KNOWLEDGE FOR ADAPTATION SERIES: 3

Climate Change and the Millennium Development Goals

Case studies for southern Africa

SYNTHESIS REPORT

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REGIONAL CLIMATE CHANGE PROGRAMME

The Regional Climate Change Programme Southern Africa (RCCP)

The RCCP aims to contribute to the achievement of southern Africa's climate change adaptation needs, socioeconomic development and poverty alleviation objectives, including the Millennium Development Goals.

By synthesising the relevant climate change science, developing strategic research and strengthening science-policy-governance-finance dialogue, the RCCP will build an evidence base for appropriate transboundary responses, strengthen the region's voice on international platforms and negotiations, and enhance its ability to equitably access the necessary finance for effective climate change adaptation.

The five-year Regional Climate Change Programme of work (2009–2014) with Southern African Development Community (SADC) partners on the impact of climate change, aims to increase regional participation in globally funded adaptation projects and improving resilience. The RCCP has four outputs, the first of which focuses on the scientific basis for understanding climate change impacts in southern Africa.

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Key messages

Across southern Africa (SADC), progress towards the achievement of the eight Millennium Development Goals (MDGs[1]) by the target date 2015 has been highly mixed and shown to be sensitive to global and regional shocks.

The MDGs encapsulate time-bound and quantified targets for achieving progress on underdevelopment and the human condition. Overall, SADC countries are falling short of the goals, although often good progress has been made on some goals (notably some of the health and environment targets) but not on others. Progress on some indicators has been halted or reversed by adverse climatic events, the global financial and economic crisis, volatile international food and oil prices, and the challenges in dealing with key diseases. In some instances, several years of La Niña[2]–related good rainfall lead to good progress on MDG1, only to be set back again when the El Niño phase (drought prevalence) returned. Unforeseen climate-related disasters can be highly disruptive and demand urgent diversion of substantial resources, to the detriment of ongoing development needs.

Climate is one of many influences on development and climate change is an additional burden in the achievement of the MDGs.

Future climate variability and extreme weather are expected to intensify, accompanied by shifting rainfall patterns, gradual warming and heat stress events. The more demanding climate could have significant direct impacts on many of the main drivers of development, namely provision of water, energy and health services, and food security, and indirectly on provision of education and infrastructure. Extreme poverty and hunger are associated with lack of access to resources and services; conversely, improved access to resources and services is an essential input into human and economic development. The necessary rapid increase in supply of climate-sensitive resources to support development is likely to come under threat from climate change over the next 20–30 years.

Poorer countries are less resilient to climate stressors and are likely to be at higher risk of not achieving their MDGs.

This could leave vulnerable people in less developed parts of the region dangerously exposed to the future stresses of climate change. Least developed countries (LDCs) with predominantly undiversified agriculture-based economies, characterised by rainfed agriculture within a subsistence framework, are particularly prone to climate-linked variability of production and income. This leads to heightened food insecurity, reduced household incomes, enhanced gender inequality, a reduced capacity to support children's needs and to deal with health problems, and increased wood cutting and charcoal burning for alternative income – thus creating significant stress on the achievement of the MDGs. Climate-sensitive water resources are fundamental for primary health and energy (hydropower and biomass); climate-sensitive ecosystem services are integral for food security and traditional household energy (firewood and charcoal). These complex linkages illustrate that climate change will have a multifaceted impact on the MDGs. Poorer underdeveloped regions are more exposed to these multiple impacts, rendering upliftment out of poverty more difficult.

Climate change and more frequent climate extremes will affect the achievement of all the MDGs directly or indirectly, but MDGs 1, 6 and 7 are likely to be worst affected.

MDG1: Climate change is likely to place increasing strain on agricultural growth thus rendering poverty and hunger reduction targets elusive as population numbers rise. When crop and livestock production fail because of drought, floods, pests or diseases, both poverty and hunger take hold. MDG6: Increases in disease pressure arising from warming, climate extremes and disasters, and linked to malnutrition, could severely impact on under-resourced health systems. MDG7: Environmental sustainability and services to communities will become increasingly more difficult to achieve if water resources become constraining. Degradation and loss of ecosystem regulating services increase vulnerability to storms, floods and droughts; damages to water and sanitation infrastructure could severely set back progress on MDG7.

Vulnerability is not evenly distributed across the region, or across a country.

Some climate impacts will be common to the whole region, whereas others will differ between and within countries, depending on national circumstances and specific biophysical and socioeconomic contexts. The semi-arid subtropics, coastal areas, regions of rapid population growth and regions experiencing conflict are more vulnerable. A key response by every country will be to sustainably capitalise on potential benefits in more resilient areas to generate employment, growth and income, whilst providing safety nets

in more vulnerable areas. Continued rapid urbanisation will occur throughout the region, demanding greater focused attention to the provision of livelihoods and essential services in towns and cities. The development of supportive infrastructure and spatially and cross-sectorally integrated strategies and polices, will in all cases be crucial.

The implications of climate change for the MDGs should be analysed within the context of the global macroeconomic situation.

By 2009 the economic crisis had resulted in an additional 35 million people falling into extreme poverty globally, and the number of chronically malnourished reached one billion. Progress toward MDG1 was almost completely reversed in 2008 as a result of rising food prices. GDP growth in southern Africa was dealt a heavy blow, with direct impacts on infant mortality, for example. Strong leadership, governance and prudent fiscal management are required to allow for tighter control over exogenous economic shocks, within a strong policy framework to guide national development and investment priorities. Long-term commitments by national treasuries and the regional private sector would reduce sensitivity to global shocks, stabilise the post-2015 MDG trajectories and build resilience against additional stressors such as climate change.

Improved regional and international cooperation are required to support national efforts towards the MDGs.

The country-based MDG approach needs to be reassessed in the context of regional inter-dependencies and longer term targets. Water, energy, food security, health and economic development are increasingly becoming regional priorities frequently associated with shared natural resource supplies, migratory patterns, and developing regional and global markets and trade. The threat of climate change thus provides a strong imperative for improved cooperation, alignment of policies and priorities, better market integration, and exchange of learning between nations. Additional finance for sustainable development and continued progress on the goals post-2015 should be leveraged to deal with the added pressure of climate change, whilst striving to create synergies between international funding streams.

[1] MDGs:
MDG1: Eradicate extreme poverty and hunger
MDG2: Achieve universal primary education
MDG3: Promote gender equality and empower women
MDG4: Reduce child mortality
MDG5: Improve maternal health
MDG6: Combat major diseases
MDG7: Ensure environmental sustainability
MDG8: Develop a global partnership for development

[2] Both El Niño and La Niña conditions are part of the global phenomenon called ENSO (El Niño Southern Oscillation) and bring dry and wet phases to large parts of southern Africa, respectively.

Economic and human development is central to the MDGs.
A villager dehusks rice in the Zomba district of Malawi.

1. Background and objectives

This report investigates the relationships between the Millennium Development Goals (MDGs) and projected climate change in southern Africa. The analysis rests on four core themes, namely water resources, food security, health and energy supply, representing those sectors which drive national and regional economies, have significant linkages with human development, and which are sensitive to climate risks. The importance and vulnerability of ecosystem services (including forestry) was acknowledged and addressed in a cross-cutting manner, as was the importance of gender issues (the various differential roles and needs of men and women). This report is a synthesis of the full technical report (Chapman *et al.* 2010) and provides an overall summary and discussion of the potential impact of climate change on the achievement of the MDGs in southern Africa.

Economic and human development is central to the global effort to reduce chronic poverty and vulnerability of the poor. In response to this challenge, in 2000 the United Nations created the MDGs to direct and monitor development efforts across the globe for the period 2000–2015. The primary aim is to make significant progress on underdevelopment and the human condition. The 15 member states of the Southern African Development Community (SADC) are committed to achieving the MDG targets set for individual member states. The achievement of the goals is particularly critical for the seven least developed countries (LDCs) within the SADC. These countries are characterised by widespread poverty and human vulnerability, as well as weak financial and human capacity to drive development.

The development of southern Africa is inextricably linked to the region's varied and unique climatic circumstances, embedded within fragile social, economic and governance contexts. All countries already experience significant exposure to climatic variability and recurring extreme events such as droughts and floods, which come at a significant human and economic cost. The many agriculture-based economies, which are strongly dependent on rainfall, are particularly prone to climate-linked variability of production and income. Decreased on-farm productivity has widespread negative social and ecological impacts. Rainfall and water resource availability vary widely spatially and temporally, and even regions with ample water resources suffer from lack of suitable access, and importantly, distribution of water for human and productive purposes.

In the subtropical and tropical parts of the region, characterised by high temperatures and relative humidity for much of the year, the burden of disease (notably malaria) is significant, and weak health systems are poorly equipped to cope. In addition, access to energy services, one of the essential determinants of economic and human development, is very poorly developed, particularly outside the urban centres. High dependency on hydropower renders even this basic input sensitive to climatic vagaries via fluctuating river flow levels. Although this study focused on these four sectors (agriculture, water, health and energy), significant impacts will also be felt in the coastal zones and the forestry and tourism sectors, to name but a few of the other sectors fundamentally dependent on ecosystem services.

In recent decades, anthropogenically induced climate change has emerged as a significant threat to societies and ecosystems globally, but especially in the poorer countries. These countries have far less resilience to climate-induced disasters and long-term climatic shifts owing to their lack of financial and educational resources, and poor infrastructure and governance systems. A more demanding climate combined with continuing extreme poverty, hunger, a heavy disease burden and growing environmental degradation in the region (if the MDGs are not achieved), will leave people dangerously exposed to the future stresses of climate change. The potential scale of climate change means it could severely affect national and regional developmental goals.

Building the adaptive capacity and resilience of southern African communities and countries to climate change is a fundamental task of the region, but one which also requires additional international assistance. Addressing poverty and existing developmental inequalities in the region in a systematic and cross-cutting manner represents an essential early step in tackling the impacts of climate change. This required the identification of the most vulnerable groups and how they will be specifically challenged.

In this report, the analysis of the interrelationships between the MDGs and the four core sectors is complemented by an identification of the climatic sensitivities of the drivers of these sectors, to provide a framework for the analysis of climate change impacts on the MDGs. The study forms part of the larger five-year Regional Climate Change Programme (RCCP), a SADC-wide initiative which aims to "enable transboundary adaptation to climate change, with equitable access to funding in southern Africa". Building an evidence base in the region that is informed by local science and knowledge is a central output of the RCCP, to influence and inform both regional adaptation strategies and the international negotiations on climate change. The

linkages between the science of climate change impacts and vulnerability, and the achievement of development goals, have not been well studied in southern Africa.

For the analysis, climate change projections for southern Africa were obtained from the Intergovernmental Panel on Climate Change (IPCC) and from the Climate Systems Analysis Group, University of Cape Town. The projections were combined with an assessment of institutional strengths and weaknesses across the region. This led to the development of the RCCP subregional map of southern Africa, which played an important role in informing the study.

