In the interim, many of the adaptation needs fall under or relate to aspects of the National Policy on Disaster Management (1996), showing some policy support for the further development and prioritisation of these research needs nationally. The SNC (2011) highlights the lack of information regarding research capacity needs due to the absence of national CC policy. The SNC also highlights briefly the technical and capacity needs for CCD, mentioning overall **research capacity, data information system development, technology transfer, modelling capacity development, and retraining experts with regards to cross-cutting issues**.

The individual and institutional capacity gaps identified in Table 3 are further discussed in sections 3.5.2 and 3.5.3.

The mapping study identified a number of programmes and projects involving government and donor agencies that are specifically focused on addressing climate change challenges, and which include research needs (implicit or explicit) that would need to be addressed through knowledge co-production involving multi-stakeholders at different levels, as shown in Table 4

below. Some suggestions are provided for research and knowledge gaps that may be at least partially addressed by these programmes. It is not clear to what extent university researchers are involved in these programmes, although it is likely that this is the case, given the small set of researchers working on climate change in Botswana.

Table 4: Climate change programmes in Botswana, with potential associated research needs

Project/programme	Partner organisations	Related research needs, linked to specific knowledge needs (as indicated in policy (P), and supplemented by workshop (W) and questionnaire data (Q))
Impacts of Climate Change, Vulnerability and Adaptation Capacity in the Limpopo Basin of Semi-Arid Southern Africa (2002-2006) Study concluded that while there are several policies and institutions that support rural development in Botswana, they hardly incorporate strategies to mitigate the vulnerability of communities to climate change risks, especially drought	▪ LEAD AGENT: UNEP ▪ PARTNERS: GEF/ START/ TWAS	▪ Need to incorporate applied adaptive management research into CC adaptation response (W) ▪ Need for robust land cover change maps for baseline of climatic change effects throughout time (Q) ▪ Community level education on climate change affects in relation to ecosystem degradation (Q)
Identifying and Overcoming Barriers to Widespread Adoption of Photovoltaic Rural Electrification	▪ LEAD AGENT: Department of Energy ▪ PARTNERS: funded by GEF	▪ Low-cost, accessible, alternative water and energy systems and creative ways of generating energy and supplying water that is efficient and renewable (W) ▪ Rural electrification and increased use of solar energy (P)
Community Adaptation to Climate Change in the Limpopo Basin	▪ LEAD AGENT: Planned sub-regional project submitted to the Special Climate change Fund for consideration. ▪ PARTNERS: Involves Botswana, South Africa, Zimbabwe and Mozambique	▪ Environmental law and intellectual property rights (Q) ▪ Integrated environmental management approaches (Q) ▪ Technology transfer: needed technologies include solar, biomass, biogas, coal washing and dealing with coal bed methane, water treatment technologies, rainwater harvesting, technologies to reduce emissions from livestock, and conservation tillage (P)
Carbon Finance Assist Programme No further information available on this	▪ LEAD AGENT: ▪ PARTNERS: World Bank	▪ Take advantage e.g. international funding sources to strengthen capacity and appropriate technology (Q)

Additional research needs are provided in the SNC (2011), as project proposals related to CCD in Botswana. These are however in the proposal development stage and are currently not operational. They include:

Mitigation:

- Generation of energy from biogas (BMC waste);
- Large scale power generation from solar energy;
- Coal Bed Methane investigations;
- Substitution of fuel-wood in rural areas through promotion and use encroaching bush;
- Residential and commercial energy efficiency;
- Fuel efficiency in transport;
- Wind farms;
- Power generation from landfill gas;
- Reducing livestock numbers; and
- Conservation tillage.

More adaptation-related research needs set out in the SNC include:

- Reverse osmosis;
- Waste stabilisation ponds;
- Constructed wetland systems for waste water treatment;
- Ground catchment tanks; and
- Improving animal productivity.

They are included here in Table 5 as they provide further insight into the nuances associated with CCD research and knowledge needs in Botswana.

Table 5: More detailed research and knowledge needs alluded to or identified in the SNC (2011), workshops and questionnaires[13]

Aspect	Theme	Research and Knowledge needs
[A] ADAPTATION	Food Security	▪ Minimum soil tillage for soil and water conservation ▪ Early drought warning systems ▪ Developing capacities of the drought early warning units ▪ Importing cereals, wider use of early maturity varieties ▪ Use of greenhouse/nets ▪ Develop agricultural infrastructure ▪ Seed and fertiliser provision ▪ Planting trees, use of alternatives to trees, community-based forest and woodland management, and enforcement of conservation policies ▪ Raising of small livestock that is adapted to arid environments ▪ Provision of feeds ▪ Diversification of farm produce

[13] As in Table 4, additions from workshop and questionnaire data are indicated in italics, (P) refers mainly to the SNC (2011) and the National Policy on Disaster Management (1996). All needs that are not labelled have been extracted from the SNC.

Aspect	Theme	Research and Knowledge needs
	Water	▪ Water conservation ▪ Water recycling ▪ Rainwater harvesting ▪ Desalination of ground water ▪ Incorporation of water demand in all national development projects ▪ Increase investment in water infrastructure development ▪ Improve efficiency and review existing national and sectoral policies ▪ Importing water, inter-basin transfers
	Health	▪ Malaria control programme ▪ Control of diarrhoeal disease programme ▪ Integrated management of childhood infections
[B] MITIGATION	Sustainable energy and low carbon development	▪ Energy efficiency ▪ Fuel wood replacement technology: i.e. biogas and rural electrification. ▪ Solar energy ▪ Landfill gas recovery ▪ Aerobic manure composting and biogas capture ▪ Reforestation ▪ Industrial energy efficiency in electric furnace ▪ Space heating and general lighting
	Institutional	▪ Coordination between government ministries ▪ Legal and institutional framework for risk assessment, preparedness planning, and tools for a system wide (trans-sectoral) analysis of risks [14] ▪ Information sharing (Q) ▪ Support technologies for adaptation and mitigation (Q)
[C] CROSS-CUTTING ISSUES	Capacity building, training and institutional strengthening	▪ Capacity building of NGOs on climate change (Q) ▪ Politician's CCD literacy and public education (formal and informal) (Q) ▪ Negotiation capacities (P)
	Research and information needs, including how to use climate change information	

[14] Becker, P. and M. Abrahamsson. 2010. *Scoping study for partner-driven cooperation in disaster risk management between Sweden and Botswana*. Gaborone/Stockholm: National Disaster Risk Management Office/Swedish Civil Contingencies Agency.

Aspect	Theme	Research and Knowledge needs
	Public awareness, participation and access to information	▪ Links between climate change and biodiversity (Q) ▪ Information sharing (Q) ▪ Individual training e.g. MSc climate change qualifications / universities to offer courses – certificates, diploma, degrees etc / Public and private officers to be made were on CCD (Q) ▪ Capacity building of farmers/ tailor-made information for different groups / simplified information on climate change for everybody (Q)
	Disaster reduction and risk management	▪ Undertake vulnerability mapping (using remote sensing techniques and GIS) to delineate areas prone to disasters such as floods and enable identification of adaptation strategies ▪ Research response of sectors (e.g. agriculture, water sector) to climate change (Q) ▪ Additional aspects of this are covered in detail in the National Policy on Disaster Management (1996) (P)
	Financial resource mobilisation and management	▪ Research and estimate cost of climate change mitigation (Carbon Finance Assist Programme funded by the World Bank), cost of adaptation not mentioned. ▪ Research participation of the private sector in the provisions of specialised services to address climate change challenges (P)
	Technology development and transfer	▪ Research capacity to develop locally appropriate solutions (P) ▪ Research Technology transfer: needed technologies include solar, biomass, biogas, coal washing and dealing with coal bed methane, water treatment technologies, rainwater harvesting, technologies to reduce emissions from livestock, and conservation tillage (Q)
	Policy and legislative development	▪ Research into integration of climate change issues in development plans and programmes (P) ▪ Weak legal and institutional framework for risk assessment, preparedness planning, and tools for a system wide (trans-sectoral) analysis of risks[15] (P) ▪ No other research and knowledge needs identified (e.g. comparative studies to inform legislation / policy development), only actions for implementation

The table above offers some indication of where the major needs are, which is of relevance for the development and implementation of the future National Climate Change Strategy and Action Plan. All these needs are highly reliant on research and knowledge (co) production processes, and it would be important that the diversity of these knowledge needs is well articulated in such policy at a suitable level of detail.

[15] Becker and Abrahamsson, *Scoping study for partner-driven cooperation in disaster risk management between Sweden and Botswana*.

What is of interest in this analysis (as presented in Table 5), is that the potential research and knowledge needs identified by workshop participants (Table 3) are more nuanced, as they are considered within thematic contexts. This is an important point to note for knowledge co-production processes, so as not to lose the specificity of the research problems and/or contexts. Needs and gaps set out in Table 3 show what specialists from universities and stakeholder groups identified as national priority areas, which could be considered in further policy development.

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. These are in some cases contextually defined, and in other cases influenced by disciplinary interest / mandate and/or role and type of responsibility. For example, the respondent in Primary Education identified the need for CCD education with special emphasis on values and ethics education in dealing with all climate change related issues that are critical; while a stakeholder in the forestry and crop science area identified a need for adaptive strategies to support better agricultural practice. In some cases a simplified understanding due to their research context (currently not associated with CCD in Botswana) offered less specific technical needs by the representative from the Ministry of Health, i.e. *"Reduce burning of materials, reduce the number of cars that emit unwanted fumes".*

Workshop and questionnaire data also identified research needs related to capacity building of NGOs and building the CCD literacy of politicians, as well as negotiation capacities, information sharing and public awareness, showing the broad societal and institutional knowledge and capacity deficit. Addressing this would need to be a prioritised aspect of the country's CCD research agenda.

Congruent with the emphasis on sociological / social change related priorities for CCD (identified in workshop data, see section 3.3 above), knowledge and research needs are recommended to not only move towards CCD, but also to deal with the social processes necessary to **implement policies and strategies related to CCD.**

A further part of addressing the process question related to CCD policy implementation is the analysis of individual and institutional capacity gaps, addressed in the following two sections.

3.5.2 Needs analysis: Individual capacity gaps

The SNC (2011) notes the main constraints are related to lack of activity data and information, and the lack of expertise in the respective sectors. Due to the unavailability of relevant data, assumptions were made and data obtained from secondary sources in the development of the SNC. Climate change is felt to be not yet a priority for the country even though there is a Parliamentary Committee on Climate Change. Thus the integration of climate change issues into development programmes and projects still remains a challenge. The current absence of a policy and legal framework to implement the UNFCCC means that climate change is weakly infused in social, economic and environmental policies.

Key considerations for individual capacity development noted in the SNC were improving modelling and early warning capacities, and capacities needed for appropriate climate change data collection, analysis and dissemination. Other suggestions included re-training of local experts in cross-cutting issues and holistic thinking within disciplines involved in environmental management; reviewing Environmental Impact Assessment reports and focusing on the capacities needed to implement these as adaptive measures. Finally, considering more integrated approaches to environmental management, negotiation capacities and social exchange capacities required attention. Some of the capacity constraints identified under the National Capacity Self-Assessment report were inappropriate institutional structures, inadequate manpower and inadequate policy framework. According to the SNC (2011), technical and financial support is urgently needed for capacity building and to establish research programmes within universities and research institutes.

Workshop participants developed contextualised sets of individual capacity gaps, related to the priority thematic areas they explored, as set out in Table 5. These include a number of discipline-specific skills, such as climate modellers, nutritionists, suitably skilled educationists, and biologists and agriculturalists to teach climate resilient agro-ecosystems, conservation farming, water harvesting techniques, integrated pest management and biological control. They also include some cross-cutting skills, like knowledge management and developing funding proposals.

In discussing the human capacity priorities of Botswana with regard to climate compatible development, the SADC Regional Environmental Education Programme (REEP) in 2012 identified that the country lacked the following individual skills: climate change modellers; Climate change adaptation specialists; Biological specialists; Environmental educators; Environmental policy planners; Environmental lawyers; System managers; Conflict management facilitators and law enforcers; and Biosafety technicians. Cross-cutting skills needed were for capacities to collect, manage and exchange information; negotiate at Conferences of the Parties; coordinate multiple sectors; and plan and conduct monitoring activities.

