Documentation of Research on Climate change and water in Southern Africa

2nd DRAFT

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For
The Danish Water Forum

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LIST OF ACRONYMS

SADC	Southern African Development Community
IWRM	Integrated Water Resources Management
AGW-NET	African Ground Water Network
DDRN	Danish Development Network
DRN	Danish Research Network
DWF	Danish Water Forum
IPCC	Intergovernmental Panel on Climate Change
CBO	Community Based Organisation
NGO	Non-Governmental Organisation
CSIR	Council for Scientific and Industrial Research
GHCN	Global Historical Climatology Network
ENSO	El Niño Southern Oscillation
IUCN	International Union for Conservation of Nature
WWF	World Wildlife Fund
MDG	Millennium Development Goal
SACAN	South African Climate Action Network
CAN	Climate Action Network
SSN	South South North

Executive Summary

Results from climate change modelling exercises consistently indicate that many of the world's major river basins may experience more severe droughts and floods. Southern Africa is particularly vulnerable to the extreme variability of precipitation given its high dependence on rain-fed agriculture and water resources for livelihoods; limited knowledge on climate change; limited resources for adaptation; and weak institutions and capacity to regulate river and stream flow.

The purpose of this paper is to identify and profile key research institutions in the Southern African Development Community (SADC) conducting research on the impact of climate change on water resources with the aim of creating a regional network on climate change, human health, water and food security.

The results show that given the range and magnitude of the development constraints and challenges facing most SADC countries, the overall capacity of SADC to adapt to climate change is low. Although there are still uncertainties pertaining to the exact future impact of climate change on water resources, SADC countries should start integrating climate change in water sector and national strategies.

It is recommended that The Danish Water Forum and other bi- and multilateral institutions support the establishment of a regional network on climate change and water. Further, these institutions should also consider setting up a fund to support research lead by scientist from the region focusing particularly on the linkages among climate change, human health, water and food security.

1. Introduction

1.1. Goal of this paper

Results from climate change modelling exercises consistently indicate that many of the world's major river basins may experience more severe droughts and floods. Southern Africa is particularly vulnerable to the extreme variability of precipitation given its high dependence on rain-fed agriculture and water resources for livelihoods; limited knowledge on climate change; limited resources for adaptation; and weak institutions and capacity to regulate river and stream flow. Whereas developed countries who are less vulnerable are already expending a lot of effort and resources on understanding and predicting better the impact of climate change as well as on adaptation and mitigation strategies, the status of preparedness in southern Africa is largely not known. The purpose of this paper is to identify and profile key research institutions in the Southern African Development Community (SADC) conducting research on the impact of climate change on water resources with the aim of creating a regional network on climate change, human health, water and food security. The paper is developed as contribution to the broader initiative on Climate change human health, water and food security in Southern Africa jointly supported by the Danish Water Forum (DWF), the Danish Development Research Network (DDRN) and the Danish Research Network (DRN).

1.2. Scope

The scope of the paper is limited to the identification and profiling of research institutions working on climate change and water resources in SADC. The paper does not discuss the science of climate change and water as this subject is better address elsewhere; by the Intergovernmental Panel on Climate Change (IPCC) for example. In this paper the science of climate change and water is discussed only as far as it related to the categorisation of identified research project and publications. The paper also focuses on fresh water resources. Issues of sea level rise are dealt with only insofar as they affect freshwater resources in coastal areas through salt intrusion for example.

1.3. Methodology

Given the nature of this project and the variety of issues to be addressed, a multi-pronged approach was adopted. Web-search, telephone and personal interviews, email discussions, literature review and participation at regional climate change and water workshops were used to identify institution, research projects and publications as well as to elicit the views of researchers on the need for a regional network on climate change and water. However, it is important to note that information was collected predominately through web-search with email or telephone follow-ups. The results at this stage are therefore limited in that they may exclude work especially of community based organisations (CBOs) who do not have the capacity to publish their work on the internet.

1.4. Outline

This paper is divided into seven main sections. After this introduction, the following section (section 2) gives an overview of observed climate change based on hydrological variables at the global level. Section 3 then focuses on the Southern African Development Community (SADC) region looking at current and projected

climate change scenarios and their impact on water resources. The socio-economic impacts of climate change on water resources are also discussed in this section. Key institutions, their profiles and research projects are discussed in section 4. Section 4 also categorises identified projects/publications into vulnerability or impact assessments, adaptation or mitigation. Having identified the institutions and their projects/publication, section 4 presents the profile of researchers active in the field of climate change and water resources. This leads to section 5 which identify and describe networks involved in climate change and/or water resources management in SADC. Section 6 synthesizes the report highlighting key points as they relate to climate change and water resources. The final section (section 8) identifies research gaps and maps the way forward.

2. Observed global change in climate and its impact on water

Climate change affect water through a number of processes since water is an integral part of the climate system (atmosphere, hydrosphere, cryosphere, land surface and biosphere). According to the IPCC (2008)[1] "*observational records and climate projections provide abundant evidence that freshwater resources are vulnerable and have the potential to be strongly impacted by climate change, with wide-ranging consequences for human societies and ecosystems".*

There is consensus among scientists on global warming as evidenced by increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global sea level. Between 1906 and 2005 the globe surface temperature increased by about 0.74°C with a more rapid increase in the past 50 years (IPCC, 2008). Temperature increase since the mid-20th century is largely attributed to observed increases in anthropogenic greenhouse gas concentration. Consequently, over the past 50years cold days, cold nights and frost have become less frequent, while hot days, hot nights and heatwaves have become more frequent.

Global warming is impacting on the hydrological cycle and hydrological systems such as changing precipitation patterns, intensity and extremes; widespread melting of snow and ice; increasing atmospheric vapour; increasing evaporation; and changes in soil moisture and runoff (ibid.). However, there are still substantial uncertainties in trends of hydrological variables because of large regional differences, and because of limitations in the spatial and temporal coverage of monitoring networks (Huntington 2006 in IPCC 2008). Understanding and attributing observed changes to climate change is also complicated by the fact that anthropogenic factors may play an important role at the local level. For example runoff may be affected by changes in extraction patterns. Notwithstanding these uncertainties and challenges, general statements can be made about the impact of climate change on the hydrology and these are included in the following sections.

2.1. Precipitation and water vapour

Climate model simulations for the 21st century are consistent in projecting very likely precipitation increases in high latitudes and parts of the tropics, and likely decreases in some sub-tropical and lower mid-latitude regions. However, unlike temperature, there are more uncertainties on the impact of climate change on precipitation. GHCN results are statistically insignificant and there are many discrepancies between data sets, demonstrating the difficulty of monitoring precipitation which has both spatial and temporal variability. Only a few regions have precipitation data series of sufficient

[1] This section borrows heavily on the IPCC Technical Paper VI on "Climate Change and Water"

quality and length to assess trends with reasonable confidence. Notwithstanding these uncertainties and data gaps, taken together, the observational and modelling studies lead to an overall conclusion that an increase in the frequency of heavy precipitation events is likely to have occurred over most land areas over the late 20th century, and that this trend is more likely than not to include an anthropogenic contribution.

2.2. Snow and land ice

Water supplies stored in glaciers and snow cover are projected to decline in the course of the century, thus reducing water availability during warm and dry periods in regions supplied by melt water from major mountain ranges, where more than 17% of the world's population currently live.

2.3. Sea level

According to the IPCC (2008), global mean sea level has been rising and there is high confidence that the rate of rise has increased between the mid-19th and mid-20th centuries. The average rate was 1.7 ±0.5mm per year for the 20th century, 1.8 ±0.7mm per year between 1961 and 2003, and 3.1 ±0.7mm per year between 1993 and 2003. Rising sea level potentially affects coastal regions.

2.4. Soil moisture

Only a few regions have historical records of soil moisture and they are often for very short durations. The longest records available from Ukraine show overall increases in surface soil moisture, although increases are less marked in recent decades.

2.5. Runoff and river discharge

At the global scale, there is evidence of a broadly coherent pattern of change in annual runoff, with some regions experiencing an increase in runoff (e.g. USA) and others experiencing a decrease (e.g. West Africa). There is however, far more robust and widespread evidence that the timing of river flows in many regions where winter precipitation falls as snow has been significantly altered. Higher temperatures mean that a greater proportion of the winter precipitation falls as rain rather than snow, and the snowmelt season begins earlier.

3. Implications of climate change for water resources in SADC

The Southern African Development Community (SADC) comprise the following 14 member states; Angola, Botswana, the Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, United Republic of Tanzania, Zambia and Zimbabwe.

Water resources in SADC are inextricably linked with climate, so the prospect of global climate change has serious implications for water resources and regional development (Riebsame et al (1995) in Desanker and Magadza)[2]. Results from climate change modelling exercises consistently indicate that many of the world's major river basins may experience more severe droughts and floods.

Climate change scenarios for Africa indicate future warming across Africa ranging from 0.2°C per decade (low scenario) to more than 0.5°C per decade (high scenario).