1.1 Southern Africa subregional vulnerability

The RCCP developed a subregional map of southern Africa (Figure 1) to help identify key challenges facing the region in responding to climatic variability and climate change (OneWorld Sustainable Investments, 2008). Six characteristic subregions were identified, based on climatic (including projected future climate), biophysical, socioeconomic and institutional similarities. The subregional map provides a clear picture of the vulnerabilities to climate change, not only for the countries studied for this MDG report, but for all countries within each subregion.

In the south-west, subregion 1 covers the more arid parts of South Africa, Botswana and Namibia where mean annual rainfall is less than 400 mm. These three countries are the most developed of the continental SADC region. Water is scarce and much of the water for this region comes from inter-basin transfers from other regions and groundwater, with limited opportunities for agriculture. It is more sparsely populated than the other subregions in southern Africa, and has stronger institutional capacity, well developed commercial agriculture and reasonable capacity to respond to climatic challenges. The area is generally malaria-free year round. The expected climatic changes in this region are moderate warming and significant reduction of rainfall in winter (the dominant rainfall season). Sea level rise is expected for the extensive coastline of this region.

Subregion 2a lies broadly within the summer rainfall region receiving about 400–1000 mm per annum. Similar to subregion 1, it has stronger institutional and adaptive capacity than the rest of southern Africa. Rainfed subsistence agriculture dominates, although large areas of commercial and irrigated agriculture exist. Most of the SADC region's farm dams occur in this zone. There is a heavy dependence on groundwater. Population densities are the highest in the SADC region apart from the Rift Valley. A minimal seasonal malaria risk exists on the northern periphery of this zone.

Subregion 2b is climatically similar to subregion 2a, but with more limited institutional and economic capacity. Transport infrastructure and electrical energy services are considerably less developed or functional than in subregion 2a. A much stronger risk of seasonal or endemic malaria exists. There is a high level of rainfed subsistence agriculture. This subregion (together with the northern parts of subregion 2a) is exposed to high levels

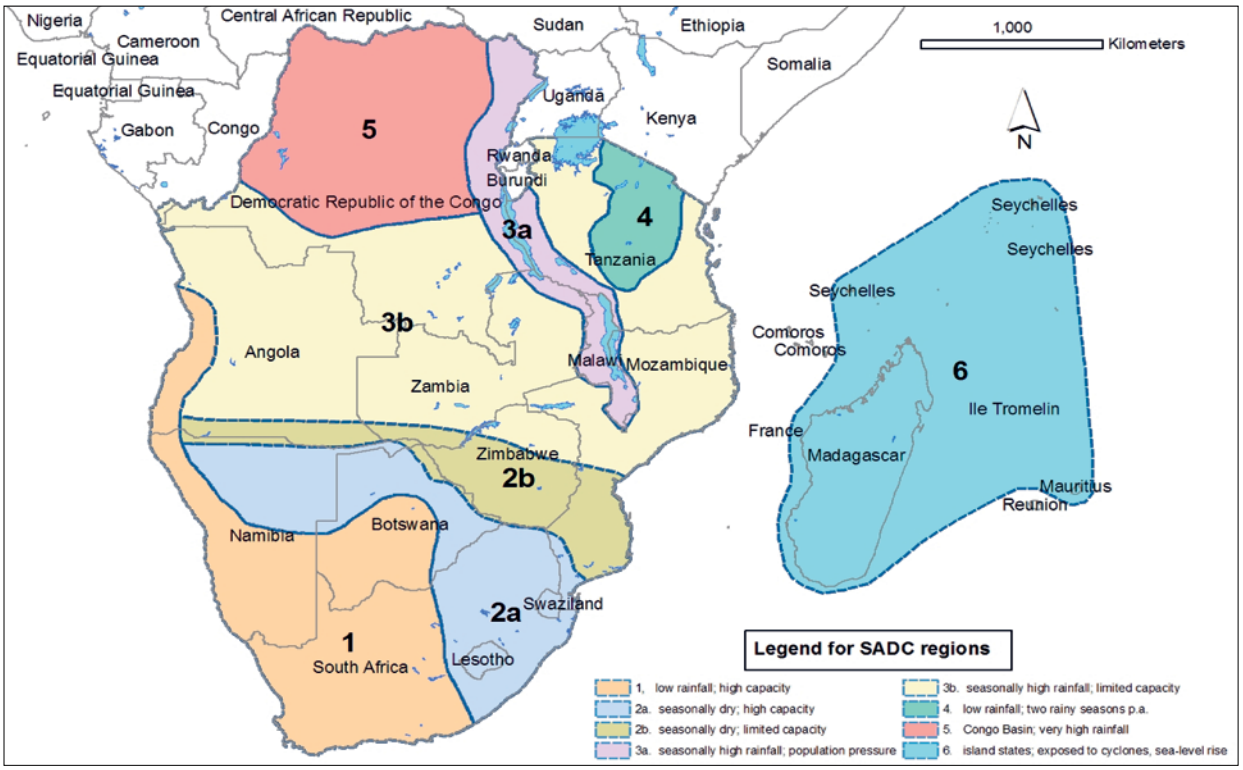
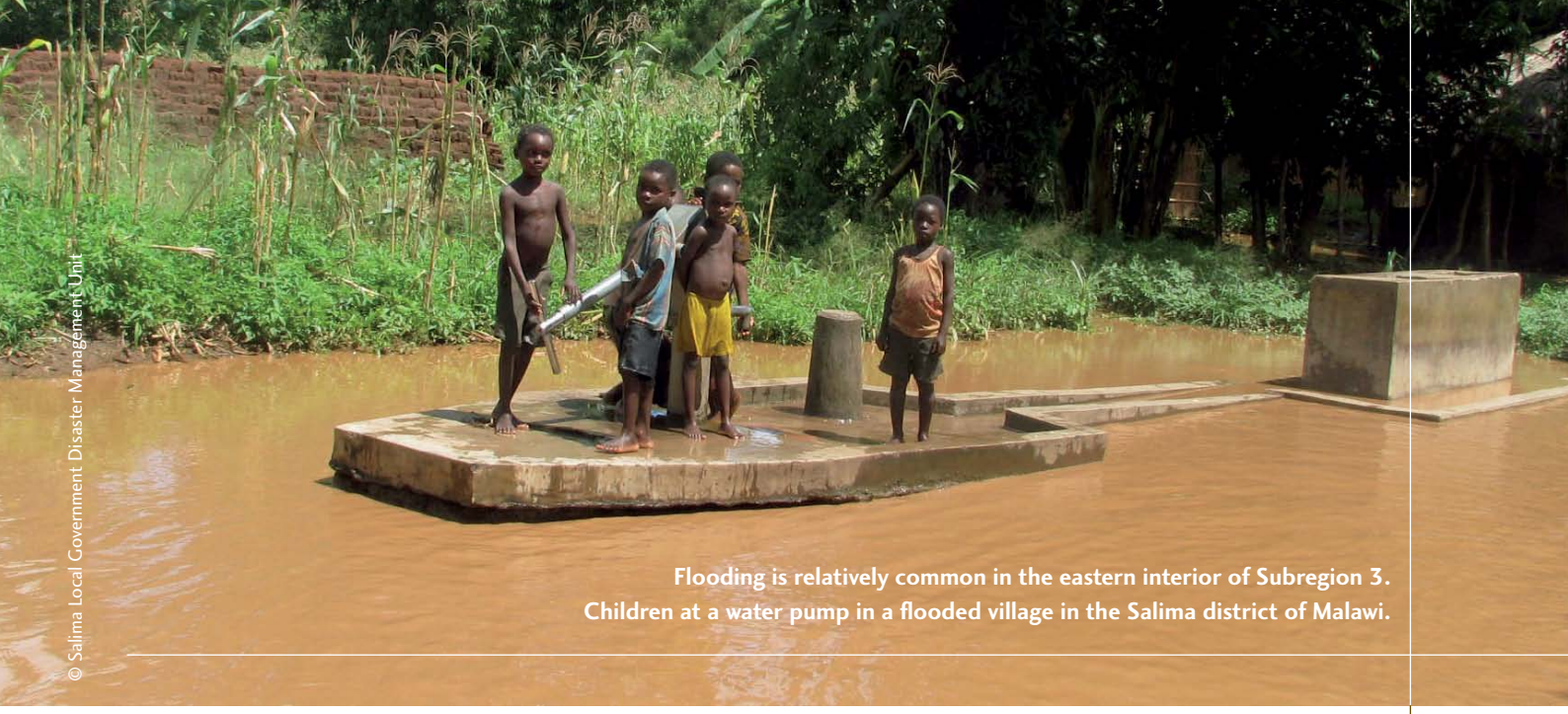


Figure 1: RCCP subregional map of southern Africa, showing regions of similar climatic (including projected climate change), biophysical, socioeconomic and institutional characteristics.



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Flooding is relatively common in the eastern interior of Subregion 3. Children at a water pump in a flooded village in the Salima district of Malawi.

of climatic variability (inter- and intra-annual variability of rainfall and periodic droughts). The eastern coastline of subregion 2b is vulnerable to cyclone activity and flooding is relatively common in the eastern interior.

The climatic changes (both types) for subregion 2 are expected to be moderate to strong (in the interior regions) temperature increases combined with winter drying. Mean annual rainfall is not projected to change much, but shifting onset of the rains and marked variability in the early rainy season is anticipated. Summer rainfall may increase. The proportion of total rainfall falling in heavy events may increase during summer and autumn. Intra-seasonal dry spell duration is likely to become longer. The challenge for this region is that a *small decrease in rainfall can lead to large decreases in available runoff*. Loss of surface water to evaporation and transpiration will have a significant impact. This means that populations dependent on subsistence and rainfed agriculture could be highly vulnerable. Along the coast, cyclone activity is anticipated to increase in intensity and severity, although not necessarily in frequency, and sea level will rise.

Subregion 3 has a mean annual rainfall greater than 1 000 mm, and has limited institutional and economic capacity. Rainfed subsistence agriculture is the primary land use activity, sustaining about 60–80% of the population. Malaria is endemic across the zone. This subregion can be divided further into two components.: While most of the region is moderately sparsely populated (subregion 3b), subregion 3a in the Rift valley has the highest population densities within the SADC and is mostly hotter and drier, with the exception of the northern areas. The south-eastern coastline of subregion 3 is vulnerable to cyclone activity and flooding is relatively common in the eastern interior. The climatic changes that will impact this region will be moderate to strong (interior regions) temperature increases, decreases in winter rainfall and moderate increases in summer rainfall mainly towards the end of the rainy season (similar to subregion 2). Because rainfall is higher, the consequences of reduced runoff and increased evapotranspiration on water availability are not as serious as in subregion 2.

Subregion 4 covers the plateau region of central Tanzania and has a semi-arid climate (<800 mm rainfall per annum), with unimodal rainfall (one rainfall season). Malaria is endemic across the subregion. Higher lying areas in the mountain ranges bordering the plateau to the north (Kilimanjaro) tend to be more highly populated because of the richer volcanic soils and higher, more reliable rainfall. The rest of the region supports pastoralists (some of them nomadic) and rainfed agriculture. This region is projected to experience strong warming. The model projections are fairly consistent in projecting increases in annual rainfall in the bimodal rainfall regions of the north-east, south-east and the Lake Victoria basin during both wet seasons, whereas the central unimodal rainfall regions could experience drying.