A summative perspective on these individual capacity needs is provided in section 6.1

3.5.3 Needs analysis: Institutional capacity gaps

The Botswana workshop and questionnaire identified the need for institutional capacity building in a range of key areas. The lack of funding for teaching and research facilities in general, such as laboratories, was found to underpin the significant lack of funding dedicated to CCD development, including for facilities and intuitions dedicated to CCD research. The lack of supportive institutions in general in rural areas was particularly highlighted, with one respondent focusing on the noticeable lack of institutional knowledge systems available at a community level, such as libraries, media or even on television; instead these systems are concentrated around Gaborone, the capital city. Another institutional capacity gap highlighted was the lack of policy research and development, and the need for a national action plan for Climate Change. A noticeable weakness in generating CCD-relevant information, and the difficulty in accessing, storing and disseminating this information was also of concern. Related

to education, a need to align curricula to approach issues of climate change and rural development was raised as an institutional capacity gap; however this was also seen as capacity gap for research. One respondent added that when there is climate change information available for curricula it is mainly westernised and for North American or European contexts, while material referring to climate change in indigenous contexts is not available. Finally a key institutional capacity gap frequently referred to throughout the workshop and in the questionnaire was the lack of political will to respond to climate change, and the slow process of decision-making and attitudes within local and national government.

Of greatest concern to the participants were the institutional capacity gaps which ranged across governmental and non-governmental sectors. Across the board limited funding and resources was considered a key shortfall. Coupled with this, weak coordination between government ministries and the fact that climate change is not viewed as a priority heightens the risk of further inadequacies in policies and legislation. Yet even if CCD were to be prioritised by government, the participants felt that there are currently weak legal and institutional frameworks, that were unable to appropriately conduct risk assessments, preparedness planning, and tools for a system-wide (trans-sectoral) analysis of risks.[16] In addition to this, more rapid decision-making capacities are needed. Currently, the participation of the private sector is not encouraged and valuable provisions of specialised services to address climate change challenges are being lost. Similarly, better institutional enabling environments are needed to support technologies for adaptation and mitigation. Data management, community participation in policy development and integration of climate change issues into development plans and programmes, were other areas of concern.

A summative perspective of institutional capacity gaps is provided in section 6.1.

[16] Becker and Abrahamsson, *Scoping study for partner-driven cooperation in disaster risk management between Sweden and Botswana*.

4 INSTITUTIONAL ANALYSIS

4.1 Introducing the institutional analysis

This section describes the current climate change related institutional responses, within the context of the above-mentioned research, knowledge and capacity gaps. Core emphasis is placed on higher education institutions, in line with the brief for this study, and in recognition of their important role in research, education and training, and in providing policy and strategy support and leadership for development.

The institutional analysis begins with a summary of wider institutional arrangements for CCD, including any relevant research and development frameworks. It then discusses some of the current CCD initiatives and programmes in Botswana, and identifies some of the key stakeholders that could form part of a Botswana CCD knowledge co-production framework.

Following that, it examines understandings of CCD amongst stakeholders and university staff, and then begins to probe research practice and capacity, as well as curriculum, teaching and learning programmes and capacity in the higher education sector. It further considers other aspects of higher education interaction with climate change and CCD, namely community engagement, student involvement, policy engagement and campus sustainability initiatives.

4.2 Policy and institutional arrangements

4.2.1 Policy and institutional arrangements governing Higher Education in Botswana[17]

Higher education in Botswana began in 1964 with the establishment of the regional University of Basutoland, Bechuanaland and Swaziland, subsequently renamed University of Botswana, Lesotho and Swaziland (UBLS), with its campus in Roma, Lesotho. Following the breakup of UBLS in 1975, Botswana and Swaziland established the University of Botswana and Swaziland (UBS), comprising the University College in Gaborone (specialising in economics, social studies and natural science) and the University College in Kwaluseni (which offered law). Co-operation between the two countries and their colleges remained high with a free interchange of students and a common vision for tertiary education which, at the time, was seen as playing an increasingly important role in national development, not only by providing the necessary skilled human resources, but also by using the university as a focus for academic and cultural activities. At the same time, both colleges concentrated on developing their infrastructural and academic resources.

[17] This short summary is derived from a SARUA Country Profile compiled by Leapetswe Malete and Kagiso Kobedi. 2011. "Chapter 3: Botswana," in *A profile of Higher Education in Southern Africa. Volume 2.* (www.sarua.org)

In 1982, UBS was dissolved and separate universities were established in each country: the University of Botswana, and the University of Swaziland. After the split, co-operation remained high with student exchanges and special consultative mechanisms established between the two institutions. In 1990, a major review was undertaken of the organisation, management and structure of the University of Botswana (UB). This led to considerable changes in governance, starting with the creation of new faculties of business, engineering and technology, and subsequently a school of graduate studies, bringing the total number of faculties to eight. The Botswana College of Agriculture (BCA), which awards degrees through UB, functions as an autonomous ninth faculty. The Okavango Research Institute (formerly the Harry Oppenheimer Okavango Research Centre, established in 1994) attracts postdoctoral researchers from different parts of the world. The institute offers excellent research facilities.

4.2.2 Policy context for climate change

Botswana initiated the process to develop a National Climate Change Strategy and Action Plan (NCCS&AP) in 2013. A climate change policy will be developed first, followed by the strategy. This will be located within the umbrella of sustainable development, and will include undertaking economic assessments of key economic sectors and considering Green Economy issues. The process to develop the strategy will reportedly be highly consultative, including going to the villages and asking people what their issues are.

Currently, in the absence of this overarching strategy, the National Management Policy of Disasters (1996) provides a relevant cross-cutting national policy framework, although it focuses on adaptation measures only through disaster management and risk reduction, and not overtly. However, the National Development Plan 10 is being developed, which will provide an important framework for Botswana's future NCCS&AP. In addition to this, Botswana has recently released "Vision 2016" which outlines a basic roadmap for the NDP-10, and briefly affirms the importance of sustainable development and the protection of the environment. There are related policies for Botswana, yet they do not focus specifically on climate change action, or offer any clear responses to climate change adaptation and mitigation, these include: National Conservation Strategy (1987), the National Policy on Natural Resources Conservation and Development (1990), the National Strategy for Poverty Reduction (2003), the Strategy for Economic Diversification and Sustainable Growth (2008) and the various National Development Plans including the current NDP-9 (2009-2015). Of note is the relative age of policies on natural resources and conservation.

Despite the current lack of a specific Climate Change Action Plan or policy, the Government of Botswana is currently implementing a number of projects in that context – see section 4.4.

4.2.3 Institutional Arrangements for Climate Change

At parliamentary level, Botswana has established a Select Committee on Climate Change to oversee the development of associated policies. The structures that are important for implementing climate change and related policies at sub-national levels are the nine District Councils and five Town Councils, headed by District Commissioners and Council

Secretaries/Clerks respectively; and the Tribal Administration and Village Development Committees at village level[18].

Within government, the Meteorological Services Department is the Designated National Authority, and also serves as the Secretariat of the National Committee on Climate Change (NCCC). The NCCC has representation from government ministries, parastatals and NGOs[19]. The government departments represented on the NCCC are: Department of Mines, Energy Affairs Division, Department of Water Affairs, Attorney General's Chambers, Department of Agricultural Research, Crop Production and Forestry, and the Ministry of Finance and Development Planning. NGOs on the committee include the Forum on Sustainable Agriculture, and the International Union for the Conservation of Nature and Natural Resources (IUCN). Quasi-government organisations involved in climate change activities include the Water Utilities Corporation, which supplies water to urban areas and major villages; the Rural Industries Promotions Company, which is involved in solar energy and water harvesting; the Botswana Power Corporation, which is responsible for electrification; and the University of Botswana, which is responsible for research in environmental, climate, water, wetlands, biological and energy issues.[20]

4.3 Research and development frameworks

With respect to higher education and research in climate change and related matters, the Botswana Global Change Committee (BGCC) provides a mechanism for developing knowledge about the implications of global environmental change in Botswana and southern Africa. BGCC was formed in 1993 by the Department of Environmental Science and the former Institute of Research and Documentation at the University of Botswana. It uses an interdisciplinary approach to global change research, thus enabling collaborative research among researchers coming from both the human and biophysical sciences. BGCC identifies Botswana's research priorities that are concerned with global environmental change, including climate change; motivates potential researchers and institutions to conduct research on priority global environmental change matters; conducts capacity building of research scientists in Botswana through training, networking and provision of an institutional framework within which (the researchers) participate in research; promotes dialogue between the researchers and policy makers; and disseminates research results for awareness creation. Its research priorities currently include: climate change; drought and food security; over-exploitation of land and water resources; fire management; air, water and solid waste pollution.[21] The Government-

[18] Aladiran, M. T., M..J. Kethoilwe, B. C. O. Molefhi and C. Kiravu. 2010. *Research consultancy on parliamentary climate change capability.* London: IIED.

[19] Ministry of Works, Transport and Communication. 2001. Botswana Initial National Communication to the United Nations Framework Convention of Climate Change. Gaborone: Printing and Publishing Company.

[20] Aladiran et al., *Research consultancy on parliamentary climate change capability.*

[21] http://www.ihdp.unu.edu/article/read/botswana

established Botswana Innovation Hub (BIH) has held a workshop on Climate Technology and Carbon Markets Partnership in Botswana.

4.4 Some current CCD initiatives and programmes

While there are a number of CCD initiatives and programmes active in Botswana, driven by government, NGOs, donors, and the private sector, limitations and the required focus of this institutional analysis meant that only a few of these have been identified. See Table 6 which sets out some of these initiatives. This list is not comprehensive, but rather illustrative of how some of the priorities and needs identified above are already being addressed. More comprehensive national analysis would be able to expand the insights into existing active programmes.

Table 6: Some CCD initiatives and programmes in Botswana[22]

Programme / initiative	Driving agency / department	Focus and time frame	Status / additional comments
Drafting and implementing governmental policies, strategies and action plans for environmental protection	Implementer: Ministry of Environment, Wildlife and Tourism (MEWT), National Climate Change Committee	MEWT is the main specialised governmental body responsible for environmental protection in Botswana, with direct responsibilities, directorates and institutions relevant to climate change GEF Focal Points and National Focal Point for the UNFCCC provide technical support and policy advice to the MEWT for implementation Coordinates the preparation of Technology Needs Assessment	MEWT, through the National Climate Change Committee (NCCC), is responsible for the preparation of National Communications to the CoP of the UNFCCC along with the overall implementation process of the UNFCCC
Impacts of Climate Change, Vulnerability and Adaptation Capacity in the Limpopo Basin of Semi-Arid Southern Africa	AIACC project, led by Dr Pauline Dube of UB; UNEP/ GEF/ START/ TWAS	2002 to 2006 Climate change vulnerability and adaptation capacity	

[22] Note: The list is not comprehensive.

Programme / initiative	Driving agency / department	Focus and time frame	Status / additional comments
Community Adaptation to Climate Change in the Limpopo Basin	Planned sub-regional project submitted to the Special Climate change Fund for consideration. Involves Botswana, South Africa, Zimbabwe and Mozambique		
World Bank Carbon Finance Assist Programme		2005	
Agricultural Adaptation to Climate Change	Implementer: Ministry of Agriculture	MoA is the main specialised governmental body responsible for agriculture and food security in the Republic of Botswana; includes many responsibilities, directorates and institutions relevant to climate change	Department of Agricultural Research has mandate to generate improved crop and livestock production technologies through research to promote a productive and sustainable agricultural sector
National Strategies for Sustainable Development and Mitigation of energy and industry sectors	Implementer: Ministry of Trade and Industry	Designs, revises and regularly updates national strategies for sustainable development of energy and industry sectors. Drafts the respective legal framework; forecasts the continuous demand for different energy sources	Monitors and mentors businesses to assist with development, sustainability and growth and disseminates business information for investment promotion
Identifying and Overcoming Barriers to Widespread Adoption of Photovoltaic Rural Electrification and Water resource management	Implementer: Ministry of Minerals, Energy and Water Affairs	The Ministry of Minerals, Energy and Water Resources has the portfolio responsibility to coordinate development and operational activities in the energy and water sectors	Participant in NCCC. Main data provider for information on water sector and energy balance
Climate Change Mitigation Analysis	Department of Environmental Science (DoES), University of Botswana	DoES is a potential provider of the technical expertise for GHG inventory and GHG mitigation analysis	DoES is represented on the NCCC

Programme / initiative	Driving agency / department	Focus and time frame	Status / additional comments
Multidisciplinary Sustainable Resource management research	Okavango Research Institute (ORI)	ORI, a branch of the University of Botswana is multidisciplinary and specialises in natural resource management research in the Okavango River Basin	Its aim is to support the development of sustainable resource use by local communities in the whole river basin so as to promote its long-term conservation
Technical development for Mitigation to Climate Change	Implementer: Botswana Technology Centre (BoTec)	BoTec is a research and development organisation specialising in energy efficiency, electronic systems, information technology, water, building materials and design	Participant in the NCCC and potential provider of the technical expertise for GHG inventory

Projects relevant for CCD currently implemented by the Government of Botswana include: (i) Botswana Integrated Water Resource Management Project; (ii) Renewable Energy-Based Rural Electrification Programme (iii) Incorporating Non-Motorised Transport Facilities in the City of Gaborone (iv) Management of Indigenous Vegetation for the Rehabilitation of Degraded Rangelands Project; and (v) Southern Africa Biodiversity Support Programme.