[2] This section borrows heavily from Desanker and Magadza

This warming is greatest over the interior and semi-arid margins of southern Africa, the Sahel and central Africa. Projected future changes in mean seasonal rainfall in Southern Africa are less well defined. However, under intermediate warming scenarios, most models project that by 2050 the interior of southern Africa will experience decreases during the growing season that exceed one standard deviation of natural variability. The dominate impact of global warming on water is predicted to be a reduction in soil moisture and a reduction in runoff. Current trends in major river basins in Africa already indicate a decrease in runoff of about 17% over the past decade. Reservoir storage in southern Africa is very sensitive to variation in runoff and periods of droughts. During droughts lake storage and major dams have reached critically low levels in some SADC countries, threatening industrial activity. Model results indicate that global warming will increase the frequency of such low storage episodes (Desanker and Magadza, undated).

Interannual variability in SADC is determined by several factors. The El Niño-Southern Oscillation (ENSO) is the most dominate perturbation responsible for interannual climate variability in Southern Africa. La Niña is said to be responsible for the devastating floods in Mozambique in 1999-2000 (Desanker and Magadza, undated).

Simulations appear to indicate possible decreases in precipitation in Southern Africa in the next 100 years. The impact of changes in precipitation and increased evaporation could have profound effects in some lakes and reservoirs in SADC. Evaporative increases of 40%, for example, could result in much reduced outflow from the reservoirs. Lake Malawi for example, has been reported to have no outflow for more than a decade in the earlier part of the 20th century (Calder et al., 1995). Arnell (1999) further project that the greatest reduction in runoff by 2025 will occur in the SADC region.

The Zambezi River has the worst scenario of decreased precipitation (about 15%), increased potential evaporative losses (about15-25%), and diminishing runoff (about 30-40%). Vorosmarty and Moore (1991) have documented the potential impacts of impoundments, land-use change, and climate change on the Zambezi and found that they can be substantial. Cambula (1991) has shown a decrease in surface and sub-surface runoff of five streams in Mozambique including the Zambezi, under various climate scenarios. For the Zambezi basin, simulated runoff under climate change is projected to decrease by about 40% or more.

Growing water scarcity, increasing population, degradation of shared freshwater ecosystems, and competing demands for shrinking natural resources distributed over an area involving many riparian states have the potential for creating bi- and muiti-lateral conflicts.

3.1. Impacts and vulnerability

Sensitivity analyses of major rivers of the continent indicate that these rivers are sensitive to climate change. In Zimbabwe for example, stored water resources fell to less than 10% of installed capacity during the 1991-1992 drought cycle (Magadza, 1996). Mean temperature averaged 2°C above the long term seasonal mean, while seasonal Penman evaporation exceeded the long-term seasonal mean temperature by more than 30% during the 1991-1992 drought cycle (ibid.).

Climate change is also anticipated to impact on hydropower generation. According to Urbiztondo (1992) a temperature increase of 4°C could reduce power generation

capacity of Lake Kariba by 50% with devastating economic consequences. Economic impacts from curtailment of hydropower generation from Lake Kariba, as a result of the 1991-1992 drought, were estimated to be US$101 million loss in GDP, US$36 million in export earnings, and loss of 3 000 jobs (Benson and Clay, 1998).

Extreme events such as floods and droughts also have huge economic costs. In Mozambique floods in 2000 cost the economy US$550 million or 12% of GDP (Grey and Saddoff, 2005).

3.2. Adaptation

Projected changes in precipitation in SADC require innovative and comprehensive adaptation strategies. Major river basins in the region are shared by several states. Recognising this fact, the region has formed international river basin management protocols such as the SADC protocol on Shared Waters and the Lake Victoria Fisheries Authority.

The region has also implemented a number of adaptation strategies that include the following:

- Enhancement of early warning systems to enable timely remedial measures
- Shared basin management, necessitating international agreements
- Water-use strategies-especially demand management-in industry, settlements, and agriculture
- More intensive monitoring to improve data reliability
- Intensive research to better understand and predict precipitation variability and change

Climate change predictability at the local level is severely limited by a dearth of historical data on temperature and precipitation for example. There is an urgent need therefore to intensify the density of monitoring station to improve climate change scenarios.

The SADC region is also lagging behind when it comes to technical strategies to optimize water resources such as water pricing and demand management tools. Crop-watering techniques are still inefficient and wasteful. Few industries and households embrace water-reuse technologies. During drought periods, management authorities have resorted to supply restrictions, such as the 3 day supply per week in Mutare, Zimbabwe during the 1991-1992 drought. Water supply shortages conventionally are addressed through construction of more impoundments (Desanker and Magadza).

Whatever strategies are adopted for optimizing water usage, successful development of such strategies is contingent on reliable meteorological and hydrological information. In many instances, application of hydrological models on a basin-wide scale is restricted by data density. Reliable impact assessments and near-term predictions depend on robust database. Flood propagation and thus flood warning capacity for example, depends on the density of measuring points.

The SADC region has invested heavily in hydropower generation. However, drought episodes and demand oscillations have highlighted the vulnerability of even the largest hydroelectrical plants to climate variability (Magadza, 1996). Energy sharing is therefore a necessary adaptation strategy for SADC.

Robust early warning strategies are also crucial for populations that live in flood-prone areas. Equally important is the need for strategies to alleviate impacts of drought on human suffering and economic development. There is also need to construct flood control infrastructure coupled with synchronization of operations of reservoirs in the same basin to alleviate the impacts of floods.

In the long-term, SADC economies need to be more diversified and adapt efficient irrigation technologies that conserve water in order to cushion them from the vagaries of climate change. As water resource stresses become acute in future as a result of a combination of climate impacts and escalating human demand, there will be intensifying conflict between human and environmental demand on water resources. SADC countries therefore need prudent water allocation strategies that ensure sustainable economic and social development without compromising environmental integrity.

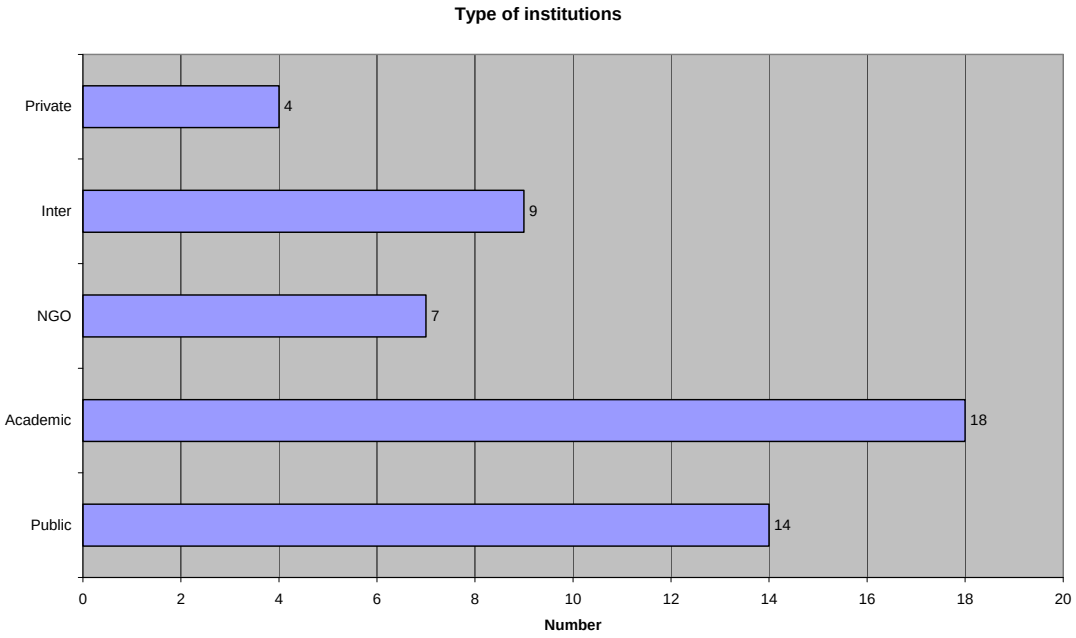
4. Research on climate change and water in SADC

Against this background of projected extreme variability of precipitation and increased severity of droughts and floods, this section looks at what the SADC region is doing in order to better understand and adapt. This section analyses the institutions involved in research on climate change and water, the key research themes addressed and the profile of researchers.