Subregion 5 includes much of the Democratic Republic of Congo (DRC) and the Congo Basin, which has high rainfall (>1 500 mm) distributed throughout the year, but low institutional and economic capacity. Malaria is endemic across the subregion and pressure from other diseases is also high. There is ample water but temperature and humidity are very high. The future climate is projected to be even warmer with increased rainfall.

Subregion 6 includes the Indian Ocean island states of Madagascar, Seychelles and Mauritius. They are particularly exposed to cyclones and storm surges. The most important manifestations of climate change for these islands will be sea level rise and more serious associated storm surges, saline intrusion of freshwater coastal aquifers and an anticipated increase in intensity and severity of cyclones, although not necessarily in frequency. While Seychelles and Mauritius are relatively well developed and have reasonable to high institutional and economic capacity, Madagascar is weak in this regard.

1.2 The 1st to 4th order framework

A second framework for the analysis was provided by the 1st to 4th order conceptual approach developed by the RCCP. the framework makes the linkages between basic climate parameters (1st order), the resulting physical and chemical processes in the physical and biotic environment (2nd order), the resulting ecosystem services and production potential (3rd order), and finally the resultant

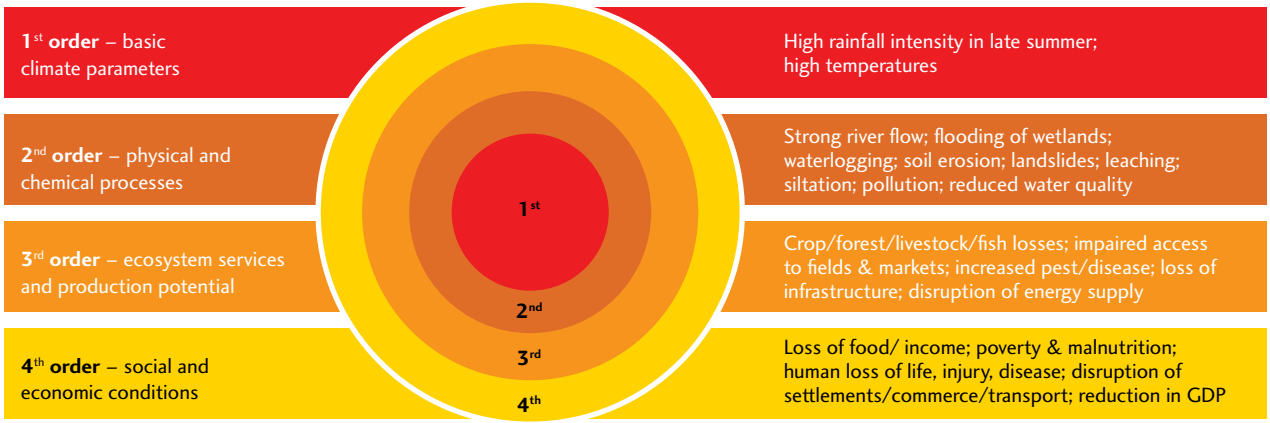


Figure 2: Example of 1st to 4th order climate impacts and vulnerability: Flooding in the Rift Valley of Malawi.

social and economic conditions (4th order) which arise. Feedbacks exist between all four orders.

The phenomenon and impacts of climate change are wide-ranging and highly complex. It is common practice in climate change assessments to take a sectoral approach, but this invariably leads to lack of cross-sectoral integration, which is critical when assessing economic and social system responses. In this study, even though the focus remains on the four core sectors, the overall approach to analysing climate impacts is more hierarchical, starting with the basic climate parameters, and gradually scaling up to organism and system levels. The levels are defined as shown in Figure 2.

1.3 Case studies

Four case studies (Zambia, Tanzania, Malawi and Mozambique) were used as a focus for further analysis, including an assessment of how their progress towards the achievement of the MDGs may be affected by current and future climate risk. The four countries selected for this analysis are all considered Least developed countries (LDCs) by the United Nations (UN) and possess limited capacity to make the required progress on reaching their MDG targets by 2015. In recognition of the fact that many other countries in the region are faced with similar challenges, and all are vulnerable to the impacts of climate change, we use these four countries only to illustrate the interlinkages which are relevant to all the countries. We also recognise that good progress and setbacks are encountered in every country's efforts to achieve the MDGs, and thus emphasise that the analysis is in no way intended to criticise any particular country. Our final discussion thus steps away from individual countries and towards integrated conclusions for the region as a whole.

Within the framework of the subregions described in Section 1.1 (Figure 1), the four countries represent a range of biophysical and socioeconomic conditions, but all suffer from limited institutional and economic capacity.

Malawi:	subregion 3a
Mozambique:	subregion 2b (south); and subregion 3b (north)
Tanzania:	subregion 3b (west/east); and subregion 4 (central plateau)
Zambia:	subregion 2b (south); and subregion 3b (north and north-east)

The following steps were taken for each country:

1. National circumstances were summarised with a particular focus on water, agriculture and food security, health and energy, to provide the local context.

2. Progress towards the achievement of the MDG targets by 2015 is provided as reported for the year 2008 (or the most recent data prior to 2008). Sources of data included the UN Statistics Division (UNSD) MDG indicator website (UNSD, 2008) and the World Bank MDG indicator website (World Bank, 2009). We also used the national MDG progress reports (Government of Malawi, 2008; Republic of Mozambique, 2008; Republic of Zambia, 2008; United Republic of Tanzania, 2006). For data on climate-related disasters, the EM-DAT database was used (EM-DAT, 2009). MDG8 was not included in this assessment due to the widespread absence of data.

3. The current climate, climatic variability and other climate risks, and their influences on development via the water, food security, health and energy sectors (climate trends) were researched and synthesised. Potential linkages were made to current progress towards the achievement of the MDGs.

4. The ways in which climate change could impact on further progress towards the MDGs was assessed, modeled on the RCCP 1st – 4th order framework.

In this synthesis report, only Step 4 (final 4th order assessment of climate change impacts on the MDGs) is presented. The full results of the case studies are available in Chapman *et al.* (2010).

The lessons learnt are interpreted for the broader SADC region, with the report concluding on the way forward in the region in terms of seizing opportunities for climate adaptation, thus strengthening the achievement of the MDGs.

2. What are the MDGs?

At the United Nations (UN) Millennium Summit in September 2000, 189 nations adopted the Millennium Declaration, which set eight Millennium Development Goals (MDGs), with subsidiary targets, to help the world attain a sustainable human development growth path. Progress towards the achievement of the MDGs is monitored and reported by member states every few years, and by the UN on an annual basis. At the 2005 World Summit, there was further agreement by the member states on the inclusion of an additional four new targets, which were implemented in January 2008. The eight MDGs set out a suite of universally accepted developmental rights, underpinned by human values and aspirations (Table 1). They encapsulate time-bound and quantified benchmarks for halving extreme poverty and comprise 8 goals, 21 targets and 60 indicators. The implementation period is 2000–2015.

Table 1: The UN Millennium Development Goals (MDGs) and subsidiary targets, as of 15 January 2008 (Source: www.un.org/millenniumgoals/index.shtml)

Millennium Development Goals and Targets
Goal 1: Eradicate extreme poverty and hunger Target 1A: Halve, between 1990 and 2015, the proportion of people whose income is less than $1 a day Target 1B: Achieve full and productive employment and decent work for all, including women and young people Target 1C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger
Goal 2: Achieve universal primary education Target 2A: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling
Goal 3: Promote gender equality and empower women Target 3A: Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015
Goal 4: Reduce child mortality Target 4A: Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate
Goal 5: Improve maternal health Target 5A: Reduce by three-quarters, between 1990 and 2015, the maternal mortality ratio Target 5B: Achieve, by 2015, universal access to reproductive health
Goal 6: Combat major diseases Target 6A: Have halted, by 2015, and begun to reverse the spread of HIV/AIDS Target 6B: Achieve, by 2010, universal access to treatment for HIV/AIDS for all those who need it Target 6C: Have halted, by 2015, and begun to reverse the incidence of malaria and other major diseases
Goal 7: Ensure environmental sustainability Target 7A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources Target 7B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss Target 7C: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation Target 7D: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers
Goal 8: Develop a global partnership for development Target 8A: Develop further an open, rule-based, predictable, nondiscriminatory trading and financial system Target 8B: Address the special needs of the least developed countries Target 8C: Address the special needs of landlocked developing countries and small island developing states (through the Programme of Action for the Sustainable Development of Small Island Developing States and the outcome of the twenty-second special session of the General Assembly) Target 8D: Deal comprehensively with the debt problems of developing countries through national and international measures to make debt sustainable in the long term Target 8E: In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries Target 8F: In cooperation with the private sector, make available the benefits of new technologies, especially information and communications

2.1 Progress towards achieving the MDGs

Progress towards achieving the MDGs has been mixed, with countries making differential progress overall, with many countries making good progress on some goals but not on others (United Nations and World Bank online databases). In many cases conditions have worsened for some indicators, especially in lieu of the financial and economic crisis of 2008 (UN, 2009). As part of the MDG progress review in 2010, the UN statistics department has released data on the achievement of the eight goals across the different regions, including Sub-Saharan Africa (SSA). In line with the timeline of the MDGs, the statistics use the 21 measurable and time-bound targets and the 60 indicators, most of which are based on a 1990 baseline. Table 2 illustrates the results of this analysis. The text within the boxes refers to information on a specific indicator (for example, 'low' under the reduced extreme poverty by half indicator, refers to the state of poverty in the region currently, and when referring to health care, 'moderate' indicates current access.

Table 2: Progress of the MDGS in 2010 (adapted from Statistics Division, Department of Economic & Social Affairs, United Nations, 2010) – The information in each box indicates the present degree of compliance with the target, whilst the coded colours show progress towards the target.