This aspect of the institutional analysis indicates a number of initiatives on the part of government, universities, and institutes/centres, with some notable strength on the mitigation side from a range of stakeholders.

4.5 Existing status of CCD research, education, outreach and networking in Botswana

4.5.1 Understandings of CCD: National policy, stakeholders and university staff

At the policy level, while there are a number of policies and initiatives that deal with different aspects of adaptation and mitigation, there is no evidence of a clear understanding of climate compatible development. This is not surprising, given the lack of overarching policy on climate change, and the pending Climate Change Strategy and Action Plan for Botswana. At present, climate change issues are addressed in some sectors as specific climate mitigation and adaptation policies such as the Botswana Energy Master Plan prepared by the Energy Affairs Division (EAD) in June 1996, which indicates that solar energy technologies should be part of national electrification planning.

Thus there is a need to develop a common understanding of the core issues and the integrated and iterative nature of CCD, to underpin knowledge co-production in this regard. Discussion on the meaning of CCD in the Gaborone workshop showed different understandings, as

summarised in the following key points in response to the question posed on ***what does CCD mean in our daily work context?***

- Development strategies to impact and promote sustainable production systems
- Technology strategies e.g. renewable energy
- Training teachers to change attitudes
- Scientifically informed and knowledge-based community to inform strategies
- Management strategies in own home/place to reduce cumulative impact
- Acknowledge the existence of climate change
- Develop strategies responsive to continuous sustainable development in the region

However, the workshop discussions led to the beginning of a shared understanding of CCD that included the following:

- CCD is located within sustainable development – it is sustainable development strategies that incorporate and respond to current and projected climate risks
- Needs to incorporate and address the poverty dynamics
- CCD involves being responsive to ongoing climate changes, and to coordinated responses between countries – iterative learning and change

Amongst the stakeholders involved in CCD related policy and knowledge mediation activities, different understandings of CCD exist, as shown by these extracts from the questionnaire data:

- 'Climate compatible development is low carbon development which is climate resilient'
- 'As I teach, climate compatible development will mean that I have to teach my students, (most of whom are young) to minimise harm caused by climate impacts, especially looking at the future world which is their home. Therefore I have to cultivate in them a culture of total caring for the environment to avoid catastrophic outcomes'
- 'Existing emissions should be reduced if warming / Changing of behaviour / Scientifically informed and knowledge based decision making'
- 'This is development that matches environmental conditions / challenges associated with climate change'
- 'Development that is sensitive and recognises existence of CC i.e. through development of adaptation, mitigation and vulnerability considerate plans'
- 'Economic activities, development activities that do not compromise environmental sustainability and emit minimal climate change triggering substances'
- 'Scientifically informed and knowledge-based decision making, in developing strategies to mitigate and adapt to climate change'
- 'Development which takes climate change into consideration'
- 'Development that does not lead to harmful effects on the environment which may eventually lead to global warming and general deterioration of the natural systems'

Within the universities across Botswana, there were somewhat different understandings of CCD, as shown by these extracts from the questionnaire data obtained from nine university respondents:

- 'Development that does not have adverse / negative effects on climate'

- 'We need to reduce all emissions which affect the ozone layer and in that way cause the climate to change'
- 'Activities that will minimally interfere with climate - such as activities that are included to greening e.g. green the economy, growing crops that have short growth period to utilise minimal water available to enable food production, reduced emissions in industries using environment friendly fuels'
- 'Development that minimises climate change and its effects on humanity / resilience and sustainable development that minimises climate change'
- 'Developmental strategies that reduce climate impact and hence results in sustainable production systems'
- 'Development that takes cognisance of climate change impacts and endeavours to either reduce the adverse impacts or also enhance the positive impacts'
- 'Climate compatible development is development that can either be adaptive or mitigating towards this changing environment and development that reduces / does not increase pollution / using a lot of energy'
- 'CDMs / Green Economy / Funding / Awareness / participation [article 6] / Research [article 5]
- Climate resilient, green and sustainable development'
- 'Don't know, but probably, it is the means of achieving climate that is closely related to the normal climate of a given environment'
- 'Any form of development (whether at policy or practical level), should take into account climate change impacts, mitigation and adaptation measures'

The questionnaire however revealed individual respondents (mainly those in the Environmental Science field) had nuanced understanding of CCD development, both with regards to technical, scientific and/or practical dynamics of climate compatible development, as well as policy, education and adaptive management needs.

From this it is possible to see that although understandings of CCD differ amongst and between stakeholders and university staff involved in CCD related work, there is generally a close conceptual association between climate compatible development and adaptation and mitigation, and climate compatible development and sustainable development. It is also apparent that the concept of CCD is relatively new to some of the stakeholders. Context also has an influence on how CCD is understood, and influences meaning making and understanding of the concept. This has important implications for knowledge co-production processes, and will require careful engagement in development of mutual understanding in such processes.

4.5.2 Current research related to Climate Compatible Development

4.5.2.1 General view

Unlike neighbouring countries such as Namibia and South Africa, Botswana currently has limited national policies directly relating to climate change and CCD. Despite this lack of direct national policy support, there is CCD research and project implementation underway in Government Ministries, the University of Botswana, Botswana College of Agriculture (BCA) and within some private consultancies, which seem to owe their genesis and funding to national-

led responses to droughts, flooding, fires and other natural disasters. Mitigation responses focus primarily on energy, and electrification of rural communities, with some research now focusing on transport. Multidisciplinary research agendas exist in the form of sustainable natural resource management at the Okavango Research Institute, part of the University of Botswana, and through the auspices of the Botswana Global Change Committee (BGCC), noted in section 4.3, which essentially functions, amongst other things, as a research promotion framework.

Due to the lack of national policies on climate change, there is limited policy-based information on the needed research outcomes for CCD. Policies contain little to no information on what research *is already being done,* other than brief details in the SNC, and mention of potential data providers to the UNFCCC on specific themes. This section seeks to provide some insight into this question.

A detailed database search of all research published on climate change / sustainable development research in Botswana would provide substantive detail on what research is already being conducted in Botswana. As this fell outside of the scope of this study, it is only possible to show ***some*** of the research that is currently being undertaken on climate change in Botswana.

The Second Communication to the UNCFF (SNC, 2011) shows the following recent[23] research-based initiatives for climate change in Botswana (taken from the reference list of the SNC, 2011):

- Wolski, P., L. Coop and M. Tadross. 2010. Assessment of change in rainfall under climate change projections for Botswana based on statistical downscaling.
- Botswana Climate Variability and Change: Understanding the Risks. 2011. World Bank.
- Vulnerability Assessment and Adaptation in the Crop Sector. 2011.
- Vulnerability Assessment and Adaptation in the Health Sector. 2009.

There are several initiatives that are being taken to build climate change capacity, including through the actions of the University of Botswana. Some capacity building initiatives are:

- The UNDP/Government of Botswana Environmental Support Programme project which builds capacity of officers from different institutions on climate mitigation and vulnerability and adaptation assessments;
- The project 'Desertification and Mitigation and Remediation of Land – A Global Approach for Local Solutions' – a five-year EU-funded project on desertification involving 28 institutions from 20 countries; and
- Capacity Building in Climate Change and Rural Livelihoods in Botswana and Malawi – involving the Universities of Botswana, Malawi and Leeds under Development Partnerships in Higher Education (DELPHE), funded by the British Council.

[23] In this section research, mostly conducted after 2009 is used as referent (last five years).

A rapid review of published research available on Google Scholar (first ten articles listed with 'climate change Botswana' in the search) shows the following research conducted on climate change in Botswana.

Table 7: First ten articles listed with 'Climate Change' and 'Botswana' in the search and the origin of the first author

Article	Origin of first Author
Batisani, Nnyaladzi and Brent Yarnal. 2010. "Rainfall variability and trends in semi-arid Botswana: Implications for climate change adaptation policy," in *Applied Geography* 30(4): 483-489.	Botswana
Dougill, A.J., E.D.G. Fraser and M.S. Reed. 2010. "Anticipating Vulnerability to Climate Change in Dryland Pastoral Systems: Using Dynamic Systems Models for the Kalahari," *Ecology and Society*: 15 (2). ISSN 1708-3087.	United Kingdom
Post D.A., J. Vaze, J. Teng, R. Crosbie, S. Marvanek, B. Wang, F. Mpelasoka and L. Renzullo. 2012. *Impacts of climate change on water availability in Botswana*. CSIRO: Water for a Healthy Country National Research Flagship.	Australia
Kwesi Darkoh, M.B, M. Khayesi and J.E. Mbaiwa. 2011. "Impact and responses to climate change at a mirco-spatial scale in Malawi, Botswana and Kenya." (Chapter 6) In *Local Climate Change and Society,* edited by Mohamed A. Salih, 119 -122.	Botswana
Alexander, K.A., M. Carzolio, D. Goodin and E. Vance. 2013. "Climate Change is Likely to Worsen the Public Health Threat of Diarrheal Disease in Botswana," *International Journal of Environmental Resources and Public Health* 10(4):1202-1230.	USA/Botswana
Zhou, Peter P, Simbini Tichakunda, Gorata Romokgotlwane et al. 2013. *Southern African Agriculture and Climate Change: A Comprehensive Analysis – Botswana*. African Agriculture and Climate Change Country Summary. International Food Policy Research Institute (IFPRI).	Botswana
Jarkko Saarinenab, Wame L Hambira, Julius Atlhopheng and Haretsebe Manwa. 2012. "Tourism industry reaction to climate change in Kgalagadi South District, Botswana," *Development Southern Africa* 29 (2): 273-285.	Finland
Kenabathoa, P.K., B.P. Parida and D.B. Moalafhi. 2012. "The value of large-scale climate variables in climate change assessment: The case of Botswana's rainfall," in *Physics and Chemistry of the Earth, Parts A/B/C* 50–52: 64-71.	Botswana
Alemaw, B. "Hydrological modelling and possible climate change impacts in a wetland system: the case of the Okavango Delta, Botswana." In *Improving integrated surface and groundwater resources management in a vulnerable and changing world* edited by F. Blöschl et al. Proceedings Symposium JS.3 at the Joint Convention of the International Association of Hydrological Sciences (IAHS) and the International Association of Hydrogeologists (IAH) held in Hyderabad, India, 6-12 September 2009.	Botswana
Dube, Opha Pauline.2013. "Climate change and sustainable development in Botswana, towards Climate Adaption Futures." (Chapter 20) In *Climate Adaptation Futures,* edited by Jean Palutikof, Sarah L. Boulter, Andrew J. Ash, Mark Stafford Smith, Martin Parry, Marie Waschka, Daniela Guitart.	Botswana

It is positive to see that the search shows a variety of different research publications available on climate change in Botswana, with six out of the first ten publications with the title including

"climate change" and "Botswana" published within the last two years. Also encouraging is that six out of ten publications were primarily authored by researchers from Botswana, further showing that there is a strong climate change research presence in Botswana, despite the limited policy environment, and despite knowledge transfer challenges raised in the workshop. The articles/chapters focus on physical climate change, including baseline data mapping of rainfall; vulnerability and impact assessment in the agricultural and water sectors, with one focusing on dryland pastoral systems; and health and tourism sectors. An important publication for the further development of Botswana's CCS&AP in Botswana is University of Botswana based researcher Dr Pauline Dube, who investigates climate change, sustainable development and livelihoods in Botswana, and is a current Review Editor for the IPCC Fifth Assessment.

Literature screened from the SNC (2011) shows that much of the sources listed come from government and other organisations. While few sources produced by local researchers or research groups were noted, and where these exist, they are often in the form of unpublished consultancies, this does not mean that local researchers are not contributing strongly to the development of documents like the SNC: a list of 32 lead and contributing authors to the SNC is provided, with most, if not all, of these being local experts and researchers. The authors of the vulnerability and adaptation assessments listed in the SNC reference list are not provided, but these are likely to be local experts, including university researchers.