4.1. Type of institutions

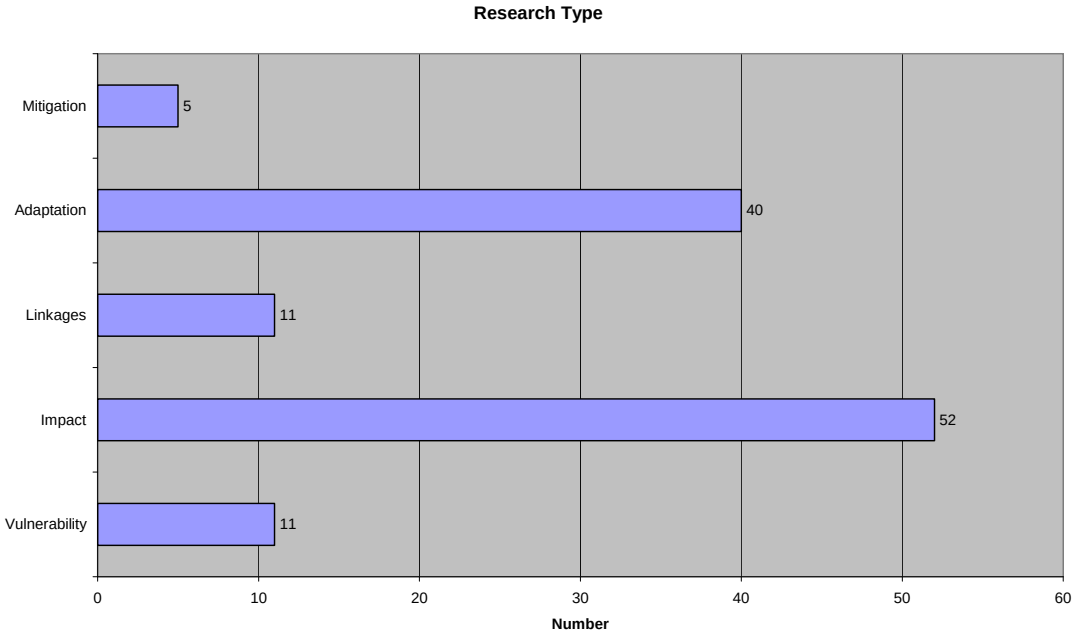
As alluded to earlier, web-based search of projects/publications was the predominate method used to identify research institutions working on climate change and water. The institutions were classified into five main categories; public (government department and research councils), academic (universities), Non-Governmental Organisations (NGOs), International (finance institutions such as the World Bank, WWF or IUCN) and Private institutions.

A total of 52 institutions were identified and these are presented in Figure 1 below. Of these the majority (35%) are academic institutions followed by public institutions (27%, NGOs (17%), international institutions (13%) and finally private institutions (8%).



4.2. Research themes addressed

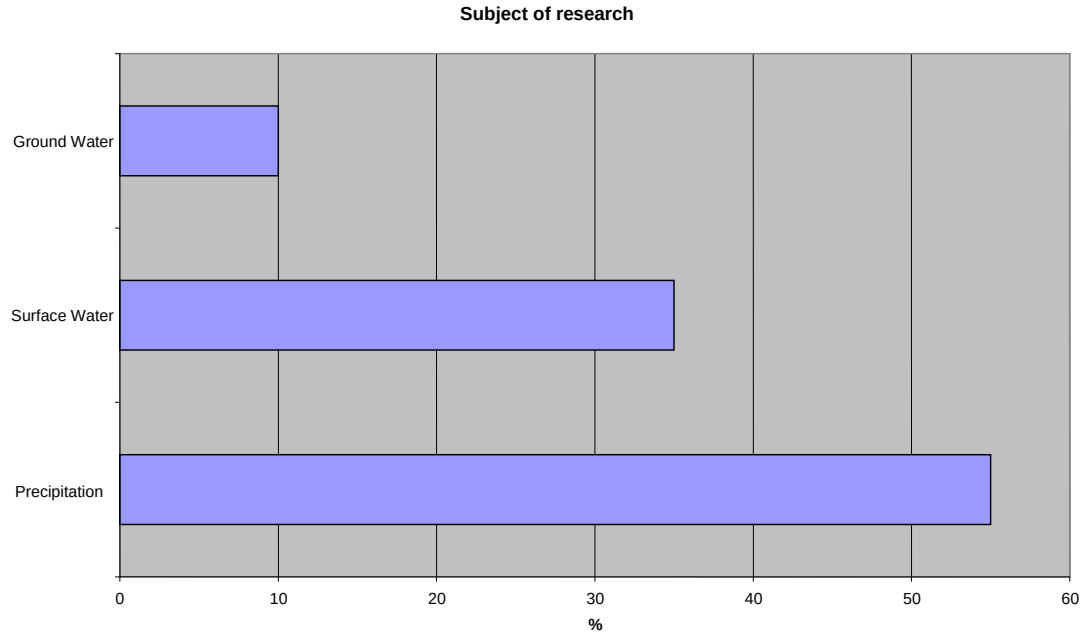
Identified research projects or publications were classified into four research themes; vulnerability; impact assessments; adaptation; and mitigation. The majority of projects (44%) are classified as impact assessments followed by adaptation (34%), vulnerability assessments (9%) and only a few (4%) looked at mitigation. Only 9% of the projects looked at linkages between water and agriculture, water and health or water, health and agriculture. The distribution of projects by research theme is presented in Figure 2.



4.2.1. Impact assessments

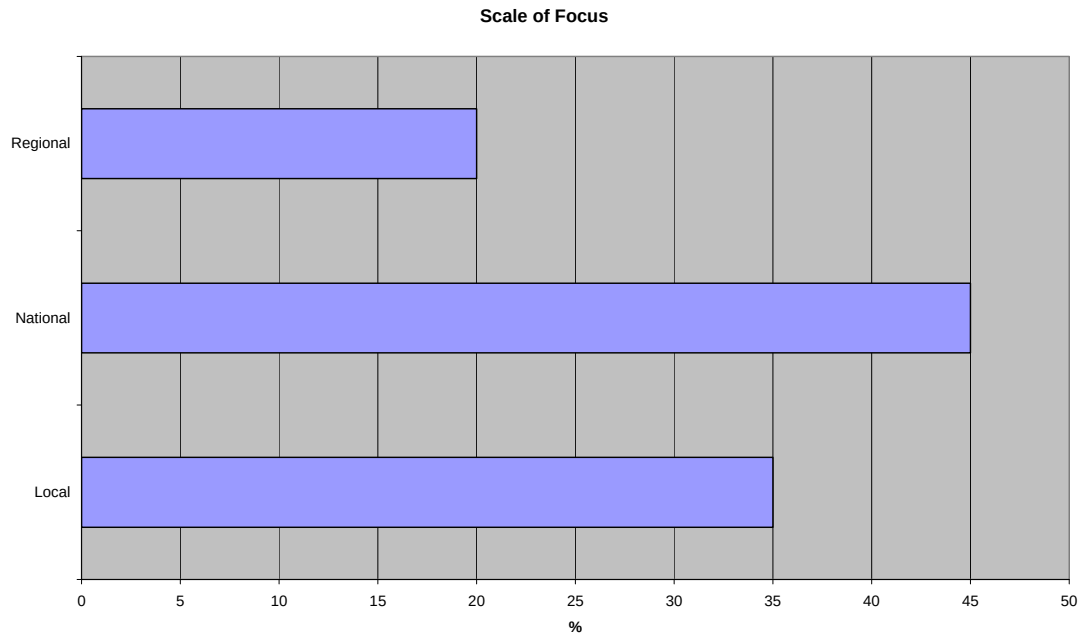
Projects that analysed impacts of climate change on water resources were further sub-categorised based on whether they were based on empirical observations (including trend analysis) or based on present and projected modelling. Since most of the research projects are conducted by academic institutions, it is not surprising that the majority of impact assessments (75%) are based on models. Only a few are based on empirical observations or trend analysis which may be evidence of a serious lack of historical records in SADC countries.

The study further looked at the focus subject of impact studies; that is whether they focused on precipitation, surface runoff or ground water. Figure 3 shows that more than half (55%) of the projects focused on modelling precipitation that is modelling the impact of temperature change on precipitation. Only 10% of the projects looked at the impact of climate change on groundwater.

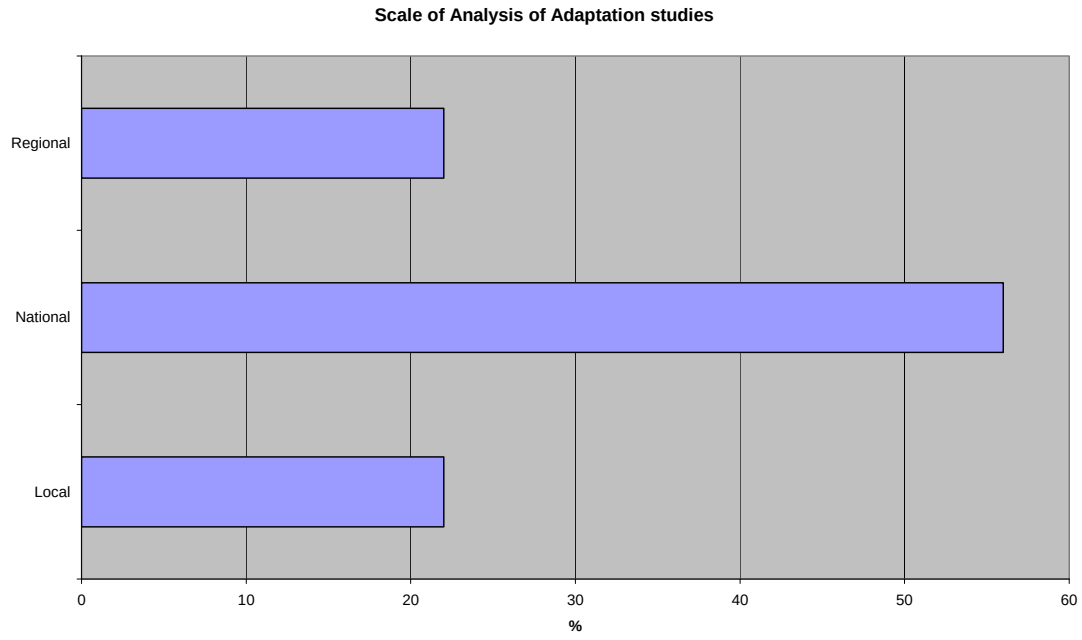


4.2.2. Scale

The study also analysed the geographical scale of impact and adaptation research projects that is whether the research was at local (community or catchment level), national or regional level. The results show that the majority of impact assessment projects focused on national scale (see Figure 4). This may reflect limitation with scaling down General Circulation Models to local levels.