KEY:	Missing/insufficient data	No progress/ deterioration	Progress insufficient for target	Progress sufficient for target	Already met/very close to target

GOALS & TARGETS	AFRICA		ASIA				OCEANIA	COMMONWEALTH OF INDEPENDENT STATES	
	Northern	Sub-Saharan	Eastern	South-eastern	Southern	Western		Europe	Asia
Eradicate extreme poverty and hunger									
Reduce extreme poverty by half	Low poverty	Very high poverty	High poverty	High poverty	Very high poverty	Low poverty		Low poverty	High poverty
Productive & decent employment	Very large deficit in decent work	Very large deficit in decent work	Large deficit in decent work	Very large deficit in decent work	Very large deficit in decent work	Very large deficit in decent work	Very large deficit in decent work	Small deficit in decent work	Large deficit in decent work
Reduce hunger by half	Low hunger	Very high hunger	Moderate hunger	Moderate hunger	High hunger	Moderate hunger		Low hunger	Moderate hunger
Achieve universal primary education									
Universal primary schooling	High enrolment	Moderate enrolment	High enrolment	High enrolment	Moderate enrolment	Moderate enrolment		High enrolment	High enrolment
Promote gender equality and empower women									
Equal girls' enrolment in primary schools	Close to parity	Close to parity	Parity	Parity	Parity	Close to parity	Close to parity	Parity	Parity
Women's share of paid employment	Low share	Medium share	High share	Medium share	Low share	Low share	Medium share	High share	High share
Women's representation in parliament	Very low represen-tation	Low represen-tation	Moderate represen-tation	Moderate represen-tation	Low represen-tation	Very low represen-tation	Very low represen-tation	Low represen-tation	Low represen-tation

GOALS & TARGETS	AFRICA		ASIA				OCEANIA	COMMONWEALTH OF INDEPENDENT STATES	
	Northern	Sub-Saharan	Eastern	South-eastern	Southern	Western		Europe	Asia
Reduce child mortality									
Reduce mortality of under 5s by ¾	Low mortality	Very high mortality	Low mortality	Moderate mortality	High mortality	Low mortality	Moderate mortality	Low mortality	Moderate mortality
Improve maternal health									
Reduce maternal mortality by ¾	Moderate mortality	Very high mortality	Low mortality	High mortality	High mortality	Moderate mortality	High mortality	Low mortality	Low mortality
Access to reproductive health	Moderate access	Low access	High access	Moderate access	Moderate access	Moderate access	Low access	High access	Moderate access
Combat HIV/AIDS, malaria and other diseases									
Halt & reverse HIV/AIDS	Low incidence	High incidence	Low incidence	Low incidence	Low incidence	Low incidence	Moderate incidence	Moderate incidence	Low incidence
Halt & reverse TB	Low mortality	High mortality	Moderate mortality	High mortality	Moderate mortality	Low mortality	Moderate mortality	Moderate mortality	Moderate mortality
Ensure environmental sustainability									
Reverse loss of forests	Low forest cover	Medium forest cover	Medium forest cover	High forest cover	Medium forest cover	Low forest cover	High forest cover	High forest cover	Low forest cover
½ proportion without improved drinking water	High coverage	Low coverage	Moderate coverage	Moderate coverage	Moderate coverage	High coverage	Low coverage	High coverage	Moderate coverage
½ proportion without sanitation	Moderate coverage	Very low coverage	Low coverage	Low coverage	Very Low coverage	Moderate coverage	Low coverage	Moderate coverage	High coverage
Improved livelihoods of slum dwellers	Moderate proportion of slum dwellers	Very High proportion of slum dwellers	Moderate proportion of slum dwellers	High proportion of slum dwellers	High proportion of slum dwellers	Moderate proportion of slum dwellers	Moderate proportion of slum dwellers		
Develop a global partnership for development									
Internet users	High usage	Low usage	High usage	Moderate usage	Low usage	High usage	Low usage	High usage	Moderate usage

The welfare and development of children is an essential target of the MDGs. Southern African progress towards universal primary education has been moderate.

The assessments shown in the charts are based on performance and help illustrate that countries in SSA are falling short of the goals set (UNECA, 2008; UN, 2008). In many cases there is a lack of data to monitor progress. The key shortfalls in SSA cluster around MDG1 (poverty, unemployment and hunger), MDG4 (child mortality) and MDG5 (maternal mortality, which is particularly slow to improve). HIV/AIDS and tuberculosis (TB) (MDG6) remain serious debilitating health issues, with the latter showing little signof improvement. Progress on MDG7 (sanitation, safe water, conditions in slums) has been too slow, albeit off a very low base. On the positive side, most countries in SSA are making good progress on access by girls to primary school education.

Present trends indicate that the health-related goals are the least likely to be met in SSA, despite the availability of powerful drugs, vaccines and other tools to support their achievement. In many cases current levels of commitment fall short of being able to achieve the targets. Significant targeted and system-wide investments across SSA are needed to improve the likelihood of attainment of targets and goals, and importantly the systemic implementation of sustainable solutions. Weaknesses in infrastructure and governance need to be overcome for more effective outcomes of programmes and investments.

3. Projected climate changes in southern Africa

Climate change projections for southern Africa were obtained from the Intergovernmental Panel on Climate Change (IPCC) (Christensen *et al.*, 2007) for the period 2080–2099, relative to 1980–1999. Additionally, medium-term regionally downscaled climate change projections for SADC were developed by Prof Bruce Hewitson and his colleagues at the Climate Systems Analysis Group, University of Cape Town (Hewitson, 2007). Projected climate change data from 11 Global Circulation Model (GCM) simulations were used, together with the Special Report on Emissions Scenario (SRES) A2 scenario for greenhouse gas emissions in the 21st century. The model data are from the PCMDI data archive of simulation output as used in the IPCC Fourth Assessment Report (AR4) of 2007. The projections are for the period 2046–2065 relative to current climate.

Since the levels of model uncertainty over rainfall projections for the summer rainfall areas remain high, focus was instead placed on broad trends and agreement between different climate model projections, thus avoiding quantitative or time-specific projections.

3.1 Atmospheric CO_2 concentration

An important and certain component of climate change, with respect to its potential effects of primary productivity, is the rising concentration of atmospheric CO_2. Generally, biomass productivity increases as CO_2 concentration in the atmosphere rises. On average, crop yields (of C_3 species, such as rice) increase by 10–20% when CO_2 concentration increases to 550ppm, compared to current concentrations (Easterling *et al.*, 2007). The response is slightly lower in C_4 species (such as maize), averaging increases of 0–10%. Above-ground biomass of trees increases by between 0% (mature natural forests) and 30% (young trees) at 550ppm CO_2.

Species which have a strong carbon demand (sink), such as young trees and plants with large underground storage organs, tend to exhibit a stronger and sustained CO_2 response. This has already contributed to the bush encroachment encountered globally across most grasslands and savannas (Bond *et al.*, 2003), with potentially negative consequences for grazing potential, either directly, or indirectly via increasing frequency of fire, as well as reduced water runoff and groundwater recharge. Equally, invasive species could become more dominant, with resulting pressure on biodiversity and native palatable plant species. However, forest growth will be stimulated in many cases.

3.2 Current and future temperature patterns

Global warming is as evident in Africa as in other parts of the globe (Boko *et al.*, 2007). Mean annual temperatures have increased across southern Africa over the last 40–50 years, and the number of hot days per year has increased whereas the number of cold nights per year has decreased (Boko *et al.*, 2007).

Regional climate change projections for southern Africa (Christensen *et al.*, 2007) for 2080–2099 relative to 1980–1999, indicate that during summer warming will be in the range 1.8˚–4.7˚C (depending on the SRES used) with a median projection of 3.1˚C. For winter, warming will be 1.9˚–4.8˚C, with a median of 3.4˚C. There will be a continuing trend of more hot days and nights, and fewer cold days and nights.

Projections of regional climate change (temperature) using empirical downscaling techniques show broad convergence with the GCMs (Hewitson and Crane, 2006), but also identify local scale variation in the projected changes. Mean temperatures are expected to increase by an average of 2˚C and possibly 3–4˚C by around 2065, but warming could be higher during late winter and early spring (Hewitson, 2007). Strong warming before the start of the planting season would significantly reduce soil moisture during this period. The landlocked inland countries (e.g. Botswana, Zambia, Malawi) show the strongest warming, whereas the coastal countries show slightly less warming. A well understood consequence of warming is an increasing rate of evapotranspiration. This has consequences for soil moisture loss and loss of water from surface bodies such as reservoirs and wetlands. Other impacts of warming include loss of crop suitability and biodiversity, and increased frequency and intensity of wildfires.

3.3 Current and future rainfall patterns

The climate of the south-central to eastern regions of southern Africa is characterised by high inter-annual, inter-decadal and multi-decadal variability, particularly with respect to rainfall. Rainfall is strongly influenced and variability increased by individual or combined shifts in the Inter-tropical Convergence Zone (ITCZ), Pacific Ocean sea surface temperature (SST) anomalies (El Niño Southern Oscillation – ENSO), Indian Ocean SST anomalies (the Indian Ocean Dipole – IOD), and land surface-climate coupling processes (Tadross *et al.*, 2005). The relative importance of, and complex interactions between the different processes are still poorly understood, and this presents a real challenge to improving certainty in modeled current and future rainfall across the region.

The increasing duration of dry spells will impact negatively on crops and livestock.
A heard of goats in the Kongwe district, Dodoma region of central Tanzania.

The southern African region is prone to climatic extremes of prolonged droughts, dry spells, heavy rainfall, severe floods and flash floods. Severe recurrent droughts have impacted negatively on human and economic development. Flooding is prevalent in low-lying areas (e.g. wetlands), along river courses and on broad floodplains. Globally, very large, long-return floods have increased in frequency, particularly towards the latter half of the 20th century (Milly *et al.*, 2002). In southern Africa floods devastate crop and livestock production and thus escalate food insecurity, hunger and malnutrition. Floods also exacerbate water and energy insecurity, soil losses and degradation, and exacerbate pressure on forest and woodland resources and ecosystem services. As a result, health deteriorates, livelihoods of large portions of the population are compromised and socioeconomic disruption occurs. Physical damage to infrastructure during storms and floods, particularly roads and bridges, imposes a heavy cost on local and national treasuries.

Varying changes in rainfall over the region are predicted over the long-term (Christensen *et al.*, 2007). The projections show reduced rainfall for much of the region in winter (May–July). While this is less significant for the summer rainfall regions, it is highly significant for the winter rainfall south-western corner and western margins of the region (subregion 1, Figure 1). Drying trends are also indicated in the south-west of the region in summer (November–April).

Modeled projections indicate increased annual rainfall in the tropical north-east portion of our study region. Small shifts in the tropical rain belts (the ITCZ in particular) will result in large changes in local rainfall. The IPCC (Christensen *et al.*, 2007) states that annual rainfall derived from the ITCZ will increase as the atmosphere warms and the amount of water vapour that is transported laterally increases, giving rise to general wetting. Dry periods are expected to become longer, but a general wetting in the tropics may be expected. However, there is still considerable uncertainty over annual rainfall changes in the summer rainfall regions.

Seasonal shifts in rainfall can be expected. In regions receiving most of their rainfall in summer, the arrival of the first summer rains is likely to become more unpredictable and occur later than at present, but rainfall amount and intensity could be higher in mid- to late-summer. This disrupts traditional cropping cycles and access to fields during harvest periods, contributing to yield reductions or total losses and thus food insecurity. These trends are already apparent; monthly rainfall records in many parts of the region show recent increases in the wet months of December to March, but this is often offset by a drying in September and October, which are regarded as months when the rainy season starts. While SSTs are thought to dominate the processes relating to rainfall occurrence, land surface conditions are increasingly recognised as being important (Christensen *et al.*, 2007). Land surface feedbacks are thought to be important in partly determining intra-seasonal variability and rainy season onset in southern Africa (Tadross *et al.*, 2005). Further work needs to be done to understand the relative importance of the different processes.