The most recent publications used by the SNC (2011) are:

- Wolski P., L. Coop and M. Tadros. 2010. "Assessment of change in rainfall under climate change projections for Botswana based on statistical downscaling."
- Hewitson B.C. and R.G. Crane. 2006. "Consensus between GCM climate change projections with empirical downscaling: precipitation downscaling over South Africa," *International Journal of Climatology* 26: 1315-1337.

The lead authors for these two publications are from the Climate Systems Analysis Group at the University of Cape Town, which is a regional source of expertise for climate modelling. Apart from this aspect, there is a good linkage between university researchers and other local experts and policy development.

4.5.2.2 University-based research

The Botswana questionnaire and workshop data shows a diversity of university faculty and department involvement in climate change related research, as shown in Table 8.

Table 8: Diversity of university faculty and department involvement in climate change research

Faculty / School / Centre	Department	Programmes / Institutes
Education (University of Botswana – UB)	Languages and Social Sciences Education	Curriculum development and community engagement
Science (UB)	Environmental Science	Mitigation; Land cover change / Geo-spatial Information / GIS and Remote Sensing; Adaptation; Poverty and CC; Tourism and CC; Desertification adaptation and mitigation
Education (UB)	Primary Education	Educational management, environmental education, school civic clubs
Science (Botswana International University of Science and Technology – BIUST)	Earth and Environmental Science	Development of resilient agro-ecosystems research
Agriculture (Botswana College of Agriculture)	Animal Science and Production	Animal nutrition
Science (UB)	Environmental Science	
Forestry (Botswana College of Agriculture)	Forestry Unit / Section - Crop Science	Forestry and Range Programme
Family Nurse Practitioner Program (Institute of Health Sciences)	Health Policy, Development, Monitoring and Evaluation - Ministry of Health	Family Nurse Practitioner Program
Science (UB)	Okavango Research Institute	Research Institute – Multidisciplinary Environmental Science – Natural Resource Management, Biodiversity conservation and Climate/land-use interactions
Faculty of Science (UB)	International Education	Water Resources Management

Note: Table may not be complete, and is therefore indicative rather than definitive.

Table 10 above shows both faculty-based diversity and departmental level diversity of participation in CCD related research and teaching at University of Botswana, Botswana College of Agriculture, Institute for Health Sciences and Botswana International University of Science and Technology. The table also shows that between the universities and institutes, most of these have *dedicated research programmes* at faculty / school level, of relevance to CCD.

Workshop and questionnaire data showed that there is research taking place on a number of topics that are related to CCD, including (but not limited to) those outlined in Table 9.

Table 9: Research projects currently being undertaken in response to CC and the need for CCD

Institution, Faculty, Department	Research Project	Researcher/s or Deans / HODs	Type of Research Project
University of Botswana – UB: Education, Languages and Social Services Education	Poverty and climate change	Jeremiah Koketso jeremiahk@mopipi.ub.bw	Poverty and climate change
UB: Science Environmental Science	Land cover change / Geo-spatial Information / GIS & Remote sensing	Joyce Gosata Maphanyane maphanyanej@mopipi.ub.bw	Malaria outbreaks and climate change / Local climate change / CO^2 emissions
UB: Education, Primary Education	Educational management	G Tsayang tsayangt@mopipi.ub.bw	
Botswana International University of Science and Technology-BIUST: Science, Earth and Environmental Science	Development of resilient agro-ecosystems research	Casper Nyamukondiwa nyamukondiwac@biust.ac.bw	Sustainable biological control of insect pests Animal thermal biology and their implications on biodiversity and Bio geography in a changing climate
Botswana College of Agriculture: Animal Science and Production	Mitigation through livestock nutrition	O R Madibela omadibel@bca.bw	Manipulation of feeding systems of ruminant livestock to reduce methane production
UB: Science Environmental Science	Climate Change adaptation: tourism and community livelihoods.	Wame Hambira hambira@mopipi.ub.bw	Various projects on water resources; tourism and community livelihoods in relation to climate change; SASSCAL
Botswana College of Agriculture: Forestry Unit / Section – Crop Science	Forestry and Range Programme-Livestock waste production of biogas	Joyce Lepetu jlepetu@bca.bw	Evergreen / Agroforestry research and development project, with World Agroforestry Centre; livestock waste production of biogas
UB: Science Environmental Science	Mitigation and Adaptation	Prof Julius R Atlhopheng atlhophe@mopipi.ub.bw	DelPHE / SASSCAL / AMEDS / DESIRE / Floors and CC – Palapye area / UNFCCC / Rio+20 / Planet under pressure / Tourism and cc in Botswana / NDP10/ IPCC / ICTP / EIA into CC

Institution, Faculty, Department	Research Project	Researcher/s or Deans / HODs	Type of Research Project
UB: Science Environmental Science	Climate Change and Livelihoods/Poverty Desertification adaptation and mitigation	Professor Raban Chanda chandar@mopipi.ub.bw	Sustainable rural livelihoods, poverty alleviation and local perspectives on environmental change analyst; UB DESIRE Coordinator http://www.desire-project.eu/
UB: Science Environmental Science	African Carbon Exchange Climate Policy Development	David Lesolle (Climatologist) Climate policy advisor at Ministry of Environment, Wildlife and Tourism david.lesollo@mopipi.bu.bw	GFCs / SASSCAL
Ministry of Health: Institute of Health Sciences Family Nurse Practitioner Programme	Health Policy and Development	Mmule Magama mmule001@gmail.com	Monitoring and Evaluation – Ministry of Health (Not directly CCD related)
UB: Education UB: Primary Education	Environmental Education	Nthalivi Silo silon@mopipi.ub.bw	Enhancing Botswana Children's Environmental Knowledge, Attitudes and Practices through the School Civic Clubs
UB: Science, Okavango Research Institute	Multidisciplinary Environmental Science – Natural Resource Management, Biodiversity conservation and Climate/land-use interactions	Michael Murray-Hudson mmurray-hudson@ori.ub.bw http://www.orc.ub.bw/	Climate, Land-use, Institutions and People – CLIP; Health, Natural-resources and Human-adaptation; BIOKAVANGO or ' 'Building Local Capacity for the Conservation and Sustainable Use of Biodiversity in the Okavango Delta'
UB: Faculty of Science	International Education Not directly CCD related	Leapetswe Malete maletel@mopipi.ub.bw	Mainstreaming Environment and Sustainability Issues in Institutions of Higher Education: The Case of the University of Botswana Not directly CCD related

Note: Table may not be complete, and is therefore indicative rather than definitive.

The table shows that the Department of Environmental Science at UB has conducted significant amounts of wide-ranging research on climate change. Much of this has included an element of policy engagement, including for the IPCC; for example, the department had three authors contributing to the IPCC Fourth Assessment Report. The research ranges from more social oriented research on tourism and climate change to more quantitative work on mitigation aspects, and includes research on water management and adaptive land management in the context of arid lands and desertification; there is also a researcher working on land cover change, geo-spatial Information, GIS and remote sensing. BIUST is carrying out a range of research on development of resilient agro-ecosystems research, while research at the Botswana College Agriculture includes exploring sustainable forms of livestock nutrition that include water sensitivity and reduce methane output, research on agroforestry and livestock waste production of biogas. Other notable areas of research include mainstreaming environment and climate change into curricula, and environmental education. There is a significant amount of multidisciplinary research on climate change conducted by the Okavango Research Institute, including CLIP – Climate, Land-use, Institutions and People; Health, Natural-resources and Human-adaptation; and BIOKAVANGO or 'Building Local Capacity for the Conservation and Sustainable Use of Biodiversity in the Okavango Delta'.

Workshop participants noted that the Faculty of Engineering and Technology from UB, not present at the workshop, is doing a considerable amount on climate change and energy. Therefore any subsequent development of the database after the end of the mapping study should include exploration of any specific relevant activities in this faculty.

There are also individual student research projects that reflect an interest in CCD-related issues. An example is the following:

- Krasposy Kujinga, PhD candidate, University of Botswana: Climate-change-related gender inequality: Toward enhancement of women's capacity to adapt to water-related challenges in Ngamiland District, Botswana.

Developing a detailed list of relevant student projects is beyond the scope of this mapping study, but would provide interesting additional perspectives on what may be new research foci, or emerging researchers.

Associated with these research programmes and other smaller scale research initiative are a number of active researchers, who were mentioned in workshop and questionnaire data. See Appendix B for a list of these researchers. The list indicates that while some researchers have only been active in the field of climate change and CCD for less than five years, Botswana has a number of researchers with over ten years experience specifically on climate change and which is relevant for CCD. This shows that while there is a group of emerging researchers in the field, Botswana is fortunate enough to have a significant cadre of very experienced researchers working on different aspects of climate change. Ten of the 12 questionnaire respondents have PhDs, indicating that Botswana is contributing significantly to the capacity development and support of CCD PhD research.

Gender and PhD profile: Of those lecturers responding to the questionnaire, five were female and eight male, showing that there is participation of women scientists in climate related questions in Botswana, although the table above shows that CCD research is currently still

somewhat male dominated. Most of those responding to the questionnaire had more than 10 to 15 years experience in their disciplines, and six had ***more than seven years of experience with climate change research*** / climate compatible development research.[24]

4.5.2.3 Centres of Expertise

Some centres of expertise[25] in climate compatible research in Botswana were identified as being

- University of Botswana (particularly the Department of Environmental Sciences, the Department of Languages and Social Sciences Education [for integrating climate change into ESD] and the **Okavango Research Institute**)
- Botswana College of Agriculture (particularly the Department of Animal Science and Production and the Forestry Unit) http://www.bca.bw/
- Botswana International University of Science and Technology-BIUST (The Earth and Environmental Science Department) http://www.biust.ac.bw/undergradEarth%20&%20Environment.php

Research Networks[26] cited include:

- The Botswana Global Change Committee (BGCC), which provides a framework to increase the understanding of the implications of Global Environmental Change in Botswana and the Southern African region, linked to IHDP – International Human Dimensions Programme on Global Environmental Change/ Botswana http://www.ihdp.unu.edu/article/read/botswana
- DESIRE – Desert Rehabilitation Research Project (International) http://www.desire-project.eu/index.php?option=com_content&task=view&id=57&Itemid=36
- Planet Under pressure: Conference held in Botswana http://www.planetunderpressure2012.net/
- International Group on Sustainable Development
- IPCC http://www.ipcc.ch/
- National network on Reducing Emissions from Deforestation and Forest Degradation (REDD +)
- Global Environmental Fund (GEF)

This shows the dominant involvement of UB's Department of Environmental Science and the Okavango Research Institute in active research networks of relevance for CCD, at least as far as

[24] Some if this relatively longstanding focus for research and teaching in Botswana may be due to the strong drought disaster relief focus introduced by the government since 1996.

[25] 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).

[26] A research network refers to interest-based research groupings that convene regularly to discuss or debate research or concerns that are relevant to CCD.

this mapping study was able to identify, as most of these research networks involve those institutions. Additional forms of networking are discussed in section 4.5.6.

4.5.3 Curriculum innovations and teaching for CCD

All ten respondents from Botswana (including University of Botswana – UB, Botswana College of Agriculture – BCA, and Botswana International University of Science and Technology – BIUST[27]), who responded to the questionnaires, indicated that there is some existing work taking place with regard to CCD curriculum innovation in their departments. Questionnaire responses indicate that all the participants from the various universities showed a high willingness to get involved in topical issues such as climate change and/or climate compatible development with regard to their curriculum innovation and teaching, and the questionnaire data showed that staff ability to get involved was good. UB and BCA showed the greatest incidence of CCD issues and opportunities incorporated into their current curriculum. UB led the way with regard to inter- and/or transdisciplinary teaching approaches to CCD; this was specifically housed at the Okavango Research Institute at UB. BIUST had courses that clearly focus on development of social and/or technical innovation and ethical actions, when compared to the other two universities.

The following specific courses were identified as being on offer (cited in the workshop discussions and questionnaire data). As climate change is often infused into existing courses, it is not easy to 'detect' climate change content in existing course descriptions, unless the courses are specifically 'named' as climate change courses. Thus it is not simply a matter of reviewing all the courses in an institution. Identification of climate change content in courses requires engaging with those that teach the courses. Data presented is therefore limited by this factor.

Table 10: Courses oriented towards climate compatible development

Course/s being developed and run	Who is involved	Type and level of course
ENVIRONMENTAL SCIENCE, UNIVERSITY OF BOTSWANA Tourism and Climate change / Remote Sensing and Geo spatial information system	Joyce Gosata Maphanyane	Undergraduate and Postgraduate (MSc)
EDUCATION (Primary and Secondary), UNIVERSITY OF BOTSWANA Environmental education courses	G Tsayang M J Ketlhoilwe Charles Musarurwa	Undergraduate and postgraduate

[27] The Institute of Health Sciences also contributed to the questionnaire, however admitted to having no direct CCD related work in their curriculum, other than courses that focused on development of social and/or technical innovation and ethical actions.