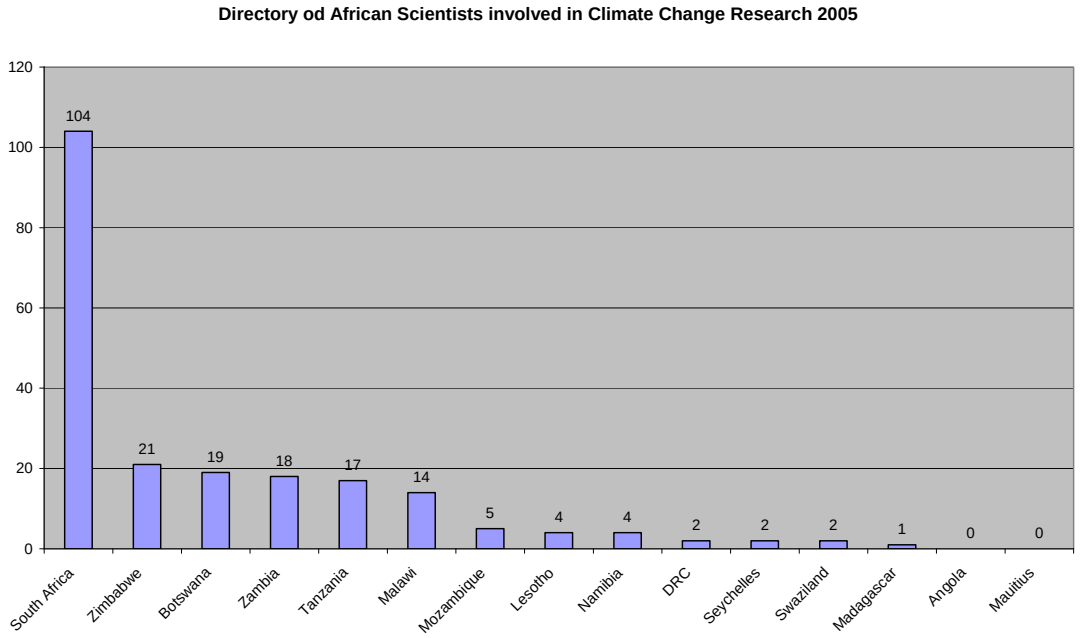
Similarly, adaptation studies also focused at the national level as shown in Figure 5 below.



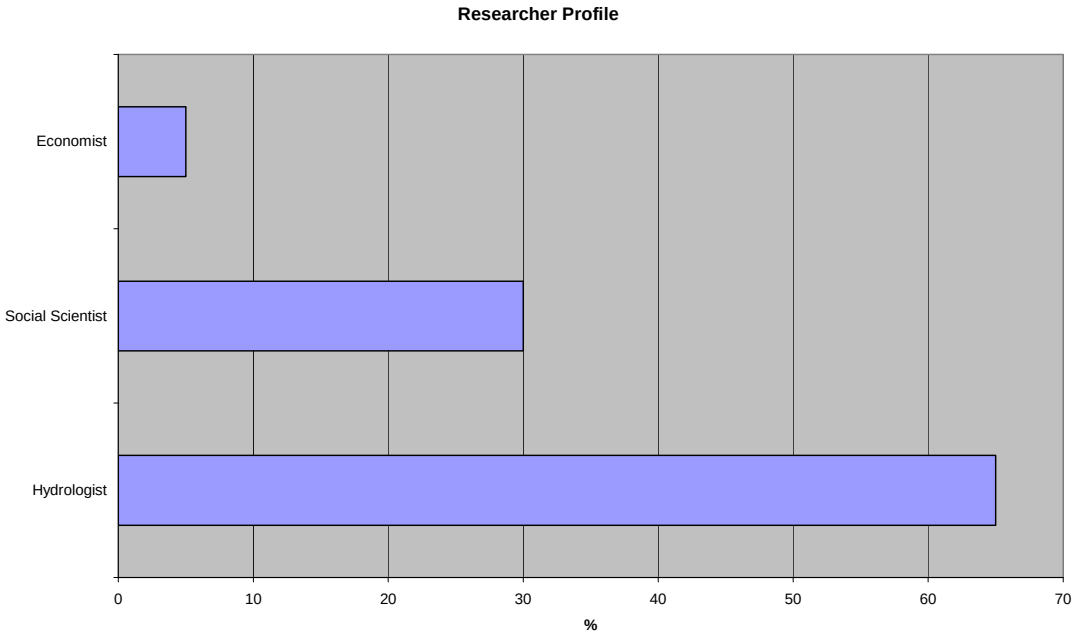
4.2.3. Researcher profile

According to Scholes et al (2005) there were 1380 scientists conducting research on climate change in Africa in 2005. Of these only 41 or 3% conducted research on climate change and water resources. Figure 6 below shows the distribution of African scientist involved in climate change research in SADC in 2005. There is a stark unequal distribution of scientists with South Africa having 5 times or more scientists

than any other SADC country. This further emphasizes the need for networking and sharing knowledge and experiences.



An analysis of the academic background of the researchers identified in this study shows that the majority are hydrologists (65%), social scientists (30%) and only a few (5%) are economists. The categorisation of researchers by profession is presented in Figure 7 below.



5. Networks on climate change in SADC

The impacts of climate change are not confined within national boundaries. There is a great need therefore for regional collaboration to deal with climate change. Furthermore, measuring and predicting climate change is complex. Developing and adapting appropriate strategies to climate change is even more complicated requiring detailed knowledge of the various hydrological factors, expertise and experience. Networking on climate change is one strategy SADC countries could employ to pool their resources, expertise and experience.

Although there are a number of networks in SADC, the author could not identify any that specifically targets researchers involved in climate change ***and*** water resources. Networks that were identified deal with climate change or water resources management in general and these networks are discussed below.

5.1. WaterNet

Housed at the University of Zimbabwe, WaterNet is one of the strongest networks on capacity building in Integrated Water Resources Management (IWRM) in the SADC region. The network comprises university departments and research and training institutes specialising in water. The aim of the network is to build regional institutional and human capacity in IWRM through training, education, research and outreach by harnessing the complementary strengths of member institutions in the region and elsewhere. WaterNet member institutions have expertise in various aspects of water resources management and are based in Southern and East Africa. More information about WaterNet can be found on www.waternetonline.org

5.2. CAP-Net

Cap-Net is an international network for capacity building in IWRM. The SADC office is located in Pretoria, South Africa. Cap-net is made up of a partnership of autonomous international, regional and national institutions and networks committed to capacity building in the water sector. Networks have proven to be effective at promoting the understanding of integrated water resources management and play a key role in supporting the development of IWRM and the achievement of the MDG's. Further details about Cap-net can be obtained on www.cap-net.org

5.3. African Groundwater Network (AGW-NET)

The African Groundwater Network (AGW-NET) was established on 22 July 2008 in Pretoria, South Africa. The network is an Africa wide group of groundwater professionals who have committed to work together to roll out capacity building on groundwater management in Africa. This group was formed in response to the results of surveys on groundwater management and capacity building needs in West Africa, Southern Africa and the Nile Basin. These surveys acknowledged the importance of groundwater to the Millennium Development Goals (MDGs) but cited capacity gaps as a limitation to meaningful intervention. The AGW-NET is open to membership from practising groundwater professionals and those from related professions. Further information about AGW-NET can be obtained from the coordinator Dr Richard Owen richard@zol.co.zw

5.4. South Africa Climate Action Network

The South African Climate Action Network (SACAN) is a network of like-minded NGOs, CBOs and individuals working on climate change issues in South Africa. As a member of the international Climate Action Network (**CAN**), SACAN works to promote government, business and individual action to limit human-induced climate change to ecologically sustainable levels. The objective of the SACAN is to coordinate information exchange on national, regional and international climate policies and issues, amongst civil society organisations and with other interested institutions. Members range from community-based organisations fighting for their right to a healthy environment to research institutions and implementers of development projects.