3.4 Climate variability and extreme events

It could be argued that extremes in climate and high variability are the key climate drivers that affect livelihoods and development, including the MDGs. Research on recent historical changes in climate extremes is limited, but available research for the southern African region shows that there may be an increase in the intensity of high-rainfall events (Tadross *et al.*, 2005; Christensen *et al.*, 2007) and that heavy rainfalls make up an increasing proportion of total rainfall (McSweeney *et al.*, 2008). The frequencies of extremely wet summers and of extremely dry winters and springs have increased (Christensen *et al.*, 2007). In regions of mean drying there is generally a proportionally larger decrease in the number of rainy days, indicating compensation between intensity and frequency of rain.

There will likely be an increase in frequency and severity of droughts, floods and storms. Regardless of annual rainfall trends, the duration of dry periods is expected to increase, even during seasons with adequate total rainfall. The drier areas of the region (e.g. south-western Zambia and southern Mozambique) have been identified as highly vulnerable to future climate change, owing to the expected shortening of the growth period and impacts of dry spells on crops and livestock. The wetter areas of the region (e.g. northern-eastern Zambia and Malawi) are likely to experience increasingly heavy rainfall and accompanying storm winds, and a higher risk of flooding in late summer. Projections indicate that heavy rainfalls will continue to make up an increasing proportion of total rainfall (McSweeney *et al.*, 2008).

As for rainfall, the frequency and intensity of extreme temperature events is expected to increase during the course of the 21st century. The higher frequency of hot days and warm nights will increase heat stress and risk of water deficit for all living organisms.

These changes are expected to be experienced as individual anomalous events interspersed with 'normal' years rather than sudden permanent changes. Thus, an 'increase in variability' means that the range of weather conditions experienced on an inter-annual basis would be larger, thus exposing regions to a less predictable and more variable rainfall season.

4. Relationships between water supply, food security, health and energy, and development (MDGs)

The main drivers of development in southern Africa include water services, energy services, health services, and agriculture and food security (with ecosystem services as a cross-cutting factor) – and their status has a strong impact on progress toward the MDGs. They also possess important linkages to other drivers of development such as education and infrastructure. Extreme poverty and hunger are strongly associated with lack of access to these resources, and conversely, improved access to these resources is an essential input into human and economic development.

This chapter aims to clarify the relationships between water, food security, health and energy and the MDG targets. These relationships are typically either direct, or indirect via intermediate factors (Table 3).

We illustrate the close overlaps between water, food security, health and energy. The importance of agriculture in its links to many of the goals is clear; the strong dependence on high risk rainfed agriculture creates significant stress on the achievement of many MDGS, and as such there are multiple direct impacts. Similarly, water resources are fundamental for the health and energy sectors and the related MDGs. Underlying indirect linkages are also important to consider in the region. For example, under MDG7 (environmental sustainability), key ecosystem services are integral for food security and human health, and also provide the raw energy source for millions of people in the form of biomass provisioning. These complex linkages between the four sectors illustrate that climate change will have a multifaceted impact on the MDGs, in most cases likely to have direct detrimental impacts on the achievement of the goals. Nevertheless, in other areas emerging opportunities (such as those provided by increasing rainfall) could provide renewed impetus towards achieving the MDGs, or if that is not possible within the current MDG set time frames, accelerate progress for the longer term.

Table 3: Direct and indirect linkages between water supply and quality, food security, health, and energy supply (as drivers) and the MDG targets. Within each target, direct linkages are shown above (blue) and indirect linkages below (white).

MDG Target	Water	Food security	Health	Energy
 **1A: Halve, between 1990 and 2015, the proportion of people whose income is less than $1 a day** **1B: Achieve full and productive employment and decent work for all, including women and young people**	• As a means of production in agriculture, hydropower and industry (primary input to the economy) water contributes to employment and wages • Water as a means of production supports livelihoods (typically small-scale agriculture, artisanal fishing) • Water-based harvesting, particularly fisheries, as a commercial activity, support livelihoods • Water-based products, including tourism, create opportunities for employment	• Agriculture-led economic development (as a primary input to the economy) leads to increased employment and rising wages • Small-scale agriculture and artisanal fishing provide a livelihood • Agriprocessing, agri-business and enhanced markets are commercial activities based on primary production	• Good health is an essential requirement for productive work and income earning potential	• Reliable modern energy is an enabler of enterprise development, including access to information and communication technology (ICT) • Lighting permits income generation beyond daylight hours • Productivity is increased through use of machinery (agriculture, industry) • Locally owned businesses create employment in energy service provision and maintenance
	• Water services improve health, food security, education, infrastructure etc. and thus support economic growth • Less time is spent fetching and purifying water and is therefore available for productive work	• Modern diversified agricultural economy is essential for economic development • Benefits through labour reduction, make time available for other productive work	• Less time and resources spent on dealing with health problems increases time available for productive work	• Modern energy services are necessary for economic development • Households benefit from cost and labour reduction, security, reduction in share of household income spent on cooking, lighting and keeping warm

MDG Target	Water	Food security	Health	Energy
 **1C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger**	• Water is a primary input to agricultural production, (commercial, small-scale) and supports subsistence farming livelihoods • Water, as an input to other economic production, increases purchasing power • Water-based harvesting, especially fisheries provides employment	• Efficient and productive agriculture is the primary driver of food availability • Diversified food production improves dietary diversity and nutrition	• Good health of farmers, farm labourers and homestead gardeners increases productivity • Good health management improves nutritional uptake	• Energy is required to improve productivity throughout the food chain (on-farm production e.g. irrigation), processing, storage, transport, market infrastructure • Post-harvest losses are reduced through better preservation and refrigeration • Energy is used for cooking of staple foods to make them safe for eating
	• Water services improve health, food security, education, infrastructure, and thus economic opportunity, employment and income • Less time spent fetching water increases time available for homestead food gardening	• Profitable agriculture generates income for food purchases – this increases dietary diversity and nutrition	• Less household spend on health problems releases income for food purchases	• Energy drives economic development and poverty alleviation, thus increasing purchasing power
 **2A: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling**	• Access to clean water and sanitation creates a more child-friendly school environment, which encourages children to attend school • Flooding can damage school and transport infrastructure and impede access to schools	• More efficient and productive modern agriculture reduces the time spend by children working on the farm, thus allowing them to attend school	• Children need to be healthy and well fed if they are to learn optimally • Burden of care for sick family members sometimes falls on children, preventing them from attending school • Children work to support sick families, preventing them from attending school	• Access to energy creates a more child-friendly school environment (clean water, sanitation, lighting, heating/cooling) • Energy services reduce the time spend by children helping with basic survival activities (gathering firewood, fetching water, cooking) • Lighting permits school use and home study after daylight hours and increases security • Energy services enable the use of educational media and communications including ICT
	• Access to clean water in schools and homes reduces the time spent by children fetching water, thus freeing time for learning • Water-related effects on poverty, hunger and health impact on children's ability to attend school	• Profitable agriculture generates income for education	• Less household spend on health problems releases income for education	• Energy as a driver of economic development and poverty alleviation, makes education more affordable

MDG Target	Water	Food security	Health	Energy
 **3A: Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015**	• Access to clean water and sanitation reduces girls' absence from school due to health/ sanitary reasons • Access to clean water in schools and homes reduces the time spend by girls and women fetching water, thus freeing time for learning	• Women farmers are empowered	• Girls spend less time at school for health reasons (sanitation) • Girls spend less time at school to care for sick family members	• Energy services reduce the time spend by girls helping with basic survival activities (gathering firewood, fetching water, cooking inefficiently, manual farm work and crop processing) • Lighting permits home study when girls stay home for sanitary reasons or after household chores are finished
	• Water-related effects on poverty, hunger and health impact on girls' and women's ability to learn	• More efficient and productive modern agriculture reduces the time spend by girls and women on household tasks, thus freeing time for learning • Agricultural profits are used towards education of girls	• Reduce the various effects of poor health-related poverty and hunger	• Various effects through better income earning opportunities, poverty reduction, increased safety • Reliable modern energy services reduce women's labour and offer scope for women's enterprises
 **4A: Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate**	• Lack of access to clean water compromises child health care • Access to clean water reduces waterborne diseases (primarily diarrheal disease which account for a high proportion of child mortality)	• Increased diversity of food production improves child nutrition	• Core health target • Achievement of this MDG is directly linked to a strong health system	• Indoor air pollution contributes to respiratory infections that account for up to 20% of child deaths annually • Gathering and using traditional fuels exposes young children to health risks and reduces time spend on child health care • Modern energy can be safer (fewer burns, accidents, fires)
	• Improved access reduces water-related effects through poverty, hunger and health, on children as well as care-givers • Flooding can damage transport infrastructure and impede timeous access to healthcare services • Poor access supports other infectious water-linked diseases (e.g. malaria)	• More efficient and productive modern agriculture frees mothers and care-givers to attend to the needs of ill children • Agricultural profits are used towards managing childhood illnesses		• Provision of nutritious cooked food, space heating and boiled water contributes towards better child health • Electricity enables pumped clean water and water purification • Energy is a key component of a functional health system (lighting operating theatres, refrigerating vaccines and other medicines, sterilising equipment), transport to health clinics

MDG Target	Water	Food security	Health	Energy
 **5A: Reduce by three-quarters, between 1990 and 2015, the maternal mortality ratio**	• Lack of access to clean water supports waterborne diseases (e.g. diarrhea) in pregnant women • Access to clean water during and after childbirth reduces the liklihood of death		• Core health target • Achievement of this MDG is directly linked to a strong health system	• Energy services are needed to provide access to better medical facilities for maternal care (e.g. medicine refrigeration, equipment sterilisation, operating theatres), transport to clinics and hospitals
	• Flooding can damage transport infrastructure and impede timeous access to healthcare services • Access to water services relieves pregnant women from fetching and carrying water • Women are affected through poverty/economic situation (affordability of service)	• Increased diversity of food production improves maternal nutrition • More efficient and productive modern agriculture relieves the burden of manual labour in pregnant women • Agricultural profits are used towards managing pregnancy-related health problems		• Access to modern energy services relieves manual labour in pregnant women • Energy is required for provision of nutritious cooked food, space heating, and boiled water which contribute towards better health for women
 **5B: Achieve, by 2015, universal access to reproductive health**			• Core health target • Achievement of this MDG is directly linked to a strong health system	
	• Flooding can damage infrastructure and impede access to healthcare services • Effects are channeled through poverty/economic situation (affordability of service)			• Energy services are needed to provide access to better medical facilities; transport to clinics and hospitals • Electricity enables access to health education media through ICTs
 **6A: Have halted by 2015 and begun to reverse the spread of HIV/AIDS**			• Core health target • Achievement of this MDG is directly linked to a strong health system	• Energy services are needed to provide access to better medical facilities (medicine refrigeration, equipment sterilisation), transport to clinics and hospitals • Incineration facilities reduce further spread of HIV/AIDS
	• Flooding has negative effects on infrastructure and access to healthcare services	• Increased diversity of food production improves nutrition which helps to combat HIV/AIDS		• Electricity enables access to health education media through ICTs
 **6B: Achieve, by 2010, universal access to treatment for HIV/Aids for all those who need it**			• Core health target • Achievement of this MDG is directly linked to a strong health system	• Energy services are needed to provide access to better medical facilities for HIV/AIDS treatment (e.g. medicine refrigeration, transport to clinics and hospitals
	• Flooding impacts on infrastructure and threatens access to clinics for collection of medication			• Electricity enables access to health education media through ICTs