Course/s being developed and run	Who is involved	Type and level of course
EARTH AND ENVIRONMENTAL SCIENCE, BOTSWANA INTERNATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY Intend to recruit postgraduate students (MSc and PhD) working on climate change effects on biodiversity	Casper Nyamukondiwa	MSc and PhD
ANIMAL SCIENCE AND PRODUCTION, BOTSWANA COLLEGE OF AGRICULTURE, Environment and you - Elective course for undergraduate / Environmental physiology	O R Madibela	Undergraduate
FORESTRY UNIT/CROP SCIENCE, BOTSWANA COLLEGE OF AGRICULTURE Climate change course, Forest and Range Ecology, Agroforestry, Community forestry	Joyce Lepetu	Undergraduate
ENVIRONMENTAL SCIENCE, UNIVERSITY OF BOTSWANA Short courses on climate change adaptation / New CC courses in curriculum being reviewed (postgraduate) / MPhil / PhD in any area of climate change	Prof Julius R Atlhopheng	MPhil, PhD and other postgraduate

Note: This table is not definitive and needs to be updated as part of the five-year programme.

As shown in Table 10 above, at least two faculties at the UB, two faculties at BCA and one at BIUST are involved in designing courses that integrate CCD aspects, which shows that it is a relevant multidisciplinary area of innovation in universities in Botswana. There appears to be a link between those lecturers involved in CC related research and curriculum innovations in this area. This shows that the relationship between CCD research and curriculum innovation should be more clearly understood, which implies that there is a need to examine *how research drives curriculum innovation* in new knowledge areas such as CCD in universities.

As can be seen from Table 10, UB and BIUST both have dedicated CC / CCD courses at postgraduate level. The dominant pattern of practice appears to be to 'integrate' aspects of CCD into existing courses. It is difficult to examine the scope and focus of such integration without a detailed curriculum analysis. The table above also shows that it may be productive to examine CCD integration within *all faculties and all departments* within the university. The university-based questionnaire (especially Section C) in Appendix C can be used for this purpose. The questionnaire would, however, need to be introduced to all staff in the university, preferably at Departmental level to obtain a clearer view of how CCD is / is not being integrated into teaching, and where the 'gaps' are for new development of CCD content into either existing programmes or the design of new programmes. Such a process would need to be led by the Academic Registrar of the university to ensure consistent and comprehensive data.

Teaching methods that were identified as being potentially effective for CCD in courses included use of satellite data for land cover change and incorporating the rainfall and weather daily readings to have a spatial comparative platform. Other methods included:

- Practical orientation methods: excursions to visits climate change affected site e.g. grazing and farming places;
- Class discussions and workshop sessions with learners;
- Learner centred field work;
- Agroforestry and community forestry courses: students review traditional conservation practices and suggest options for whether they are sustainable or not, and why, then look at ways these could be upscaled into adaptive strategies; and
- PBL / student centred learning / outcomes based learning.

Inter- and transdisciplinary approaches to curriculum innovation are discussed in section 5.

4.5.4 Community and policy outreach

Questionnaire data shows that university staff are actively contributing to the policy processes in Botswana, for example Professor Julius Atlhopheng from UB is currently working on the National Development Plan 10 on Environment and Climate Change, and holds public discussions on climate change with Ministers, parliamentary committee and traditional leaders. Another example is Wame Hambira from UB, who has contributed to the area of tourism and climate change policy. Researchers are additionally involved in 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.

Questionnaires show that researchers more involved in policy development were those that were a) more experienced with climate change issues (e.g. Prof Julius R Atlhopheng, a seasoned environmental scientist), b) more senior (e.g. Professor Madibela who has 22 years experience in ruminant nutrition, and developing water sensitive and low methane producing livestock nutrition), or c) researchers with specialist skills (e.g. Wame Hambira who specialises in environmental economics at UB, and is called on for this expertise for policy advice).

In general the workshop and questionnaire data showed a low level of community outreach or engagement amongst university staff, and it seemed that where they had time available it was being used for research support to government, or policy outreach. Researchers such as Jeremiah Koketse (UB) work on traditional ecological knowledge and climate change and therefore their work requires intensive community engagement. Others like Professor Madibela (BCA) have community engagement projects linked to SASSCAL in the pipeline. Joyce Lepetu (BCA) 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.

4.5.5 Student involvement

The Department of Environmental Science at the University of Botswana and Botswana College of Agriculture cited higher levels of student involvement in CCD-related matters than other departments who responded to the questionnaire. The following student organisations were cited as having potential for engaging more with CCD issues:

- UB – Student Environment Conservation Association; and
- UB – YEA, the Youth Environment Association.

It was not possible to obtain further information on this issue, given the constraints of this mapping study.

4.5.6 University collaboration and networking

In addition to the research networks discussed above, researchers responding to the questionnaire and discussions in the workshop identified the following important networks that university staff were either involved in, or that they could become more involved in and that also supported knowledge production and use that is relevant to climate change:

- Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL) http://www.sasscal.org/
- Civil society – Botswana Council of Non-governmental Organisations (BOCONGO)- http://www.bocongo.org.bw/
- Education for Sustainable Development programme (ESD)
- Botswana's National Committee on Climate Change

4.5.6.1 Potential knowledge co-production partners

The institutional analysis also shows that there is a high level of *potential* for knowledge co-production partnerships, and numerous knowledge partners exist for CCD knowledge co-production in Botswana. Table 11 shows these 'mapped' out, with ascribed roles (as per workshop discussions).

Table 11: CCD Knowledge co-production partners (potential, with some already actualised)

Research organisations	Civil society organisations	Private Sector	Government	Regional organisations	International organisations
▪ Okavango Research Institute (UB) ▪ Earth and Environmental Science (BIUST) ▪ Environmental Science (UB) ▪ Forestry Unit (BCA) ▪ Animal Science and Production (BCA)	▪ WENA Environmental Education Trust ▪ Botswana innovation HUB	▪ AIKA (Pty) Ltd	▪ National Climate Change Committee ▪ Department of Agricultural Research ▪ Department of Environmental Affairs and Tourism ▪ National Development Plan 10 group ▪ National committee on REDD++	▪ Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCCAL)	▪ DESIRE- U

Different roles were ascribed to different partners involved in the knowledge co-production process.

Table 12: Roles ascribed to the different partners involved in the knowledge co-production process

Universities	Private sector	Donors	Governments
▪ University promotion depends on research and publication. Need to be first author and that does not support transdisciplinary research ▪ Give more weight to research ▪ University should treat all journals in isolation and grade them according to merit ▪ Increased collaboration between companies, NGOs and universities ▪ Promote local journals for easy access	▪ Private sector already wooed by researchers for any endeavour ▪ Private sector research in areas of mutual interest ▪ Need for local financing/ sponsorship for CCD programmes, projects and strategies ▪ Need for political support (Government) ▪ Plans that incorporate environment ▪ Private sector should research in areas of mutual interest ▪ Need to review current policies or develop all-encompassing new policies	▪ Forge strong and effective partnership with higher education through meaningful MOU ▪ Government must change its attitudes towards university staff especially academic staff ▪ Acknowledge and use research findings for policy development ▪ Establish a funding body ▪ Incentives for research and publication ▪ Government help university to enhance quality so that private sector will willingly buy university services and fund research	▪ Avail more funds ▪ Donors should have funds set aside for African researchers ▪ Donor should be flexible and develop user friendly procedures

Engaging with such knowledge partners in / for knowledge co-production requires capacity for collaboration. The discussion on university collaboration (and data on this the questionnaires) on university collaboration revealed the following 'status quo', also outlining possibilities of how such collaboration can be enhanced. The insights are captured in Table 13.

Table 13: Perspectives on university collaboration

Collaboration inside the university	Collaboration between universities in country	Collaboration with partners nationally	Collaboration regionally (in SADC region and in Africa)	Collaboration internationally
▪ UB – Centre of climatic change issues and excellence / Cross-cultural courses throughout faculties ▪ BIUST – Interfaculty collaboration especially Faculty of Science, Education and Engineering Department ▪ UB – Inter-departmental ▪ Across faculties i.e. Science, Education, Social Science, Agriculture etc. ▪ UB – Inter-department, amongst colleagues, university services	▪ Lecturer exchange, benchmarking / student exchange / research collaboration ▪ UB and BUIST as well as other universities such as Limkokwing ▪ BCA–UB–BIUST ▪ UB – only university, strong links with BCA	▪ Sources for funds / development and production from research innovations and patent ▪ Swedish Sida ▪ Some collaboration with colleagues, Pretoria University and University of Stellenbosch, South Africa ▪ BCA – Companies dealing with fossil fuel / Renewable energy companies / NGO in environment ▪ UB – Government departments / UB – NGOs i.e. joint research projects / UB – CBOs e.g. presentation on Climate Change	▪ Information exchange and expensive equipment sharing / sharing of knowledge and giving each other short courses ▪ SADC universities ▪ With Stellenbosch and Pretoria University ▪ (BCA) Botswana – South Africa – Zimbabwe ▪ SARNA / REEP ▪ Publications / Workshops e.g. LEAD	▪ Collaboration on research / collaboration on fund sourcing / collaboration on publication on innovative research groundbreaking / capacity building ▪ Across university e.g. Botswana and Rhodes University. Internal funders ▪ With the University of Western Ontario (Canada) ▪ Botswana – Australia, Egypt, North Africa = Arid Environments ▪ Publications, conferences, negotiations

4.5.7 University policy and campus management

The University of Botswana was the only university mentioned by the participants to have university policies that are aligned with CCD: Professor Julius Atlhopheng stated that UB has a policy for Environmental Sustainability and Social Responsibility. The other universities did not have any known policies aligned with CCD. UB had also changed to sustainable food packaging at their canteens and practise energy conservation with a variety of energy sources including solar water heaters and they are considering biogas. The other universities did not mention any campus-based activities that are aligned with CCD objectives.

It was not possible to obtain further information on this issue, given the constraints of this mapping study.

4.6 What existing practices can be strengthened and what can be done differently?

4.6.1 A multi-faceted process, needing an integrated approach

Discussions in the workshop on 'who is doing what and how' led to some high quality reflections on the status quo, and what could be done differently. These show that Botswana stakeholders, researchers and lecturers have a very clear understanding of what needs to be strengthened and what could be done differently when it comes to CCD in research, teaching, outreach and networking in their contexts. Some direct citations from the workshop report show that responding to CCD from within the Higher Education system is a multi-faceted process involving a range of different social practices such as curriculum change, research and staff capacity building and support, collaboration mechanisms, and commitment, leadership and will. Lack of political leadership, will and support for CCD research and implementation was cited as one of the major challenges for Botswana. A representative from the Ministry of Environment, Wildlife and Tourism noted the lack of government legislation for CCD which goes with policy to ensure implementation. Inadequate monitoring and evaluation apparatus was also cited as a something that universities could help with. In addition, universities can assist in improved collaboration between sectors through harmonisation of such policies. Individuals and representatives from the private sector felt that universities and government departments needed to strengthen their collaboration and coordination in order to provide technical experts and also submit bankable proposals to access climate change finance.

Concerns were also raised regarding the lack of government support for CCD research in universities as one participant explained:

> *"It is not lack of advisors, but its lack of political will and support, because the government does not consider research as key to development."*

Another participant added to this concern:

> *"Funding in Botswana cannot improve as long as Botswana does not have a National Research Foundation of some sort."*

It was further highlighted that in Botswana climate change is seen simply as a function under a single department, with the usual challenges this brings for horizontal collaboration and coordination with other ministries. In order to enhance strong collaboration and coordination, there is need for strategically locating coordination at a focal point like the Office of the President, such as is the case for Disaster Management and Poverty, which is receiving a lot of wide-ranging attention because they are strategically located. The Public-Private partnership and institutional research support from private companies is weak because, it is felt, companies only finance corporate social responsibility to market their products. There is no policy describing any responsibility for the private sector in funding research.

These coordination issues show that responding to the current situation in Botswana with a view to 'doing things better' requires an integrated approach, and will require especially the participation of university and government leadership, but also leadership of other stakeholders (e.g. business).

4.6.2 Co-ordination, collaboration and improved partnership building:

Internal co-operation, collaboration and improved partnership building: As indicated above, there was much discussion in the workshop on collaboration, and how collaboration could be improved. Of particular interest was the significant question raised by one participant on the conflict between collaborative knowledge production, and publication and performance standards of researchers that potentially inhibit collaboration, as highlighted in the following quotation.