5.5. South South North

South South North (SSN) is an international network based non-profit organisation, which has offices in all parts of the world. SNN Africa has its head office in Cape Town, South Africa. SSN seeks to place poverty reduction efforts at the centre of all climate change issues. The focus of the international group is to find links between climate change project work in mitigation and adaptation, and poverty reduction. The network has five programmes. The first two programmes focus on mitigation and adaptation. The other three programmes address cross-cutting themes: capacity building; technology receptivity and transfer; and policy intervention. The projects primarily investigate how poor communities might adapt to the negative effects of climate change, as well as what opportunities mitigation options might present for such communities.

6. Synthesis

If climate change follows projected scenarios, changes in temperatures and weather patterns will affect the frequency or rain and the severity of droughts and floods. The SADC region will be disproportionately affected by erratic and extreme weather, given it limited resources for undertaking adaptations and its limited capacity to regulate river and stream flows. Dealing with climate change and its impact on water resources will call for *greater* coordination and collaboration among SADC countries.

Given the range and magnitude of the development constraints and challenges facing most SADC countries, the overall capacity of SADC to adapt to climate change is low. Although there are still uncertainties pertaining to the exact future impact of climate change on water resources, SADC countries should start integrating climate change in water sector and national strategies.

6.1. Knowledge gaps and research agenda

6.1.1. Data needs

Lack of data is one of the constraints confronting SADC counties. There is need for improved measurement at the local level in order to be able to scale down regional and global models. Current impact assessment models are limited by input data, limiting their use to fairly general questions. Examples exist where detailed spatial database have been built and are being used to integrate agrohydrological models such as in South Africa.

6.1.2. Linking researchers with policy makers and practitioners

Much of the research on climate change and water is conducted by academic institutions. This is understandable since the thrust in SADC at the moment seems to be to better understand and model the impacts of climate change on water resources. However, there is a danger that we wait for too long for this knowledge before taking action and by the time we fully understand the science some irreversible damage might have been caused. There is a fundamental need to ensure that what ever information generated by scientists in academic institutions is conveyed to policy makers and practitioners so that real time decisions are made.

6.1.3. Mitigation

This study shows a limited number of research projects on mitigation strategies which is worrying since some of the climate change mitigation strategies such as afforestation may impact on water resources.

6.1.4. Linkages

It is also worrying to not that only a limited number of projects address linkages between climate change, human health, water and food security. Yet understanding these linkages is imperative if we are to develop comprehensive adaptation strategies. Whereas research follows professional disciplines, communities do not live water today, health tomorrow and food security the day after. Rather these problems more often than not manifest themselves at once at the household level. There is an urgent need therefore for further research to better understand the linkages.

6.1.5. Socio-economic dimensions of climate change

There is also a dearth of information on community strategies to cope with climate variability and change. This could be due to the fact that not many research projects addressed social dimensions of climate change and water. Similarly, research on the economic dimension is also limited. Studies in Ethiopia, Kenya and Mozambique have shown shocking correlation between rainfall and economic growth.

6.1.6. Ground water

Research on ground water resources is also limited yet this resource is key when it comes to adapting to the impacts of climate change on water in SADC.

6.1.7. Transboundery research

Most river basins in SADC are shared by 2 or more countries. The Zambezi is shared by 8 countries, the Limpopo, Orange and Congo 4 countries. There is an urgent need therefore to increase collaborative research especially on adaptation which could be regional in nature; e.g. South Africa depends on water from Lesotho

6.1.8. Networks

Currently there is no network of researchers involved in research on climate change *and* water although there are networks that look at climate change and water resources management in general. The proposed regional network is therefore necessary although this new initiative should learn from and inform existing networks.
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7. Way forward

The Danish Water Forum and other bi- and multilateral institutions should support the establishment of a regional network on climate change and water. These institutions should also consider setting up a fund to support research lead by regional scientist on the linkages among climate change, human health, water and food security.

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Annex 1: Research on Climate change and water in Southern Africa

Botswana	
Initial National Communication UNFCCC	**Climate Change Challenge** • Classified as semi-arid, the Kalahari desert occupies 77% of Botswana's land mass leaving the country with limited supplies of fresh water, infrequent rain, and drought as its most frequent natural disaster. The value of this scarce resource is evident in the naming of the currency, pula (rain). • Botswana will on average be 1-3deg C warmer by around 2050 than at present. • Rainfall will be 10-25% less by the same time.
Institution	Centre for Applied Research (CAR) • The Centre for Applied Research (CAR) was established in 2000 in response to the growing demand for high-quality research and consultancies. Increasingly, governments and donor agencies wish to engage local institutions for their work. The Centre is registered in Botswana and located in its capital Gaborone. • Activities o Research o Training o Consultancy
Research Topic	Groundwater and Water Accounting in Southern Africa within the Perspective of Global Climate Change
Researchers	Jaap Arntzen jarntzen@car.org.bw Rashid Hassan Glen Marie Lange
Institution	University of Botswana: Harry Oppenheimer Okavango Research Centre • The Harry Oppenheimer Okavango Research Centre (HOORC) is becoming established as a world class centre of academic excellence for the study and conservation of the world's largest wetland ecosystem, the Okavango Delta. Situated in Botswana's north western capital of Maun on the fringes of the Okavango Delta, HOORC specialises in natural resource management research of the Okavango River Basin. A primary focus of this research is to influence policy-making at different levels on the region's most pressing social and environmental issues.
Research Topic	Simulation of effects of development and climate change scenarios on the hydro-ecology of Okavango Delta
Researchers	Piotr Wolski and Mike Murray-Hudson
Institutions	University of Botswana: Department of Environmental Science • Environmental Science is the multidisciplinary subject that facilitates the understanding of the complex interactions involving natural processes, on the one hand, and between the biophysical (or natural) environment and human activities, on the other
Research Topics	'Climate change and water resources management in semi-arid Southern Africa' in Climate Change: Five Years after Kyoto (ed. Velma I. Grover) Science Publishers, Inc, Plymouth, UK, Chapter 10, pp. 211-229.
	'Hydroclimatological approach to sustainable water resources management in Semi arid regions of Africa' In Water Resources in Arid Areas (eds. Stephenson D., Shemang, E. M. and Chaoka T. R.) A A. Balkema Publishers, London, pp 389 395.
	"Implications of climatic variability on water resources management in Africa" IAABD Proceedings: Building Bridges For African Business and Development , pp. 290 294.
	"Implications of climatic variability on water resources management in Africa" IAABD Proceedings: Building Bridges For African Business and Development , pp. 290 294.
	'Regional Modelling of Climatic Variability on Streamflow' Paper to be presented at Third International Conference on Water Resources and Environment, Dresden, Germany, 22 26 July, 2002
Researchers	Umoh U. T; S. Kumar; and A. A. Oladimeji
Institution	Environmental Research Policy Solutions (ERPS) • Environmental Research and Policy Solutions (ERPS) is a consulting firm based in Botswana offering a comprehensive range of services broadly divided into five areas, namely, Environmental Management, Environmental Policy Analysis, Water Resources Management, Biodiversity Assessments and Community Based Natural Resources Management (CBNRM).
Research Topics	Gender differential impacts of CC in Southern Africa
	Capacity assessment to implement MEA's
Researcher	Kulthoum Omari kulthoum.omari@gmail.com
Institution	Energy Environment Computer and Geographical (EECG) consultants-Botswana • NGO
Research Topic	Climate Change Mitigation in Southern Africa Phase II
Researcher	Peter Zhou pzhou@global.bw

Democratic Republic of Congo	
NAPA	**Adaptation projects on climate change and water** No specific project on climate change and water in NAPA but has the following projects: • Energy related projects • Biodiversity conservation
Institution	Official University of Bukavu
Researcher	Lefranc Basima Busane francbusane@yahoo.fr
Institution	Vision Verte
Researcher	Jean Muhingwa jeanmuhingwa@yahoo.fr

Lesotho	
NAPA	**Climate Change challenges** • Lesotho is prone to a number of key environmental stresses mainly drought, land degradation, desertification and loss of biodiversity. • Climate change will have severe impact on water resources in Lesotho, as diminishing rainfall will lead to the shrinkage of surface and ground water resources. Already catchments yields have waned to the extend that springs that were once perennial have run dry, the once great and robust rivers have been reduced to mere trickles and dams remain dry for most part of the year. • The future climate conditions that were predicted by the different GCM climate change scenarios showed that by 2075, Lesotho was likely to be a warmer country with less precipitation, particularly during spring and summer months. The lower yield in both surface and ground water that goes with this finding indicates that the country could experience an absolute water scarcity by 2045 unless bold adaptation strategies were adopted.
	Objectives • Identification of regions and communities vulnerable to climate change • Assessment of impact of climate change on community livelihoods • Identification and prioritisation of responsive adaptation activities for implementation in the vulnerable zones
	Adaptation Projects on Climate change and water • Priority 4: Improvement of an Early Warning System Against Climate Induced Disasters and Hazards • Priority 5: Securing Village Water Supply for Communities in the Southern Lowlands
Institution	Ministry of Natural Resources Department of Meteorological Services
Research Topic	Adaptation to climate change; Technology needs for Lesotho • Appropriate technologies for rural water supply in the context of climate change
Researchers	• Limpo Fobo limpfo@yahoo.com • Lebohang Maseru lebomsu@yahoo.co.uk