MDG Target	Water	Food security	Health	Energy
 **6C: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases**	• Improved infrastructure and water management has potential to reduce Waterborne diseases and water-dependent disease vectors		• Core health target • Achievement of this MDG is directly linked to a strong health system	• Energy services are needed to provide access to better medical facilities (medicine refrigeration, equipment sterilisation), transport to clinics and hospitals
	• Improvement through (clean) water supply and better sanitation • Flooding can damage infrastructure and prevent access to healthcare services • Various effects channeled through poverty, health and healthcare, infrastructure, economy	• Increased diversity of food production improves nutrition which helps to combat major diseases • More efficient and productive modern agriculture frees care-givers to attend to the needs of the sick • Agricultural profits are used towards managing health problems		• Provision of nutritious cooked food, space heating and boiled water contributes towards better health • Electricity enables access to health education media through ICTs
 **7A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources**	• Core water target. • Water provides a medium for aquatic, wetland and riparian ecosystem goods and services • Deforestation incurs changes in albedo, evapotranspiration and even cloud cover, resulting in the loss of dry season baseflow in rivers, i.e. a shortened flow of seasonal rivers and the drying of formerly perennial rivers	• More productive agricultural technologies allow the withdrawal of agriculture from marginal, sensitive environments, and reduces the rate of land use change • Sustainable farming practices e.g. conservation farming, can help to reduce losses in soil fertility and water holding capacity		• Access to modern efficient energy services and substitution of traditional fuels reduces deforestation, erosion, loss of fertility and desertification • Agricultural mechanisation and irrigation contribute to higher productivity, which allows the withdrawal of agriculture from marginal, sensitive environments and reduces the rate of land use change • Cleaner and more efficient fuels reduce greenhouse gas (GHG) emissions which are the major contributor to climate change
	• Water-related effects are increased through poverty, education and economic situation	• Various effects through loss of access to forest and other ecosystem food products lead to hunger and malnutrition	• Various effects through poverty, deforestation (increased labour for harvesting forest products), pollution of water, air and soil comprise health hazards	• Rural energy services enable non-farm-based enterprise development and less pressure on ecosystem services • Clean and efficient energy use reduces local pollution

MDG Target	Water	Food security	Health	Energy
 **7B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss**	• Water provides a medium for aquatic and water-dependent ecosystems	• More productive agricultural technologies allow the withdrawal of agriculture from species-rich environments, and reduces the rate of land use change • Sustainable farming practices e.g. conservation farming, can help to reduce losses in farmland (including soil) biodiversity		• Access to modern efficient energy services and substitution of traditional fuels reduces deforestation and loss of forest biodiversity • Agricultural mechanization and irrigation contribute to higher productivity which allows the withdrawal of agriculture from species-rich environments, and reduces the rate of land use change
	• Water-related effects are increased through poverty, education and economic situation	• Loss of wild food sources exacerbates hunger and malnutrition	• Loss of wild-harvested natural remedies impacts on treatment options • Strong and affordable health care system reduces reliance on use of wild-harvested remedies	
 **7C: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation**	• Core water target • Water is a resource that must be available and must be of the requisite quality • The state of water infrastructure is a determinant of reliable supply		• Access to safe water and sanitation directly influence health outcomes	• Energy can be used to pump and purify water
 **7D: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers**	• Clean water supply made available through urban water services		• Poor urban dwellers are exposed to serious health hazards. • Improvement through a well-functioning healthcare system.	• Access to energy services drives development and provides local work opportunities in poor peri-urban areas • Energy enables better functioning peri-urban healthcare and education systems
	• Improvement through infrastructure provision	• Efficient and productive agriculture (food supply) and markets can supply urban population		

Overall, the drivers of water supply are highly sensitive to climate change.

Young woman collect water from a well in the Laikala Village, Dordoma region, central Tanzania.

5. The drivers of water supply, food security, health and energy, and their climate sensitivities

In order to meet the MDG goals of providing access to clean and affordable water, food, health services and energy services for the poor, there must be sufficient supply of these resources and services to meet the demand. The current gap between demand and supply in southern Africa is large in many cases, but can be bridged in two ways by increasing supply or by decreasing demand. Decreasing demand will be difficult if not impossible in most poor SADC countries, given population and demographic trends and current development needs, but increasing supply is possible. Across all four sectors, demand and supply sides have very different drivers and so the potential impact of climate change will vary. The first step in understanding how climate change may impact the achievement of the MDGs, therefore, is to identify the underlying supply and demand drivers of water, food, health services and energy services, their current climate sensitivities, and finally how these drivers could be impacted by climate change.

Climate change will, to some degree, affect demand directly and indirectly (e.g. increased demand for water for irrigation, reduced overall economic output, thus reducing demand for energy). These linkages are often highly uncertain and complex and suffer from severe lack of data and information. For the water, food security and energy sectors, this study will focus on the effects of climate change on the supply side. However, the demand-side effects will be included in the case of the health sector, where the climate-health linkages, for example malaria and heat stress-related health conditions, are understood to some degree.

Some of these sectors, e.g. energy and food production, have direct effects on the processes contributing to climate change. This report does not address these issues, but focuses on how climate change itself will impact on the sector. The direct impacts of climate change on energy generation, for example the implications of reduced runoff and increased evaporation on hydropower generation, have been particularly poorly researched.

Table 4: Climate-sensitive drivers of water availability, food security, health and energy

	Water	Food Security	Health	Energy (biomass)	Energy (hydro-power)
Temperature: annual and seasonal means, variability	•	•	•	•	•
Rainfall: mean, inter-annual variability, seasonality, intensity	•	•	•	•	•
Atmospheric carbon dioxide concentration		•		•	
Extreme events (incidence and intensity)**:** floods, droughts, heat waves, cyclones, storm surges	•	•	•	•	•
Soil quality: production potential		•		•	
Soil structure and erosion: siltation, runoff, groundwater	•	•	•	•	•
Water quality: salinisation, eutrophication	•	•	•		
Current forest cover and deforestation rates	•		•	•	
Competition from other sectors **for water resources**	•	•		•	•
Competition from other sectors **for land and its biomass potential**		•		•	
Sea level: salt water intrusion into aquifers	•				
Air quality			•		

5.1 Drivers of water supply, and their climate sensitivities

Water supply is driven by the following factors:

1. **Primary climate drivers (1st order):** temperature including water temperature; rainfall; frequency and intensity of events; inter- and intra-seasonal variability; sea level responses – coastal aquifers and estuaries, extreme events, evapotranspiration. High sensitivity to climate change.
2. **Hydrological drivers (2nd order):** runoff/drainage, groundwater recharge, multi-year and inter-annual floods and droughts; water quality effects; siltation and sedimentation; salinisation. High sensitivity to climate change.

3. **Additional drivers (3rd and 4th order):**
   a. Demand management – policies, pricing and other interventions. This will be driven by increasing water scarcity under climate change.
   b. Technological development e.g. desalinisation, water purification, water harvesting. Climate change and resulting water scarcity will hasten the development of these technologies.
   c. Invasive alien plant management. Climate change could worsen bush encroachment with implications for runoff.
   d. Water quality management – industrial, agricultural and human impacts. Climate change could worsen these impacts.

Overall, the drivers of water supply are highly sensitive to climate change.

5.2 Drivers of food security and their climate sensitivities

Food security is driven by the following components (FAO, 2008):

1. **Food availability:** The supply of sufficient quantities of food as determined by production, stock levels and net trade, including food aid.
2. **Food access:** An adequate supply of food does not guarantee access, which also depends on incomes and expenditures (cash), market dynamics and food prices.
3. **Food utilisation:** This captures the importance of factors such as adequate dietary diversity, care and feeding practices, clean water, sanitation and access to health care, which contribute to a state of nutritional wellbeing by determining how well the body can utilise the nutrients in the food.
4. **Stability:** Food security incorporates a temporal dimension since households or individuals must have access to adequate food at all times. This could be put at risk by sudden shocks (political, economic or climatic crises) or cyclical events (seasonal food insecurity at the end of the dry season).

Climate variability affects food security, particularly at the prodcution (farming) end of the system. Lack of rainfall at the required time, heat waves, changing stream flows, soil nutrient responses, extreme weather events, atmospheric carbon dioxide concentration and plant pests and diseases all affect yields directly (3rd order response), with rainfed farming significantly exposed to climate risk (Lobell *et al.*, 2008). Post-production food system processes and activities, such as storage, processing, distribution, acquisition, preparation and consumption, in their most basic low-technology form (as practiced in most of southern Africa), are also exposed to the impacts of climate. For example, higher temperatures increase the rate of spoilage of fresh produce including meat and milk. Frequent and intense weather hazards such as heavy rainfall and storms result in damage to infrastructure, thereby disrupting food chains at all levels of sophistication (Midgley *et al.*, 2010) – a 4th order response.

The environmental, economic, social and political drivers of food system performance are also affected by climate, both directly and indirectly (4th order response). These include, for example, access to energy sources, access to off-farm income opportunities and other entitlements, and access to clean water and sanitation, and health care. There are also indirect pressures arising from displaced people and migration and affected trade flows (de Wit, 2009).

5.3 Drivers of health and their climate sensitivities

Human health is determined by the interaction of social and environmental conditions. Climate is amongst the myriad factors influencing the occurrence and range of human health determinants and outcomes (Patz *et al.*, 2005). As a driving force, climate pressure is also recognised to have a significant influence on other driving forces such as economic, social, political and institutional structures and functioning, which impact (health) indirectly.

The health impacts of climate variability and other climate pressures are broadly characterised into three exposure types.

1. **Direct impacts** include morbidity and mortality associated with direct exposure to hazardous meteorological conditions, such as heat waves, floods, or cyclones (1st order).
2. **Indirect impacts,** constituting the majority of *climate-related morbidities*, are mediated by environmental conditions which change the geographic range and incidence of vector-, rodent-, water- and food-borne diseases, and alterations in air pollution and aeroallergen related diseases (2nd and 3rd order).
3. **Health conditions,** indirectly exacerbated by economic, resource or social losses caused by climate variability or change that affects mental health, or creates economic barriers to health care, food, or water (4th order).

5.4 Drivers of biomass and hydropower energy and their climate sensitivities

The supply of energy may come from biomass, hydroelectricity, fossil fuels or other renewable energy sources. Currently, in most SADC member states the majority of the primary energy comes from biomass (wood fuels) and most of the electricity from hydropower (IEA, 2009). Rural energy will remain reliant on wood fuels for the foreseeable future, contributing to deforestation. The management of wood fuel resources is a major issue for environmental sustainability in Africa (Gustafson, 2001). Demand for wood fuels in urban areas results in rapid overexploitation. Where urbanisation takes place without a shift to affordable commercial electrical power, a shift to charcoal industries takes place and this accelerates the trend in wood fuel use.