> *"Institutional constraints that inhibit collaboration e.g. collaboration may mean less credit going to participants and thus 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."*
>
> University of Botswana staff member

This 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.

Another issue inhibiting coordination and collaboration in Botswana is poor communication, knowledge transfer and coordination, for example participants felt that although there were national and regional committees addressing climate change, these committees fail to adequately coordinate and communicate their activities.

4.6.3 Strengthen and expand understandings of CCD

As shown in section 4 above, CCD is a relatively new concept to some stakeholders and university researchers, while for others it was a very familiar and integrated part of their research and teaching. For Dr. Mmule Magama, a senior lecturer working for over 30 years in family nursing and health policy development, CCD was a new unexplored area in her field, while for Professor Madibela, CCD related themes have been part of his research for 22 years, and his teaching for at least the last decade. From the workshop and questionnaire data it can be seen that the concept of CCD also has different meanings, and lends itself to a diversity of contextual interpretations. It is also multidisciplinary, and multi-faceted and has diverse research and capacity building implications. This was further explored in the workshop which brought in regional perspectives, stressing that there is need for alternative development options that are continually responsive to changing climate change and emerging global and regional development paradigms related to climate which take into account what is happening in the region in and around Botswana. Linked to this was the need to see CCD as not a static concept, but rather an emergent and evolving research area that needs to include indigenous forms of mitigation and adaptation as one participant put it:

> *"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."*
>
> University of Botswana participant

Linked to this, workshop participants stressed the importance of integrating climate change and CCD into Botswana's education system, including public education and grass roots community programmes. The workshop discussion concluded with noting that sustainable development forms the context in which countries mainstream climate change; CCD should be oriented along a sustainable development pathway – it is essentially sustainable development, with climate risks fully integrated.

Lack of awareness of how their work may be linked to climate change affects the further involvement of many stakeholders in climate change fora and partnerships. This was ascribed to the predominant idea of the physical science nature of climate change, which prevents some stakeholders – and academics – from seeing how this issue affects their work. The issue is not felt to be a lack of interest, but rather highlights the need for expanded awareness raising and appropriate dissemination of the results of climate change research.

4.6.4 Capacity building for CCD and staffing

Across the data sources, there was a strong call for capacity building, particularly for undertaking research but also 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 multi-disciplinary approach that allows for knowledge exchange and the development of collaboration. The Okavango Research Institute seems to have the greatest experience in multidisciplinary research and capacity development, and

could play a valuable role in CCD capacity development. The findings of this mapping study could be picked up further in the process to develop the NCCS&AP, including through the elaboration of these findings into a roadmap for climate change capacity development in the country.

4.6.5 Curriculum development and curriculum innovation

As shown in the institutional analysis above, CCD is currently mainly being 'integrated' into existing courses. However both UB (Environmental Science) and BCA (Forestry Unit) have specialist courses. It is also encouraging to see that UB has postgraduate courses in CCD, including PhD programmes in this field, and that BIUST has expressed interest in developing courses with a CCD focus. There is some strong expertise in CCD adaptation and mitigation research and subsequent curriculum development. Botswana offers some substantial contributions in approaching dryland adaptation to climate change, and curriculum development support.

It was also noted that BIUST is at an advantage since they have recently begun to develop courses so they will be able to infuse climate change activities into courses from the start. It was suggested that all those courses that are due for revision should have climate change infused – as noted by one participant, "A lot of courses are too old and they do not incorporate climate change".

This being said, workshop participants did raise the issue of current problems with disjointed curricula within the university and between the university and the feeder institutions. Regardless of the content of curriculum changes, these institutional flaws will need to be addressed to ensure an appropriate environment to contribute to further curriculum innovation in Botswana.

Finally, it was concluded that there still seems to be a general failure in Botswana's universities to recognise that every discipline can contribute towards issues of addressing climate change.

4.6.6 Research

Many recommendations were made on how research for CCD could be improved in Botswana's university and between other stakeholders. Key amongst these was to improve the CCD research culture in the universities, and research partners, especially local and national government, who are responsible to create an overarching CCD policy and action plan. This would require integrated coordination and collaboration of universities with government, and other partners. Currently a national development plan (NDP 10) is underway, and seems to be creating a new space for multidisciplinary collaboration and innovation.

> *"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

Another key research area recommended by workshop participants, which came up several times in the questionnaire data is improved monitoring, modelling and tracking climate changes in Botswana. It was clear that baseline research still needs to be a key research focus, despite longstanding good practice in both BCA and UB on been researching land changes, crop production and related matters.

Environmental education and climate change information sharing processes were further repeated research themes. This moved beyond traditional education systems which need to adopt CCD into their research and teaching, but also into other realms of Botswana's intuitional landscape, from grass roots settings to higher political landscapes.

Food security and sustainable rural livelihood development were also high on the research agenda in both the workshop and the questionnaire. This has also be a principal area of concern for government and national policy. The dryland environment of Botswana, and the high proportion of people living in rural areas, makes it a vital research area for Botswana's academics.

Multidisciplinary research was also highlighted as a key area for Botswana's approach to CCD, particularly research that aims to understand cross-sectoral impacts – such as increased health risks due to climate-change induced increased urbanisation. Although this sentiment was echoed in both the workshop and among different participants in the questionnaire, again institutional limits both within the university (conflicts between collaboration and impact of individual researchers) as well as limited incentives or capacity support to encourage multi/transdisciplinary research, hampered achieving this. Multidisciplinary research practised by the Okavango Research Institute is geographically focused on the delta area.

What is clear from this picture of Botswana's overall research concerns is 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.

4.6.7 The role of university leaders

The role that university leaders play in supporting CCD research and development mostly focused on policy development, which would require university wide infrastructure (legislative, financial and capacity) to promote CCD related research across all departments and disciplines and across all universities. In connection with this, it was agreed that managers and leadership have a responsibility to develop incentives for developing new CCD study fields. This includes fundraising and supporting funding applications by university staff. The mapping study further found support for leaders in universities to play a strategic role in facilitating the development of CCD related institutes, units and centres. It was also mentioned that academic performance monitoring by university leadership inhibits the development of collaborative research between departments as well as between universities and other partners. It was therefore suggested that university leaders have a role to play in promoting collaborative research, and developing new performance management tools that incorporate collaboratively research projects and collaborative published work. Human resources skills development and capacity development was also highlighted as a core responsibility of university leaders.

5 KNOWLEDGE CO-PRODUCTION POSSIBILITIES

5.1 Current knowledge co-production practices via multi-, inter- and transdisciplinary approaches

5.1.1 Clarifying the meanings of multi-, inter- and transdisciplinary approaches to research

The scope and scale of problems and challenges associated with climate change, and climate compatible development – as shown in the needs analysis of this mapping study Country Report – 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.[28] Figure 5 below shows that over time, research can build towards and include a wider range of research approaches that include multi-, inter- and transdisciplinary research approaches.

Note: Diagram showing 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.[29]

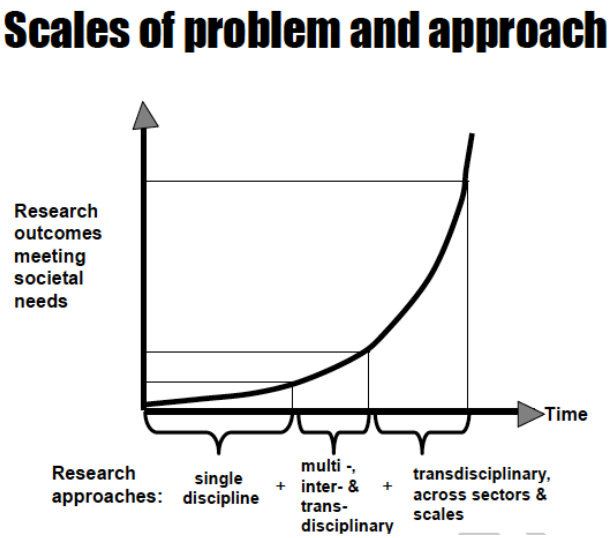


Figure 5: Research approaches

[28] This is because universities are organised and established around a disciplinary knowledge production structure.

[29] 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.[30]

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.

Interdisciplinarity

This marks a position between multi- and transdisciplinarity. 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 interpenetration of disciplinary perspectives or understandings, and a 'creative re-deployment' of these in contexts of practice[31]; 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 much deeper into developing new and more complex ways of understanding and engagement in contexts where new forms of theory and practice come together[32] across sectors and at different scales.

---

[30] 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.

[31] 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.

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

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.[33] 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 are changing towards inter- and transdisciplinary knowledge production, especially in the social-ecological sciences. 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, 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 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.[34] Knowledge co-production is also referred to as knowledge co-creation. This requires working to bring together different contributions in the knowledge production process.

5.1.2 The current 'status' of multi-, inter- and transdisciplinary approaches to research and knowledge co-production

Participants agreed that the majority of the work they do is not well coordinated, and that most of their research tended to be disciplinary based, rather than multi, inter, or transdisciplinary. One participant felt differently, stating that "at the moment in Botswana the estimate could be that 2 to 5 percent of research is transdisciplinary, 60 percent multidisciplinary, and the rest is single discipline research."

However, Botswana does have several examples of research and research institutions where there is significant engagement in collaborative knowledge production and use processes, such as the Okavango Research Institute's Biokovango Project. Thus inter- and transdisciplinary approaches are somewhat developed as knowledge co-production processes in Botswana, with UB leading the way in this regard. The interdisciplinary research projects at the Okavango Research Institute potentially also have elements of transdisciplinary knowledge co-production elements embedded in them, should stronger policy and community engagement emerge. For example the **BIOKAVANGO** (Building Local Capacity for the Conservation and Sustainable Use

[33] Max-Neef. 2005. "Commentary: Foundations of Transdisciplinarity".

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

of Biodiversity in the Okavango Delta) project was designed to support the implementation of the Okavango Delta Management Plan (ODMP). Similarly the **Climate, Land-use, Institutions and People – CLIP** project seeks to understand and predict the impact in southern Africa of climate variability and climate change on land-use and land-cover change via socio-economic institutions. Another transdisciplinary project at ORI is the **Ecohealth** project, which involves four ORI researchers working with personnel from the Departments of Agricultural Research and Environmental Affairs and the UB campus in Gaborone. This project is training six graduate students and focuses on health issues and the environment associated with flood recession (molapo) farming in the downstream Okavango in the context of climate change. The Ecohealth project, led by Prof Moses Chimbari, is funded by the Canadian International Development Research Centre (IDRC), and runs from 2010 to 2014.

A further relevant institution identified through an online search is the Centre for Scientific Research, Indigenous Knowledge and Innovation (CESRIKI), located at UB. The stated aim of CESRIKI is to bring researchers from various disciplines together to carry out research on Indigenous Knowledge (IK). The multidisciplinary approach was adopted in the realisation that various disciplines were operating on their own to understand various research questions, which defeated the idea of understanding issues from different angles (disciplines). No further information is known on this centre.[35]

Further examples of collaborative approaches to knowledge co-production include the completed AIACC study that specifically focused on the impacts of climate change, vulnerability and adaptation capacity in the semi-arid Limpopo Basin, and the DESIRE project, summarised in the boxes that follow. The DESIRE project has a transdisciplinary orientation, as it involves defining new conservation strategies with stakeholder communities and working closely with government policy makers and implementers.

[35] http://www.ub.bw/home/ac/1/fac/8/dep/47/Centre-for-Scientific-Reseach,-Indigenous-Knowledge-&-Innovation-(CESRIKI)/

Box 1: The AIACC Limpopo Basin Study

The AIACC Limpopo Basin Project refers to the 'Impacts of Climate Change, Vulnerability and Adaptation Capacity in the Limpopo Basin of Semi-Arid Land Southern Africa: The Case of Eastern Botswana' study, carried out under the UNEP/GEF/START/TWAS Assessment of Impacts of and Adaptations to Climate Change in Multiple Regions and Sectors (AIACC) project. This was formulated to build capacity in climate change assessments in developing countries. The AIACC Limpopo project, which was led by Pauline Dube, was carried out between 2002 and 2006 and involved ten scientists from the University of Botswana. The project relied on biophysical and socio-economic surveys to assess the effect of climate variability on food and water resources in the basin. The results were used to reflect the potential impacts of climate change on food and water in future and the implication on adaptation. The study showed that there are numerous institutions and policies to support rural development in Botswana but most of these frameworks do not purposefully incorporate strategies specifically aimed at mitigating the vulnerability of rural communities to the most common climate risk in the country – drought. Despite the fact that drought is a frequent event, it is not fully incorporated in the long term development planning of the country and is often treated as an emergency. The study recommended diversifying livelihoods and promoting income-generating activities in rural areas to reduce vulnerability to drought.