Madagascar	
NAPA	**Adaptation projects on climate change and water** The following are water related projects in the National Adaptation Program of Action : • Rehabilitation and/or construction of protective dams and dykes • Implementation and mobilisation of water management associations • Implementation of dams and dykes to control the gradual rise of sea level
Institutions	Someah, l'expertise & l'ingénierie au service du développement durable
	University of Madagascar

Malawi	
NAPA	**Climate change challenges** • Malawi is heavily dependent on natural resources including water resources • Malawi has experienced a number of adverse climatic hazards over the last several decades. The most serious have been dry spells, seasonal droughts, intense rainfall, riverine floods and flush floods. • Some of these, especially droughts and floods, have increased in frequency, intensity and magnitude over the last two decades, and have adversely impacted on food and water security, water quality, energy and the sustainable livelihoods of rural communities.
	Objectives • The goal of NAPA is to enable Malawi to address her urgent and immediate adaptation needs caused by climate change and extreme weather events.
	Adaptation projects on climate change and water • Priority 1: Sustaining life and livelihoods for the most vulnerable communities, including access to clean and save drinking water • Priority 9: Develop food and water reserves for disaster preparedness and

	response
Institutions	Ministry of Research and Environmental Affairs • The mission of the Ministry is to coordinate, facilitate and promote full participation of all stakeholders in the sustainable development, utilization and management of natural resources and environment for socio-economic development including poverty reduction.
Research Topic	Republic of Malawi 1996, Effects of climate change on water resources of Malawi Preliminary report
	Rainfall variability and sustainability of smallholder irrigation
Researchers	Chavala, G.M.S and A.B.Chirwa Sangwani Khasa sangwaik@yahoo.co.uk Osward Mwamsamali Betrice Makwenda
Institution	The Malawi Polytechnic: Department of civil engineering • The Malawi Polytechnic was established in 1965. The Civil Engineering department aims to produce graduates with a broad field of engineering that deals with the planning, construction, and maintenance of fixed structures, or public works, as they related to earth, water, or civilization and their processes. Most civil engineering today deals with roads, structures, water supply, sewer, flood control and traffic. The depart of also conducts research on water and climate change
Research Topics	The evaluation of present and potential water resources management for lake Chirwa
	The Potential Impact of Climate Change on Water Resources of Malawi: Vulnerability Assessment and Adaptation Strategies." Paper presented at the African Global Analysis, Interpretation and Modeling Workshop, 2 - 13 March, 1997 in Mombasa, Kenya.
Researcher	Geoffrey M. S. Chavula,
Institution	Ministry of Transport and Public Works: Meteorological Department • The purpose of the Meteorological Department is to contribute to Malawi 's socio-economic, and environmental goals through the execution of its functions in general, and in particular for the purpose of water resources, irrigation and other developments. The department also conducts research on climate change and water resources, dam design, and provides information on drought monitoring, prediction, warning and management
Research Topic	Impact of climate change on water and wetlands in Southern Africa
Researcher	Nicholas D. Mwafulirwa
Institution	University of Malawi: Geography and Earth sciences/Natural resource and environment centre • The Department of Geography and Earth Sciences offers courses in both Geography and Earth Sciences. Research centres are an important section of a University that enhance its research capacity and respond to the needs of the nation in solving problems that require expert analysis. Such centres are also important for the generation of baseline data for identifying intervention strategies and use in decision and policy making. The Natural Resources and Environment Centre (NAREC), a Faculty of Science initiative and based on market needs, has been established by the University of Malawi to address environmental and natural resources management issues. The general objective of NAREC is to provide an institutional infrastructure and capacity for research, training and consultancy in natural resources and the environment for poverty reduction at household and national levels. • The centre conducts research on climate change and water.
Research Topics	Impact of cc and variability on water resources availability in Southern Malawi: The case of Shire river Basin
	Strengthening local agriculture innovative systems in more and less favoured areas of Malawi and Tanzania to adapt to challenges and opportunities of CC
	Sustainable soil and water management technologies to mitigate climatic vulnerability in drought prone areas of Malawi
Researchers	narec@chirunga.sdnp.org.mw Ishmael Bobby ikosamu@poly.ac.mw Mphangwe Kosamu ishkosamu@yahoo.com Miriam Kalanda Cosmo Ngongondo msabola@chanco.unima.mw Amon Mkondambiri Kabuli, Albert kachapila alo.kachapila@yahoo.co.uk

Mauritius	
Institution	University of Mauritius • The Consultancy and Contract Research Centre (CCRC) was launched in August 1998 under the aegis of the Pro-Vice-Chancellor for Research, Consultancy & Innovation. The CCRC is headed by a Director and comprises a lean staff/structure, supported by Research Assistants dedicated to major projects

	• To provide expert Consultancy and Contract Research services to local and regional clients so as to contribute to the socio-economic development of Mauritius within the global economy
Research Topics	A Modelling and Management of Areal Precipitation over Digitally-derived Catchment Areas of Mauritius
Researchers	Soonil DDV Rughooputh*, sdr@uom.ac.mu Rody Nigel, Ravi Boojhawon, Jayrani Cheeneebash, Chris Graham and Shvin Gopaul
Institution	Mauritius Meteorological Services • The Mauritius Meteorological Services (MMS), is the specialised agency on matters relating to the atmosphere, weather and climate. The Meteorological Services is an essential service working round the clock. In order to function effectively, this service has in place an extensive program to utilise modern technology, including space-based, into its observing systems and for the preparation of meteorological products. The MMS is also privileged to be an active participant among regional and international meteorological communities, where it is playing highly constructive and lead roles. • The main objective of the MMS is to assess weather and the state of the climate and provide accurate and timely predictions. • The MMS in collaboration with regional and international institutions conducts research on climate change and water resources.
Research Topic	Climatic Parameters in a changing Climate in Mauritius
Researcher	Y. Boodhoo meteo@intnet.mu
Institute	Mauritius Research Council • The Mauritius Research Council (MRC) was set up in May 1992 (Act no. 10 of 1992) as an apex body to promote and coordinate Governments investment in research. The MRC acts as a central body to advise Government on S&T issues and to influence the direction of technological innovation by funding research projects in areas of national priority and encouraging strategic partnerships • The MRC funds research on climate change and water resources
Research Topic	Climate indicators for climate change of Mauritius and Rodrigues
Researchers	Mr P Booneeady

Mozambique	
NAPA	**Climate change challenges** • The occurrence of extreme climate events in Mozambique constitutes a great barrier to swift sustainable economic development due to human and material damages. This includes the loss of crops due to extreme events, which can occur at least once a year. As a result, the population lives in a situation of threat and instability.
	Objectives of NAPA • The purpose of the NAPA is to strengthen national capacity to cope with the adverse effects of climate change.
	Adaptation projects on climate change and water • Priority 1: Strengthening early warning system • Priority 4: Management of water resources under climate change
Institution	World Wildlife Foundation (WWF) • The WWF climate program is a team of dedicated experts working worldwide to examine the effects of climate change and develop, implement and advocate for solutions that protect people, places and wildlife. To date, WWF has led a variety of adaptation and resilience projects around the world, published a leading text on climate change adaptation, *Buying Time: A Users Manual to Building Resistance and Resilience to Climate Change in Natural Systems* and created a climate adaptation training program called Climate Camp, in which staff from NGOs and governments come together to share ideas and information for developing new approaches to climate change.
Research Topic	Impact of climate change in Africa • Outlines the extensive effects of climate change on Africa, and highlights that if carbon pollution continues at current rates, people, animals and plants will suffer serious consequences. As natural resources become scarce or disappear, many African communities will suffer the effects of climate change-induced alterations of agriculture, water supply and disease. At the same time, climate change will exacerbate the already numerous stresses on biodiversity in Africa, possibly even causing some ecosystems to go extinct.
Researchers	Jose Antonio Chiburre jchiburre@wwf.org.mz Rui Manuel Soares rui_soares_fonseca@yahoo.com
Institution	Swiss Agency for Development and Cooperation (SDC) • Mozambique has been receiving SDC support since 1979. At the outset, it consisted of humanitarian aid, but in the 1990s, the programme was regularly

	adapted to the changing framework conditions and has expanded considerably to include climate change and water resources.
Research Topic	Climate change and drinking water supply • The SDC was involved in Mozambique's water sector since the very beginning of its cooperation in 1979 and redefined its strategic orientations in 2003.
Local Contact	maputo@sdc.net
Institution	University of Eduardo Mondlane
Researcher	Dr. Dinis Juizo juizo@uem.mz