South Africa and a small number of neighbouring countries rely primarily on fossil fuels. However, the fossil fuel supply is not significantly impacted by climate or climate change (at least not until reductions in greenhouse gas (GHG) emission start to make an impact) because the main drivers are resource availability, technology and capital plant availability. Because of the very low current penetration of any renewable energy sources other than hydropower and biomass in southern Africa (such as wind and solar energy) they are not addressed in this analysis. We will, therefore, focus on biomass and hydropower.

Figure 3 and Figure 4 show the drivers of energy supply (representing all four orders in the 1st to 4th order framework), and those which are likely to be affected by climate change (highlighted in light brown). Note that while many of the drivers indicated are strongly influenced by policy/regulatory environment, investment (both private and public), and human capital within the country, these will not be discussed in depth here because they are also not directly impacted by climate change.

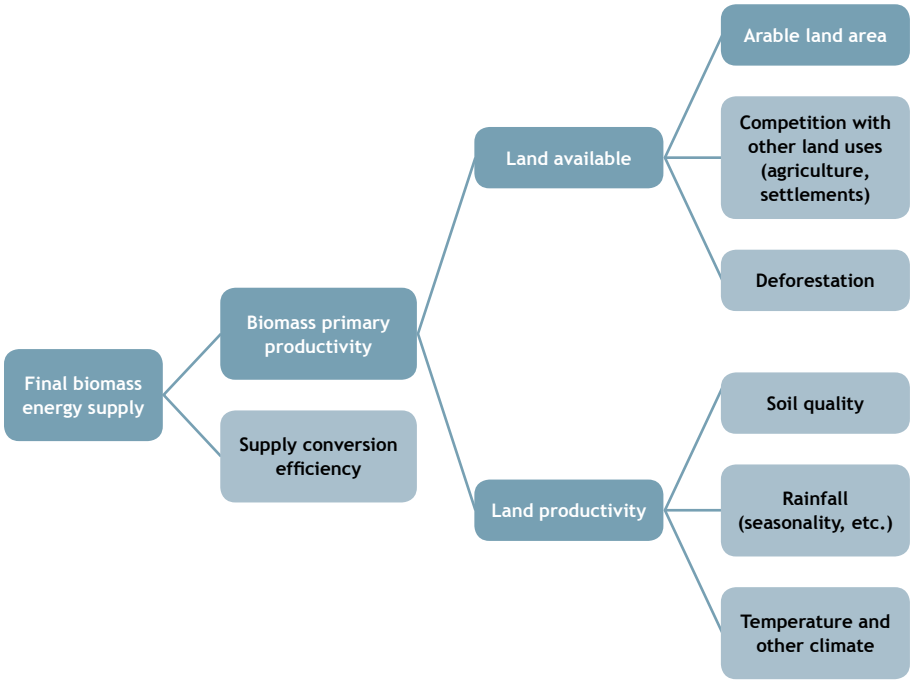


Figure 3: Drivers of biomass energy supply (primarily fuel wood). Those drivers likely to be most affected by climate change are shown in light blue. Source: Econ Pöyry (2009).

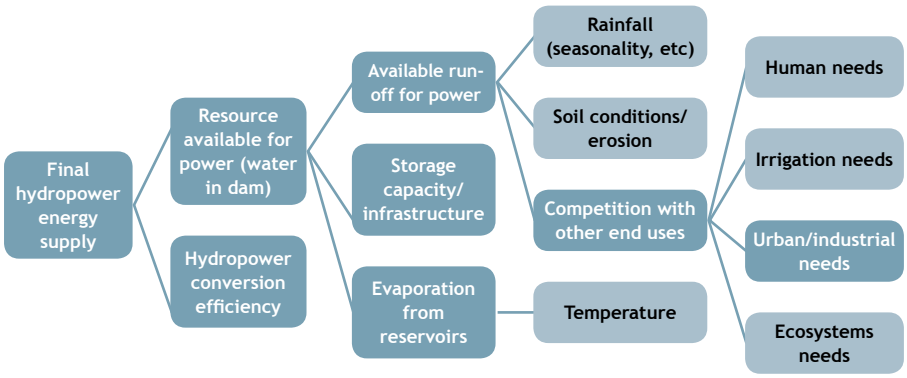
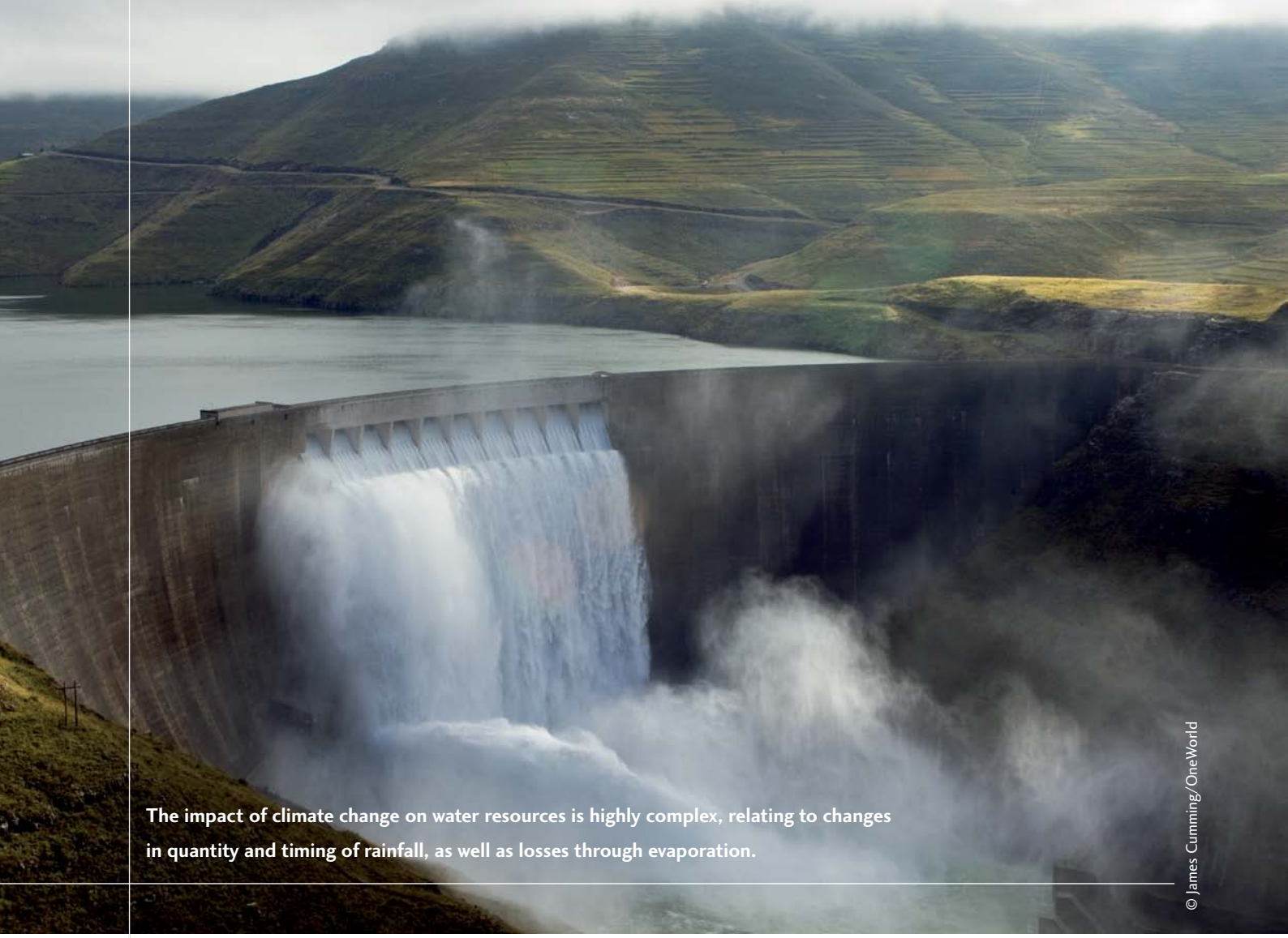


Figure 4: Drivers of hydropower energy supply. Those drivers likely to be most affected by climate change are shown in light blue. Source: Econ Pöyry (2009).



The impact of climate change on water resources is highly complex, relating to changes in quantity and timing of rainfall, as well as losses through evaporation.

The impact of climate change on hydropower generation is complex because it relates not only to changes in quantity of rainfall, but also to the changes in timing, intensity, and duration of rainfall (1st order). As Mukheibir (2007) points out, lack of runoff is only one factor that could reduce hydropower output. The others include increased surface water evaporation, increased runoff and damage caused by flooding, and increased siltation deposits in reservoirs (2nd order). While the largest hydropower facilities in the region, on the Zambezi River and its tributaries the Shire and Kafue, may not necessarily have reduced runoff (climate models show the headwaters of this river potentially receiving more mean annual rainfall) they could nevertheless suffer from increased siltation and damage due to flooding.

In addition to impacts on major hydropower facilities, changes in runoff could affect many of the smaller ones. Although these stations might be small relative to national or regional demand, they are often the only local source of electricity, and in some cases are not even connected to a national or regional grid. In these cases relatively small changes in runoff (or flooding, in cases of increased rainfall) could jeopardise energy supply to communities with no other local alternatives (Econ Pöyry, 2009).

For countries that export hydropower, particularly Mozambique but to a lesser extent Zambia, any changes in dam capacity and hydropower output would also adversely affect the trade balance and the overall economy (4th order).

6. Malawi: Projected impact of climate change on the MDGs

Table 5: The expected possible impact of climate change on the trajectory of achieving the MDGs in Malawi. A brief narrative of the water-, food security-, health- and energy-related drivers is included.

KEY:	Possible impact of climate change on the trajectory of achieving the MDGs			
	Positive impact	No/small impact	Weak negative impact	Strong negative impact

	Poverty	Weak negative impact

- Significant livelihood and economic effects on pelagic fishery in the lakes – temperature changes could reduce fish catch by up to 30%; given the importance of the lake fishery on livelihoods, this effect could impact negatively on poverty.
- Increasingly erratic rainfall will have negative effects on rainfed agriculture, leading to greater rural poverty.
- Floods and droughts may have negative effects by destroying livelihood assets and impacting negatively on hydropower production.
- On the other hand, increased availability of water (if rainfall increases) may support increased productive use of water resources in agriculture, hydropower and industry, and better support small-scale farming.
- This, however, is a dramatic oversimplification, as the ability of the economy to respond to increasing water resources is an institutional and economic issue more than a natural resource issue – it is not clear that more rainfall and more runoff /ground-water will in-and-of itself increase prosperity and livelihood options.
- Negative impacts on health could slow down labour productivity and economic growth.
- **The key response is to utilise potential increased rainfall to develop alternative livelihood strategies and support alternative economic and productive use of water.**

	Hunger	Weak negative impact

- Food and hunger negative effects increase through the reduction in pelagic fishery in the lakes, and reductions in rainfed agricultural productivity (including livestock) under conditions of increasingly variable rainfall during summer.
- This may be offset by increased production under rainfed conditions with increased annual rainfall, increased availability of water for irrigation, and improvements in rangeland condition. However, if irrigated agriculture continues to expand, this could impact the runoff available for hydropower production.
- A recurrence of droughts would reverse progress on the 'food security' MDGs unless further measures are taken to secure yield improvements and food production systems.
- **The key response is to utilise potential increased rainfall to develop alternative livelihood strategies and support alternative economic and productive use of water.**
- **The importance of water infrastructure and institutions to manage water (and reduce uncertainty around climate and hydrological response) is underlined.**

	Education/gender	No/small impact

- These MDGs are not likely to be greatly impacted, although indirect negative impacts could be felt if variable rainfall and extreme weather increase poverty, food insecurity, health problems and energy insecurity, and destroy infrastructure.
- On the other hand, these negatives could be reduced by increasing annual rainfall available for productive use.