Box 2: Desertification and Mitigation and Remediation of Land – A Global Approach for Local Solutions (DESIRE)

DESIRE is an EU-funded five-year research project on desertification that involves 28 institutions from 20 countries (12 from Europe). The University of Botswana is the only partner institution in Southern Africa, of the three in continental Africa. DESIRE is premised on the understanding that fragile arid and semi-arid ecosystems are in urgent need of integrated conservation approaches that can contribute significantly to preventing and reducing widespread land degradation and desertification processes, such as overgrazing and drought. The project in Botswana commenced in 2007, led by Prof. Raban Chanda (chandar@mopipi.ub.bw) and involves seven scientists from the University of Botswana. The DESIRE project will establish alternative land use and management conservation strategies through close collaboration between scientists and stakeholder groups in the degradation and desertification hotspots, such as the Boteti area. An integrative participatory approach has been adopted because it ensures both the acceptability and feasibility of conservation techniques and sound scientific basis for their effectiveness at various scales. DESIRE will employ the UNCCD-endorsed bottom-up approach whereby:

- Desertification hotspots and stakeholder groups are identified in all case study areas;
- Desertification indicator sets are defined in a participatory approach and a harmonised information system is constructed containing all socio-economic and geo-information data;
- New and existing conservation strategies are defined with the stakeholder communities;
- These strategies are implemented in the field in partnership with land users, and are monitored and modelled to quantify their effectiveness at various scales;
- The results are extrapolated using both the indicator sets, geoinformation data, and integrated modelling systems combining socio-economic and environmental aspects; and
- Finally, the results are translated into a series of practical guidelines for good agricultural practices and environmental management, which will be disseminated to practitioners, agricultural extension officers, governmental authorities, policy makers, NGOs, land users, land owners, and local communities.

Among other government stakeholders in Botswana, the DESIRE project team will work closely with the Department of Forestry and Range Resources in the Ministry of Environment, Wildlife and Tourism, complementing their past and ongoing efforts in the implementation of the recently adopted National Action Programme to Combat Desertification. DESIRE will also build on the work of the GEF and Government of Botswana funded Indigenous Vegetation Project (IVP) in the Boteti area. IVP, which ended in June 2007, shared DESIRE's goal of developing models for stakeholder-driven management and rehabilitation of degraded rangelands.

5.2 Multi-, inter- and transdisciplinary research possibilities: Benefits and constraints

5.2.1 Benefits and constraints

The benefits and concerns of transdisciplinary research were discussed, and are captured briefly in the table, and elaborated on below.

Table 14: Benefits and constraints of transdisciplinary research

Benefits	Concerns
▪ Transdisciplinary approach may minimise the research costs ▪ May maximise the benefit to communities as they will be part of it in practice ▪ It may enhance CCD and sustainable development ▪ It may enhance the research skills among researcher e.g. students	▪ Limited funding ▪ Need for national research funding foundation ▪ No established structures for researchers to brief government of research outcomes ▪ Lack of political will and support by Government ▪ Lack of scientific minded government advisers ▪ Universities research incentives may compromise research ethics ▪ Institutional constraints that inhibit collaborative research e.g. performance management systems (PMS)

From Box 3 below, it can be seen that currently university staff and other stakeholders are faced with far more challenges to conducting transdisciplinary/ collaborative research, than viable avenues for enabling this. A combination of institutional factors inhibits potential expansion of collaborative research approaches, which include limited government support in the form of appropriate legislation, incentives and facilitation as well as narrow assessment standards and performance management tools within universities that inhibit such work. In addition to this, funding is a major barrier to researchers in Botswana attempting to enable collaborative research practices, as one participant suggests:

> *"Funding in Botswana cannot improve as long as Botswana does not have a National Research Foundation of some sort."*

Addressing these institutional barriers to collaborative research in Botswana will help to enable CCD-related research and subsequent implementation, appropriate to the CCD needs of Botswana.

Box 3: Concerns relating to transdisciplinary research approaches (workshop discussion)

- "Funding is limited and does not including implementation. This does not translate to change and practice. There is need for someone to advise government on the outcomes of the research. The Government needs specialist advisors, and should not rely on civil servants only."
- "It is not lack of advisors, but its lack of political will and support, because the government does not consider research as key to development."
- "Funding in Botswana cannot improve as long as Botswana does not have a National Research Foundation of some sort."
- "Government needs scientific-minded advisers to recommend and deal with research issues so that funding is availed on time."
- "The funding for transdisciplinary research may not necessarily come from one source, but needs to be built up from different sources – from various funders who have different purposes that are in alignment with the objectives."
- "Institutional constraints that inhibit collaboration e.g. collaboration may mean less credit going to participants and thus 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."
- "How do we understand transdisciplinary research: How do we even do our budget? There is need for researchers to develop a proper research proposal that includes implementation stages. We must consider how the client is going to be involved in the project."
- "The way research has been pegged to incentives in universities compromises the ethical responsibility of academics/researchers to research."

5.2.2 Possibilities

The workshop discussions and questionnaire data highlight that possibilities to strengthen emerging transdisciplinary knowledge co-production processes lie in the following activities:

- Strengthening research collaboration, including through university policy support;
- A national research foundation (or equivalent);
- Developing new performance management standards at universities that encourage working collaboratively;
- Incentives for inter- and transdisciplinary research; and
- Publishing support – i.e. with writing academic papers (for new researchers), and enhancing skills for writing funding proposals.

Implementing these activities will assist in developing a more CCD-friendly research culture. A number of the critical factors are in place in Botswana: there is an agreed need for collaborative research on climate change; multiple research partnerships are possible within the stakeholder networks that are interested in CCD research; and there is an understanding of the societal benefit of such approaches to research. However, research systems and cultures of practice in universities are not 'set up' to support such research innovation.

In the next section, the possibility of developing CCD knowledge co-production pathways will be discussed, and one such pathway mapped out, based on the analysis in sections 2, 3 and 4. This may assist with initial steps to develop a broad-based research agenda for CCD in Botswana, which will need to be refined at a local level by participating organisations and groups.

6 SUMMARY AND CONCLUSION

6.1 Synthesis perspective knowledge, research, individual and institutional capacity needs analysis

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 context, 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 lack 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.

6.1.1 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.* 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 climate-proofing the agriculture sector, 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.

6.1.2 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.

6.1.3 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.

6.1.4 Notable themes

Emerging from the Botswana workshop and questionnaire data were the importance of not only exploring indigenous knowledge systems (IKS) for contributions to climate-proofing livelihoods, but also firstly acknowledging and valuing IKS; as well as the importance of integrating the poverty dynamic into the CCD framework.

6.1.5 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 (workshop participants, questionnaires, policy documents – mainly the SNC) 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 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.

6.1.6 Institutional capacity gaps

All three main data sources 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.

If one considers the issues reported on above *in relation to each other;* one can begin to map out CCD capacity development pathway/s for Botswana, as outlined in section 6.3.

6.2 Synthesis perspective on the 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 Appendix B, and CCD areas of expertise in Botswana, mainly with respect to universities, are summarised in Table 17. 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 though 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 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.

See Appendix E for a summary table of identified sources of expertise for Botswana.

6.3 A broad map of Botswana CCD knowledge co-production pathways

Considering the workshops and questionnaires, as well as other data sets *in relation to each other;* one can begin to map out CCD capacity development pathways for Botswana. One example is provided here (Table 15) of key CCD priority areas in Botswana. Table 15 focuses on **Water, energy and infrastructure needs for climate compatible rural development**, which would require an integrated approach to adaptation and mitigation. This provides a synthesised perspective of key knowledge, research, individual and institutional capacity gaps for Botswana, for this priority area, providing insight into the research, capacity building and institutional development pathways needed for enhancing future contributions to CCD. This is not an exhaustive synthesis, but would need to be enhanced in the design of specific activities.

Table 15: CCD Knowledge, Research, Capacity Building and Institutional Capacity Gap Analysis for one of the Botswana CCD Priorities: Water, energy and infrastructure needs for climate compatible rural development

CCD PRIORITY	Knowledge and research gaps (Research agenda)	Individual capacity gaps (Education and training agenda)	Institutional capacity gaps (Institutional capacity development agenda)
Mitigation: ▪ Water, energy and infrastructure needs for climate compatible rural development	Feasibility and Technology Innovation Research: ▪ Investigate future energy needs of Botswana and choose the most cost effective energy supply ▪ Understanding future climate effects on for e.g. ground water Impacts and Adaptation Research: ▪ Water: Research into impacts of climate change on ground water, localised technologies for water conservation; water recycling, rainwater harvesting ▪ Desalination of ground water, incorporation of water demand in all national development projects, investment in water infrastructure development, improved efficiency and review existing national and sectoral policies, Importing water, advisability / ecological sustainability of inter-basin transfers; etc. Energy: ▪ Research into energy efficiency, Fuel wood replacement technology: i.e. biogas and rural electrification; Solar energy; Landfill gas recovery; Aerobic manure composting and biogas capture; reforestation; industrial energy efficiency in electric furnace, Space heating and general lighting Economic Research: ▪ Research and estimate cost of climate change mitigation (Carbon Finance Assist Programme funded by the World Bank), cost of adaptation not mentioned ▪ Research participation of the private sector in the provisions of specialised services to address climate change challenges	Agricultural Extension Services: ▪ Initiate and support agricultural extension services to popularise new agricultural practices that will contribute to GHG reduction and water security at local and commercial farm levels Land Use Resource Users (including women): ▪ Empower local level and other land resource users including women to apply and work with new water and energy technologies ▪ Waste management stakeholders: Empower waste management stakeholders to make use of better technologies, innovation and communication Scientists: ▪ To share information on climate resilience agro ecosystems, conservation farming, water harvesting techniques, and alternative energy forms	Policies, Investments and Incentives: ▪ Improve energy efficiency in domestic and commercial sector (including agriculture and industrial processes) and the transport sector through appropriate policies, investments and incentives Renewable Energy Technology and Energy Efficiency Capacity: ▪ Understand and address techno-economic, social and institutional constraints and build capacity for adoption of renewable energy technologies (including biomass, wind, solar). Promote and develop production approaches that ensure energy efficiency Environmental Management Systems and Standards development: ▪ Promote and implement EMS and apply standards that integrate reduction of GHG emissions, particularly with 22 years of expertise in developing reduced GHG emissions in the agricultural sector, at the Botswana Agricultural College

The analysis such as the one modelled above, can be developed for all major CCD priorities, and should ideally form part of national climate change policy development. Such an analysis provides a starting point for knowledge co-production at a national level.

Critical issues to be addressed for Botswana to expand its CCD knowledge co-production capacity are:

- Further consolidate the national knowledge co-production analyses based on the needs and institutional analyses in this country mapping study, and as modelled in the example above (Table 15), to guide further action at country level.
- Expand the capacity of the research institutions that have been identified as having some capacity and expertise for research, teaching and learning on CCD. Develop strategies for strengthening individual research competence, so that individual interest and research capacity can grow into a 'node of expertise' and then into a 'centre of expertise', and potentially a Centre of Excellence. Strategic policy support from the climate compatible development policy community, and the Higher Education community will be needed to facilitate such capacity building pathways in Botswana.
- Improve co-operation, communication, knowledge management and shared access to climate change relevant data at all levels.
- Develop motivation and incentives for researchers, especially for engaging in multi-, inter and transdisciplinary research approaches. Support capacity development of researchers in these areas.
- Strengthen research partnerships and research infrastructure, including research funding and incentives for students.
- Support ongoing processes of curriculum innovation to mainstream CCD into existing courses and programmes, and engage in development of Masters Degree curriculum design, potentially in partnership with other southern African universities.
- Strengthen existing policy and community outreach activities within a knowledge co-production framework, building on promising activities such as the collaborative community-based research and engagement undertaken for the DESIRE project, and relevant research at the Okavango Research Institute; and develop tools for monitoring and dissemination to make the impact of such work visible within the university system.
- Develop campus management policies and practices that demonstrate commitment to CCD at the institutional level, and support student organisations that are beginning to tackle CCD-related matters.