Namibia	
National climate change program	Climate change is considered one of the most serious threats to Namibia's environment, human health and well-being as well as its economic development. The arid environment, recurrent drought and desertification have contributed to make Namibia one of the most vulnerable countries to the effects of climate change. According to International Institute for Environment and Development (2007), Namibia is "highly vulnerable" to climate change and calls for urgent mainstreaming of its impact into all government policies. Namibia has been referred to as a sandwich country, a slice of bushveld between two deserts: the Namib to the west and the Kalahari in the east. The risks of global warming lie predictably in increased intensity of drought leading to desertification and water scarcity, ironically combined with extreme flooding. The report says that there have been limited studies of the effect of changing sea temperatures on Namibia's rich fishing resources which "rely on the nutrient-rich upwellings of the cold Benguela current". It suggests that, with 30% of GDP dependent on the natural environment, including tourism, global warming could account for annual losses of between 1% and 6% of GDP. In March 2008 the government declared a state of emergency in response to sever flooding and cholera outbreak in the northern parts of the country (Oneworld, 2009).
Institutions	Ministry of Environment and Tourism • The Ministry of Environment and Tourism (MET) was established in 1990 and is responsible for the safeguarding Namibia's environmental resources. MET has ever since began to implement far-reaching policy and legislation reforms within the environmental sphere in an attempt to alleviate many of the constraints that the environment place upon people and vice versa. These reforms were also aimed at encouraging the various innovative collaborative partnerships between key players in the environmental field, such as various Ministries with environmental interests within their areas of jurisdiction, non-governmental organisations, community-based organisations and donor agencies of various countries. • In order to meet its mandate MET commission research on climate change
Research Topic	Namibia Climate change country study • Another notable output of the climate change program was the completion of a country study on climate change in Namibia in 1998. This study included an overview of the vulnerability of Namibia to climate change, an assessment of the source and sinks of green house gases in Namibia and a preliminary overview of the emissions scenarios and the corrective choices which the country faces
	The national Climate change program • Include the preparation and presentation to the Convention of the Initial National Communication on the status of climate change as well as corrective actions to reduce the predicted effects of climate change on Namibia. • The INC also included the first greenhouse gases (GHG) inventory for Namibia, an analysis of vulnerability to the effects of climate change and recommendations on adaptation measures, capacity development, research, monitoring, public awareness and technology needs
Researcher	Teofilus Nghitila Nghitila@dea.met.gov.na tel +264-61-249015
Institution	Desert Research Foundation (DRF) • The DRFN is a Namibian non-governmental sustainability organisation aiming to enhance decision-making for sustainable development through research, training and consultancy in the country's land, water and energy sectors
Research Topic	Climate change vulnerability & adaptation assessment Namibia. Final report March 2008. Desert Research Foundation of Namibia & Climate Systems Analysis Group for the Ministry of Environment and Tourism. Windhoek: 1-167
	Climate variability: implications for sustainable natural resource management. International Conference on Integrated Drought Management, Pretoria: 391-398. (Conference paper)
	An overview of Namibia's vulnerability to climate change. Namibia's country study on climate change (March 1999). Desert Research Foundation of Namibia, Windhoek: 1-161 pp.
Researchers	Dirkx, E. claus.hager@drfn.org.na, Hager, C., Tadross, M., Bethune, S. and B. Curtis; Tarr J; Seely MK.
Institution	University of Namibia: Multidisciplinary Research Centre (MRC) • The key mission of the MRCC is to promote, conduct and coordinate

	multidisciplinary research. The Centre also provides consultancy, advisory, and other related services to the community and also contributes to the attainment of excellence in research and development.
Research Topics	Report on Climate outlook
	'Millennium Development Goals 7 and Climate Change: Challenges and Opportunities'
Researchers	John Mfune; Hochobeb, B

Seychelles	
Initial National Communication UNFCCC	Despite the plentiful rainfall the islands receive annually, 98% is lost through run-off and evapotranspiration, primarily due to the steepness and length of the catchment. Only 2% is left as infiltration to feed the streams and groundwater. Because of the high run-off and the seasonality of the rainfall, the country experience water shortages during the dry months of the year. Climate change is expected to result in changes in rainfall pattern, evaporation, river runoff, groundwater recharge, and water quality in the Seychelles. These could have significant implications for the water resources in the country. In most part of the country, anomalies in climatic conditions, such as prolonged periods of drought and abnormal high quantity of rainfall, had been experienced, and these had brought much economic cost to the country. However, the issue requires further study, especially, the nature of the changes in the rainfall pattern expected.
Institution	Ministry of Environment, Natural Resources andTransport • The ministry is responsible for ensuring sustainable conservation of biological diversity, Seychelles environment protection by set acts, policies and regulations. In addition ensure sustainable agricultural development, without compromising human health and the environment to enhance the national food security by acting as a facilitator.
Research Topic	Government of Seychelles (2000), Initial National Communications under the United Nations Framework Convention on Climate Change • Gives a national overview of the potential impact on water resources and make recommendations on adaptation strategies
Researchers	Rolph Payet, rolphap@seychelles.net; Antoine Moustache, Nirmal Shah, Rondolph Payet, Dawson Labodo, Andrew Jean-Louis, Danny Poiret and Wills Agricole. metops@seychelles.net

South Africa	
Initial National Communication UNFCCC	Potential changes in climate may have significant effects on various sectors of South African society and the economy. The South African Country Studies Programme identified the health sector, maize production, plant and animal biodiversity, ***water resources***, and rangelands as areas of highest vulnerability to climate change, and proposed suitable adaptation measures to offset adverse consequences. Even without climate change it is predicted that South Africa will utilise most of its surface water resources within a few decades. The most significant impacts of climate change on water resources are the potential changes in the intensity and seasonality of rainfall. While some regions may receive more surface water flow, water scarcity, increased demand for water and water quality deterioration are very likely to be problems in the future. Climate change may also alter the magnitude, timing and distribution of storms that produce flood events. The arid and semi-arid regions, which cover nearly half of South Africa, are particularly sensitive to changes in precipitation. Desertification, which is already a problem in South Africa, could be exacerbated as the climate changes. Adaptation options identified to limit the effect that climate change may have on water resources include strategic resource management issues, drought relief measures, design of infrastructure and communication.
Institutions	The Council for Scientific and Industrial Research (CSIR) • The CSIR is the largest research institution in Africa. The objects of the CSIR are, through directed and particularly multi-disciplinary research and technological innovation, to foster, in the national interest and in fields which in its opinion should receive preference, industrial and scientific development, either by itself or in co-operation with principals from the private or public sectors, and thereby to contribute to the improvement of the quality of life of the people of the Republic, and to perform any other functions that may be assigned to the CSIR by or under this Act. • Research on climate change and water is conducted in two departments; Water and Sanitation for Development (WSD) and Natural Resource and the environment (NRE)
Research Topics	How does climate change affect groundwater in South Africa?
	Global change and the NEPAD
	Should Africa contribute to climate change mitigation?
	Links between Transboundary Groundwater, the MDG's, Human Security, Climate Change and the Environment in Africa

	Proposal and Statement of Capabilities for CCAA Pilot Action in South Africa
	A Bayesian approach towards facilitating climate change Adaptation on the South African Agricultural sector
	Impact of Climate Change on Groundwater Recharge Estimation
	Economic Impacts of Climate Change on water resources
Researchers	G. Manase gmanase@csir.co.za; R Maserumule, rmaserumule@csir.co.za C Colvin and S Woodborne M, Dr RJ Scholes, Rina Taviv F, Jude Cobbing, Rob Hounsome RHounsom@csir.co.za JK Musango1 & C Peter1 jmusango@csir.co.za;cpeter@csir.co.za Cavé, L., Beekman, H.E. and Weaver, Marius Claassen mclaassen@csir.co.za
Institution	University of KwaZulu-Natal : School of Bioresources Engineering and Environmental hydrology • Established in 1948, when the Faculty of Agriculture was formed, the Department of Agricultural Engineering, now the **School of Bioresources Engineering and Environmental Hydrology**, has become one of the strongest in the Faculty and is recognised both nationally and internationally for its successful and dynamic research programmes. The **School of Bioresources Engineering and Environmental Hydrology**, situated on the picturesque Pietermaritzburg campus, enjoys an international reputation for teaching and research. BEE is the first university in South Africa to pioneer a science degree course in Hydrology, having the largest Hydrology Department in the country with an applied environmental focus, and being the largest university hydrological research group in South Africa, with local and international funding
Research Topics	South Africa Country Study on climate change: Sythesis Report for the Vulnerability and Adaptation Assessment Section
	Assessment of the impact of climate change on hydrology and water resources in South Africa:
	Coping with variability and change: Floods and droughts
Researchers	Dr G A Kiker, RE Schulze and LA Perks,
Institution	University of Cape Town: • Energy Research Centre • Environmental and Geography science (EGS) The department strives to further our knowledge, understanding and management of the interactions between humans and their social, biological and physical life support system. The Climate Systems Analysis Group (CSAG) based in the EGS department focuses on climate modelling and climate change studies www.csag.utc.ac.za. Other Research groups under EGS include Disaster Mitigation for Sustainable Livelihoods program and the Environmental evaluation Unit
Research Topics	Access to water - the impact of climate change in small municipalities
	Economic Impacts of Climate Change in South Africa: A preliminary Analysis of Unmitigated damage Costs
	Changes in Surface Water Supply Across Africa with Predicted Climate Change
Researchers	PIERRE MUKHEIBIR Pierre.Mukheibir@uct.ac.za J. TURPIE, H. WINKLER, R. SPALDING-FECHER & G. MIDGLEY, Maarten de Wit* and Jacek Stankiewicz maarten@cigces.uct.ac.za
Institution	Water Research Commission • The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa. The WRC serves as the country's water-centred knowledge 'hub' leading the creation, dissemination and application of water-centred knowledge, focusing on water resource management, water-linked ecosystems, water use and waste management and water utilisation in agriculture.
Research Topics	Climate change: a new focus area for the WRC • Climate change requires both understanding and adaptability. In order to meet with the challenges of the future the WRC has included this critical focus area in its endeavours to develop adaptive strategies to ensure the sustainability of the country's water resources and services in the face of continuous changes in climatic conditions and potential extreme events, which may severely affect existing infrastructure or diminish further our scarce water resources. Environmental functioning within the hydrological cycle • All environmental components and processes within the hydrological cycle depend on and are regulated by the structural, functional and compositional aspects of biodiversity. Environmental components and processes also respond to and impact on society's decisions and actions. Historically, research has been narrowly