6.4 Possibilities for linking into a networked system of knowledge co-production in the SADC region

Climate Change and CCD research and teaching in Botswana includes valuable and significant research on both adaptation and mitigation, with an emphasis on arid and semi-arid land systems. Particular areas of strength identified in Botswana include:

- **Applied climate science:** applied climatology, climate services, early warning (in conjunction with the SADC Centres of Excellence based in Gaborone);

- **Integrated adaptation/mitigation research**: Food security and sustainable rural livelihood development within the drylands context; sustainable and adaptive agriculture (including sustainable biological control, agroforestry, sustainable forest management);
- **Climate change mitigation research**: Methane reducing animal feed production, GHG mitigation analysis;
- **Cross cutting issues research**: GIS Remote Sensing;
- **Systems of social change research**: Poverty and climate change; and
- **Teaching and curriculum innovation:** Tourism and climate change; remote sensing and geo-spatial information systems, integrating climate change into environmental education, curriculum development support.

APPENDIX A: WORKSHOP ATTENDANCE LIST

List of participants at the Botswana workshop, 18 April 2013 (Day 1)

CRESTA PRESIDENT HOTEL, BOTSWANA

Full name	Organisation	Designation	Contact number/S	Email
Casper Nyamukondiwa	BIUST	Lecturer/Researcher	75360701	nyamukondiwac@biust.ac.bw
Charles Musarurwa	UB	Lecturer	72561116	charles.musarurwa@mopipi.ub.bw
Ntha Silo	UB	Lecturer	75195329	silon@mopipi.ub.bw
Balisi Gopolang	MEWT	Meteorologist	3612200	bgopolang@gov.bw
Lebogang Seitshiro	Cowater International Inc.	Environmental Consultant	72140042/3951028	lseitshiro@yahoo.com
Bojosi Otlhogile	Self		3908275	otlhogile@botsnet.bw
Casper Bonyongo	SASSCAL	Coordinator	3973178	bonyongomc@gmail.com
Boat Modukanele	UNDP-PEI	Coordinator	72386808	b.modukanele@undp.org
Thabang Botshoma	MET Services	Director	3612271	tbotshoma@gov.bw
Tsayang Gabatshwane	UB		3552390	tsayangt@mopipi.ub.bw
Stella Mzumara	UB	PhD student	76179631	stellamzumara@yahoo.co.uk
Wame Hambira	UB	Lecturer	3552524	hambira@mopipi.ub.bw
RJ Opelo	MEWT	Deputy PS	3934479	jopelo@gov.bw
JP Lepetu	BCA	Senior Lecturer	3650390	jlepetu@bca.bw
Dikeme Kgaodi	Department of Environmental Affairs	Natural Resource Officer	3902050	dkgaodi@gov.bw

Full name	Organisation	Designation	Contact number/S	Email
Lordick Mokobi	Okavango Junior Secondary School	Teacher/Enviro Education Coordinator	71620193/73729900	lordickm@gmail.com
Othusitse Madibela	BCA	Professor – Animal Nutrition	3650225	omadibela@bca.bw
Ari Kalmari	Aika (Pty)	Director	72332995	ari.kalmari@aikagroup.com
Botlhe Matlhodi	DEA	Natural Resources Officer	3644662	btlmatlhodi@gov.bw
Muyeye Chambwera	UNDP	Technical Specialist	3633700	muyeye.chambwera@undp.org
Derick George	DAR	Researcher	3668252	dgeorge@gov.bw
Claire Glass-Rudaks	DWMPC	Principal Waste Management Officer II	3716906/3934479	cglass@gov.bw
Olaotswe Kgosikoma	DAR	Researcher	3668162	mfana450@yahoo.com
Julius Atlhopheng	UB	Professor– Enviro Science	72418734	atlhophe@mopipi.ub.bw
MM Kewagamang	MOESD	DPS	3655400	mkewagamang@gov.bw
Arnold Letsholo		Freelance Reporter	73222958/3188784	arnoldletsholo@yahoo.co.uk
Douglas Machacha	DAR	Researcher	3668188/71724982	dmachala@gov.bw
Joyce Maphanyane	UB	Lecturer	71220526/73499399	maphanyanej@mopipi.ub.bw
Keneilwe Moseki	Somarelang Tikologo	Director	3913709/71738776	kenmos26@gmail.com
David Lesolle	UB	Lecturer	72857121/3552520	david.lesolle@mopipi.ub.bw
MBK Darkoh	UB	Professor	71610570	darkohmb@mopipi.ub.bw
Koketso Jeremiah	UB	Lecturer	74204172	jeremiahk@mopipi.ub.bw
M.J. Ketlhoilwe	UB	Senior Lecturer	71729401	ketlhomj@mopipi.ub.bw

19 April 2013 (Day 2)

CRESTA PRESIDENT HOTEL, BOTSWANA

FULL NAME	ORGANISATION	DESIGNATION	CONTACT NUMBER/S	EMAIL ADDRESS
Lordick Mokobi	Okavango Junior Secondary School	Teacher/Enviro Education Coordinator	71620193/73729900	lordickm@gmail.com
Ntha Silo	University of Botswana	Lecturer	75195329	silon@mopipi.ub.bw
Stella Mzumara	University of Botswana	PhD Student	76179631	stellamzumara@yahoo.co.uk
Mphemelang J. Ketlhoilwe	University of Botswana	Lecturer	71729401/3555097	ketlhomj@mopipi.ub.bw
Olaotswe Kgosikoma	DAR	Researcher	3668162	mfana450@yahoo.com
Casper Nyamukondiwa	BIUST	Lecturer/Researcher	75360701	nyamukondiwac@biust.ac.bw
Wame Hambira	University of Botswana	Lecturer	3552524	hambira@mopipi.ub.bw
Julius Atlhopheng	University of Botswana	Professor – Enviro Science	72418734	atlhophe@mopipi.ub.bw
Casper Bonyongo	SASSCAL	Coordinator	3973178	bonyongomc@gmail.com
Charles Musarurwa	University of Botswana	Lecturer	72561116	charles.musarurwa@mopipi.ub.bw
Tsayang Gabatshwane	University of Botswana	Deputy Dean – Education	3552390	tsayangt@mopipi.ub.bw
Dikeme Kgaodi	Dept of Environ. Affairs	Natural Resource Officer	3902050	dkgaodi@gov.bw
Ari Kalmari	Aika (Pty)	Director	72332995	ari.kalmari@aikagroup.com
Koketso Jeremiah	University of Botswana	Lecturer	74204172	jeremiahk@mopipi.ub.bw
Balisi Gopolang	MEWT	Meteorologist	3612200	bgopolang@gov.bw
Florah Mmereki	WENA Environ Education	Environmental Journalist	3907678/71403897	florahmmereki@yahoo.com

FULL NAME	ORGANISATION	DESIGNATION	CONTACT NUMBER/S	EMAIL ADDRESS
Claire Glass-Rudaks	DWMPC	Principal Waste Management Officer II	3716906/3934479	cglass@gov.bw
Othusitse Madibela	BCA	Professor – Animal Nutrition	3650225	omadibela@bca.bw
Arnold Letsholo		Freelance Reporter	73222958/3188784	arnoldletsholo@yahoo.co.uk
Keneilwe Moseki	Somarelang Tikologo	Director	3913709/71738776	kenmos26@gmail.com
Joyce Maphanyane	University of Botswana	Lecturer	71220526/73499399	maphanyanej@mopipi.ub.bw
Derick George	DAR	Researcher	3668252	dgeorge@gov.bw

APPENDIX B: ACTIVE RESEARCHERS IDENTIFIED WHO ARE CONTRIBUTING TO CC /CCD RELATED RESEARCH ACTIVITIES

Table 16: Active researchers contributing to CC/CCD related research activities in Botswana

Note: This list is based on information provided in the country workshop and from completed questionnaires, and is possibly incomplete.

Name and qualification	Department / Area of expertise	Years experience: years experience in climate change research	Contact details
Jeremiah Koketso (PhD)	Department of Languages and Social Sciences Education /Education, Curricula	16 years : –	University of Botswana –UB: Department of Languages and Social Sciences Education jeremiahk@mopipi.ub.bw
Joyce Gosata Maphanyane (PhD)	Earth Sciences/ GIS Remote Sensing, Landforming, Land Administration	13 years: 1	UB: Science Environmental Science maphanyanej@mopipi.ub.bw
G Tsayang (PhD)	Education/Environmental Education	24 years: 4 years	UB: Education, Primary Education tsayangt@mopipi.ub.bw
Casper Nyamukondiwa (PhD)	Earth and Environmental Science/ Physiological ecology and pest management under changing climates	8 years: 5 years	Botswana International University of Science and Technology-BIUST: Science, Earth & Environmental Science nyamukondiwac@biust.ac.bw
O R Madibela (PhD)	Animal Science and Production/ Ruminant Nutrition (Developing Methane reducing feed)	22 years: 22 years	Botswana College of Agriculture: Animal Science and Production omadibel@bca.bw
Wame Hambira (MSc)	Environmental Science/ Climate change adaptation for the tourism sector.	13 years: 10 years	UB: Science Environmental Science hambira@mopipi.ub.bw
Joyce Lepetu (PhD)	Forestry Unit/ Sustainable Forest Management	19 years: 19 years	Botswana College of Agriculture Forestry Unit / Section - Crop Science jlepetu@bca.bw
Prof Julius R Atlhopheng (PhD)	Environmental Science/ Geomorphologist and geochemistry expert – adaptation to Desertification	11 years: 11 years	UB: Science Environmental Science atlhophe@mopipi.ub.bw

Name and qualification	Department / Area of expertise	Years experience: years experience in climate change research	Contact details
Prof O.P. Dube	Environmental scientist working on the use of remote sensing for monitoring rangelands, land use, land cover change, land degradation and fire in addition to issues of impacts of climate change; also gender and environment	27 years: 20 years	UB: Science Environmental Science dubeop@mopipi.ub.bw
David Lesolle (MSc)	Environmental Science/ Carbon Trading – African Carbon Exchange	3 years	UB: Science Environmental Science david.lesollo@mopipi.bu.bw
Dr Mphemelang J. Ketlhoilwe, UB: Researcher/Educator	Education for Sustainable Development; Climate Change, gender and the environment	27 years: 12 years	UB: DLSSE ketlhomj@mopipi.ub.bw
Nthalivi Silo (PhD)	Education/ Children's Environmental Knowledge, Attitudes and Practices through the School Civic Clubs	15 years: 7 years	UB: Education UB: Primary Education silon@mopipi.ub.bw
Michael Murray-Hudson (PhD)	Okavango Research Institute/ Wetland ecology, Systems Ecology, Ecological modelling	30 years: 10 years	UB: Okavango Research Institute mmurray-hudson@ori.ub.bw
Dr. Kolawole, Oluwatoyin (PhD)	Okavango Research Institute/ climatic forecasting and adaptive farm management knowledge of farmers in Ngamiland in Botswana		UB: Okavango Research Institute His research will be used to develop a farmer-scientist extension for knowledge and research integration as a way to mitigate climate change risks to farmer livelihoods.
Dr. Hillary Masundire	Ecologist; application of the ecosystem approach in the management of natural resources; ecosystem-based disaster risk reduction		UB: Biological Sciences masundh@mopipi.ub.bw

Note: Table is not complete, but based on best available information obtained in this mapping study, and is therefore indicative rather than definitive.

APPENDIX C: UNIVERSITIES 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 **inter-disciplinary** 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 post-graduate (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: IDENTIFIED SOURCES OF EXPERTISE FOR CCD IN BOTSWANA

Table 17: 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	Research in environmental, agricultural, climate, water, wetlands, biological and energy issues Faculty of Science: ■ 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 Faculty of Education: ■ Department of Languages and Social Sciences: research on curriculum development; ESD and integrating climate change into this Faculty of Agriculture: ■ Department of Agriculture: Research on how CC will affect rangeland and livestock sector; reducing livestock methane emissions;	UB Centre of Study in Renewable and Sustainable Energy (CSRSE)	■ 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	■ Botswana Global Change Committee (BGCC) – initiated by UB Dept of Environmental Science; inter-disciplinary 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)36 – consultancy headed by Peter Zhou ■ SASSCAL programme

[36] http://www.eecg.co.bw/about.html

University	Nodes of expertise	Centres of expertise	Centres of excellence	Active CCD related Research Networks
	Okavango Research Institute: ■ Multidisciplinary research on natural resource management in the Okavango River Basin; specific research programmes focused on climate change		Centre ■ SADC Regional Early Warning Centre (REWC) – at SADC HQ in Gaborone; hub to link with National Early Warning Centres	
Botswana College of Agriculture (BCA)	Department of Animal Science and Production and the Forestry Unit http://www.bca.bw/: ■ 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	The Earth and Environmental Science Department (as BIUST is a very new institution, this is more of a potential than an actual node of expertise at this stage)			

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.