	focused on separate environmental components within the hydrological cycle rather than the processes and relationships between them. This thrust focuses on understanding these relationships within the hydrological cycle, their role in maintaining flows of water-related goods and services to society, and their vulnerability to change in the broader environment.
Contact	Jay Bhagwan jayb@wrc.org.za
Institution	Rhodes University: Institute of Water Research • The objectives of the IWR are to contribute to the knowledge of and promote the understanding and wise use of natural water resources in southern Africa.
Research Topics	Impact of climate change and development scenarios on flow patterns in the Okavango river
	An evaluation of the potential use of satellite rainfall data for input to water resource estimation models in southern Africa. Climate Variability and Change - Hydrological Impacts (Proceedings of the Fifth FRIEND World Conference held at Havana, Cuba, November 2006), IAHS Publication 308, 75-80
Researcher	Denis A. Hughes

Swaziland	
Initial National Communication UNFCCC	**Climate change and water challenges** • The high vulnerability of Africa to various manifestations of climate change has been confirmed in reports of the IPCC and other publications. In the context of Swaziland, the sectors that are climate sensitive and hence highly at risk include water resources. • The response of the Usutu river to climate change was evaluated using outputs of the three GCMs (GFDL, UKTR, and CCC-EQ) The results obtained were then used as inputs to the WatBall model which is an integrated rainfall-runoff model for forecasting stream flow. The model runs gave projections up to the year 2075 for this river. In summary, the model projects stream flows that are higher than those under current climate in the late spring to mid summer period (October to January). For the rest of the months of the year projections give future flows that are substantially lower than those of corresponding months under the current climate. In terms of total annual runoff, the GCMs give an overall average reduction in runoff ranging from 2 to 6% in a normal year and even higher for dry years. Such changes will translate to increased possibilities of flooding in the rainy season due to higher flows and drought-related conditions in winter due to low flows. As the projections depict an overall reduction in annual runoff, the drought conditions are expected to be more pronounced and frequent features of future climate than shall be the floods. Effects of this will likely find its way into groundwater recharges and salinity as well as dam capacities.
Institution	University of Swaziland: Department of Geography • The Department of Geography, Environmental Science and Planning strives to build capacity in human resources for the nation's development in the fields of natural resources, environmental management, urban and regional planning.
Research Topic	Managing water under climate change for peace and prosperity in Swaziland
	Water resources development in Swaziland under expected climate change
	Estimation of the Impact of Climate Change on Hydrology and Water Resources in Swaziland
	Evaluation of the Impact of Climate Change on Water Resources in Usutu River Basin, Swaziland
Researchers	Matondo, Jonathan I.; Peter, Graciana; Msibi, Kenneth M. matondo@uniswacc.uniswa.sz / Fax: 2685185276 /

United Republic of Tanzania	
NAPA	**Climate change and water challenges** • Tanzania's economic base is dependent on the use of natural resources, rain-fed agriculture and biomass for household energy. The economy is highly vulnerable to the adverse impacts of climate change and to extreme weather events. The impacts are already vivid. There has been a steady increase in temperature for the past 30 years. Due to the increasing temperatures, the adverse impacts are now felt in all sectors of the economy and are threatening human life. Severe and recurrent droughts in the past few years triggered a devastating power crisis in 2007. The extreme drop of water levels of Lake Victoria, Lake Tanganyika and Lake Jipe in recent years and the dramatic recession of 7km of Lake Rukwa in about 50 years, are associated, at least in part, with climate change, and are threatening economic and social activities. Eighty per cent of the glacier on Mount Kilimanjaro has been lost since 1912 and it is projected that the entire glacier will be gone by 2025. The intrusion of sea water into water wells along the coast of Bagamoyo town and the inundation of Maziwe Island in Pangani District, off the Indian Ocean shores, are yet another evidence of the threats of climate change.

Institution	University of Dar es Salam: Water Resources Engineering • Water Resources Engineering Management (WREM) considers the hydrological cycle in its entirety and in connection with ecosystems; including all water resources and their quality: surface water, ground water (blue water), green water and, most importantly, rainfall; paying attention to upstream-downstream relations and interactions (basin-wide, also across national borders). • Secondly, WREM considers the full range of sectoral interests and uses, including environmental interests; allocation decisions entail a process whereby all relevant objectives and constraints of society are considered, and, if necessary, priority-setting is made by weighing the objectives in an informed and transparent manner. • Water Resources Engineering Management is part of ANSTI (The African Network of Scientific and Technological Institutions). • WREM organize conferences, conducts research and training activities for member institutions within the Water Resources Engineering Management field.
Research Topic	Rainfall variability and its impact on Maize production in Malawi
	Research Protocols for Assessing the Impact of Climate Variability and Change in Rural Tanzania: Water, Food Systems, Vulnerability and Adaptation
	Climate Human Environment Interactions in Africa
	Environment and water Resources management
Researcher	Dr TA Kimaro kimaro@wrep.udsm.ac.tz Amos Majule amajule@ira.udsm.ac.tz Prof. J.O.Ngana Pius Z. Yanda, Dr. A. E, Majule, Prof. R. Mwalyosi, Dr R. Kangalawe and Dr E T Liwenga
Institution	ECEI Tanzania : Department of Natural Resource and Environment
Research Topic	Community responses to water stress in Tanzania
Researchers	Rev E.Upendo ngaoezekie@yahoo.com
Institute	Tanzania Nile Discourse Forum
Research Topic	
Researcher	Amos Majule, amajule@ira.udsm.ac.tz
Institution	ECCT
Research Topic	Community responses to water stress in Tanzania
Researcher	Rev E.Upendo ngaoezekie@yahoo.com
Institution	IUCN
Research Topic	Ice melting on mount Kilimanjalo
Researcher	Mark Smith,

Zambia	
NAPA	**Climate change and water challenges** Zambia has experienced a number of climatic hazards over several decades. The most serious have been drought, seasonal floods and flush floods, extreme temperatures and dry spells. Some of these, especially droughts and floods have increased in frequency, intensity and magnitude over the last two decades and have adversely impacted on food and water security, water quality, energy and the sustainable livelihoods of rural communities. The hydro-electric power generation has been negatively affected by the droughts and floods. Drought has had devastating effect on the hydropower generation in Zambia with significant economic reduction in the power potential. A study into the baseline period (1970-2000) established the influence of rainfall fluctuations on run-off, reservoir storage capacity and hydropower potential on the Zambezi River basin. The analysis shows that climate change/variability, indeed has effects on hydropower generation. Significant wet and dry episodes were identified in the sub basins for the baseline period of 30 years. And the response of run-off, reservoir storage capacity and hydroelectric power potential to extreme wet and dry years was ascertained. In the 1991/92 rainy season, a devastating drought crippled many sectors of the economies in the riparian states of the Zambezi basin. Amongst the sectors worst affected were agriculture and hydroelectricity power generation.
Institute	National Environment Council of Zambia (ECZ) • The Environmental Council of Zambia (ECZ) is a statutory body created under an Act of Parliament:-the Environmental Protection and Pollution Control Act of 1990, Cap 204 of the Laws of Zambia. The Council, established in 1992 is mandated to protect the environment and control pollution so as to provide for the health and welfare of persons, and the environment. • The mission of ECZ is to safeguard human health and the environment through effective environmental management to provide for present and future generations
Research Topic	State of the environment reporting in Zambia
Researcher	Edwin Chipompo, echipombo@yahoo.com

Institution	UNICEF
Research Topic	Climate change and water resources
	Malama Agnes Munkonge mmunkonge@unicef.org

Zimbabwe	
Institution	University of Zimbabwe
Research Topic	Impact of climate change on water resources in Zimbabwe. Report for the Climate Change Project, United Nations Development Programme, 58 pp.
	Global Climate Change and Implications for Water Resources Management in Zimbabwe
Researchers	Mazvimavi D; C. H. Mataira and L. Unganai
Institution	Midlands State University
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