	Health	Strong negative impact

- Increased rainfall, increased temperature and increased flooding will significantly increase the risk of waterborne diseases and malaria, and cause damage to health system infrastructure.
- The extent of that increase in risk, given the endemic nature of these health effects in the Rift Valley, is difficult to qualify.
- Increased hunger and malnutrition will decrease resistance to diseases and ability to recover.

	Environmental sustainability	Strong negative impact

- Significant temperature effects can be expected on the ecology of the lakes. Given the importance of these lakes – socially, economically and ecologically, these temperature effects could be dramatic.
- The impact of aquatic invasive weeds in the Rift lakes, and the threat of eutrophication (local, in-shore) is elevated by the temperature and CO_2 effects, with concomitant risks for the natural habitat.
- Heavy rainfall will exacerbate current high rates of soil erosion and siltation of rivers, lakes and reservoirs. This will impact negatively on fisheries, forestry and hydropower production.
- Potentially positive influences on the afforestation programme, are expected with increased net primary productivity resulting from CO_2 fertilisation, moderate warming and increased rainfall (if spread evenly). Supply of biomass for energy will increase. However, this could be offset by greater frequency and intensity of wildfires.
- **Key response is careful management of the vulnerable system and reducing extraneous stressors, such as overexploitation, water contamination, invasive aquatic weed infestations, and injudicious clearing of land.**
- Policy failure in the forestry and environment sectors under the scenario of increasing frequencies of climatic extremes would have serious repercussions. Alternatively, policy successes could allow the environment to benefit from the projected changes.

	Water supply and sanitation	Positive impact

- The availability of water will likely increase, with increased availability of perennial water courses. This reduces stress on water supply and sanitation, all else being equal.
- This, of course, is an oversimplification, as population growth, institutional, economic and infrastructural issues, and associated land-use changes place significant stress on water supply and sanitation (particularly on improved supply). This stress is however not exacerbated by climate change, and the increase in rainfall and runoff will likely alleviate some of the possible negative, non-climate impacts.

7. Mozambique: Projected impact of climate change on MDGs

Table 6: The expected possible impact of climate change on the trajectory of achieving the MDGs in Mozambique. A brief narrative of the water-, food security-, health- and energy-related drivers is included.

KEY:	Possible impact of climate change on the trajectory of achieving the MDGs			
	Positive impact	No/small impact	Weak negative impact	Strong negative impact

	Poverty	Semi-arid south	Strong negative impact
		Wetter north	Weak negative impact

In the semi-arid south:

- Reduced rainfall and more erratic summer rains undermine rainfed subsistence production, thus undermining livelihoods.
- Reduced water availability (surface and groundwater) for productive means.
- Increased time spent collecting water for domestic and productive means undermines ability to pursue livelihoods.
- Flood-poverty cycle will intensify under increased flooding and more intense cyclone events. Destruction of infrastructure and capital undermines ability to provide services and establish markets.
- Sea level rise and reduced freshwater availability and quality will impact on estuaries and associated near-shore fisheries.
- Sea level rise will threaten homes, particularly during storm events where coastal settlements will be susceptible to flooding.
- **A key response is the development of infrastructure and institutions – the latter are particularly important given Mozambique's dependence on transboundary waters.**
- These changes could present major problems for hydropower generation – high intensity events can cause increased siltation and damage due to flooding, and drier periods between these events could reduce power output. This would impact on the macro- and micro-economy.

In the wetter north:

- Economically depressed area, with limited opportunities for employment and alternative livelihood strategies.
- Tourism potential a rising economic factor, but poor infrastructure makes penetration and dispersal poor.

	Hunger	Semi-arid south	Strong negative impact
		Wetter north	Weak negative impact

In the semi-arid south:

- Reduced rainfall and more erratic summer rains undermine rainfed subsistence food production.
- Sea level rise and reduced freshwater availability and quality will impact on estuaries and associated near-shore fisheries.
- Flood and cyclone related infrastructure destruction undermines food markets and distribution.
- Reliance on food aid and importation will likely intensify, as local conditions for food production weaken (although potential for food production along river courses is very good).
- **Key response is the development of irrigation infrastructure and protection of key infrastructure from flood and cyclone damage – storage and flood protection infrastructure (dams).**
- Development of key institutions to ensure adequate water and good management will increase, coupled with improved technology to ensure water use efficiency.

In the wetter north:

- Significant reliance on subsistence agriculture and harvesting of natural resources. But potential for agriculture good.
- Extreme events and poor physical and economic infrastructure significantly undermine food security.
- Environmental integrity provides food alternatives, increasing resilience to food insecurity.
- Challenges are largely non-climatic.

	**Education/gender**	**Semi-arid south**	**Weak negative impact**
		Wetter north	**No/small impact**

Whole country:

- These MDGs are not likely to be greatly impacted, although indirect negative impacts could be felt if variable rainfall and extreme weather increase poverty, food insecurity, health problems and energy insecurity, and destroy infrastructure.
- This is a particular risk in the semi-arid southern regions of Mozambique.
- On the other hand, these negatives could be reduced by increasing annual rainfall available for productive use in the northern regions.

	**Health**	**Semi-arid south**	**Weak negative impact**
		Wetter north	**Strong negative impact**

In the semi-arid south:

- Flooding increases the risk of spreading waterborne diseases, particularly linked to poor water supply and sanitation.
- There is increased risk of malaria, under hotter and humid conditions (especially after flooding).
- Effect of poor water supply and sanitation will impact on HIV/AIDS patients.
- Increased hunger and malnutrition will decrease resistance to diseases and the ability to recover.
- Cyclones (exposure, lightning, etc.) will impact directly on health.
- Indirect effects through poverty and hunger, infrastructure destruction and reduced availability of natural resources.

In the wetter north:

- Poor under-5 mortality and maternal care in the region will increase, as will poor penetration of healthcare facilities.
- Consistent downward trend in indicators owing to poor penetration of services and increasing prevalence of malaria, TB and HIV/AIDS.

	**Environmental sustainability**	**Semi-arid south**	**Weak negative impact**
		Wetter north	**Positive impact**

In the semi-arid south:

- Estuarine effects will be severe through reduced water availability, deteriorating water quality (organic runoff, land-degradation, siltation), flow modulation (reduced low intensity floods – flushing) owing to abstraction, sea level rise, and over-exploitation.
- Salt-water intrusion in shallow coastal groundwater aquifers will result in significant damage to coastal forest belt and wetland systems.
- Floods and cyclones will increase damage on the coast.
- Flood damage to riparian environments – could be the tipping point where reduced overall water availability does not enable rehabilitation following flood damage.
- Heavy rainfall will exacerbate current high rates of soil erosion and siltation of rivers, lakes and reservoirs. This will impact negatively on inland fisheries, forestry and hydropower production.
- Increased reliance on natural resources will drive unsustainable harvesting or marine and terrestrial resources.
- Increased forest productivity, resulting from CO_2 fertilisation and moderate warming, will result in an increased supply of biomass for energy. However, this could be offset by greater frequency and intensity of wildfires.
- Indirect effects on policy and enforcement through poverty, hunger, health and infrastructure effects.

In the wetter north:

- Protected areas are very remote with pristine environments. Impacts of climate change are likely to be weak or positive.
- Increased forest productivity will result from CO_2 fertilisation, moderate warming and high rainfall (if spread evenly). Increased supply of biomass for energy. Risk of wildfires lower than in the south.

	**Water supply and sanitation**	**Semi-arid south**	**Weak negative impact**
		Wetter north	**Weak negative impact**

In the semi-arid south:

- Salt-water intrusion into coastal groundwater aquifers will have profound effects on the numerous shallow well water collection systems along the coast.
- Floods may damage infrastructure.
- Failing infrastructure, particularly during floods, may increase surface water contamination and increase risk of water borne disease from un-protected water sources.
- Wash-off of pollution from peri-urban and informal settlements will increase, increasing pollutant load on rivers.
- Response is significant investment in infrastructure, protection of infrastructure, appropriate technology and maintenance/refurbishment (institutional and financial capacity issue).

In the wetter north:

- Extent of water supply and sanitation is poor, given the deep rural nature of the region.

8. Tanzania: Projected impact of climate change on the MDGs

Table 7: The expected possible impact of climate change on the trajectory of achieving the MDGs in Tanzania. A brief narrative of the water-, food security-, health- and energy-related drivers is included.

KEY:	Possible impact of climate change on the trajectory of achieving the MDGs			
	Positive impact	No/small impact	Weak negative impact	Strong negative impact

	**Poverty**	**Semi-arid centre and coastal areas**	**Strong negative impact**
		Wetter underdeveloped south	**Weak negative impact**

Semi-arid centre and coastal areas:

- Reduced rainfall and more erratic summer rains undermine rainfed subsistence production.
- There will be reduced water availability (surface and groundwater) for productive means and reduced water flows for hydropower.
- Increased time spent collecting water for domestic and productive means undermines ability to pursue livelihoods.
- Flood-poverty cycle will intensify under increased flooding.
- Destruction of infrastructure and capital undermines ability to provide services and establish markets.
- Sea level rise and reduced freshwater availability and quality will impact on estuaries and associated near-shore fisheries.
- Sea level rise will threaten homes, particularly during storm events where coastal settlements will be susceptible to flooding.
- A key response is the development of infrastructure and institutions.

Higher rainfall areas – wetter underdeveloped south:

- Challenges are largely non-water/climate – being primarily institutional and infrastructural in nature.
- Increased water resource availability introduces potential for increased productive use of water (particularly for agriculture).
- Increased intensity of extreme events (floods and cyclones) can have very significant detrimental effect through crop damage.

	**Hunger**	**Semi-arid centre and coastal areas**	**Strong negative impact**
		Wetter underdeveloped south	**Weak negative impact**

Semi-arid centre and coastal areas:

- Reduced rainfall and more erratic summer rains undermine rainfed subsistence production.
- Sea level rise and reduced freshwater availability and quality will impact on estuaries and associated near-shore fisheries.
- Flood and cyclone related infrastructure destruction undermines food markets and distribution.
- Reliance on food aid and importation will likely intensify.
- **Key response is the development of irrigation infrastructure and protection of key infrastructure from flood damage – storage and flood protection infrastructure (dams).**
- Development of key institutions to ensure adequate water and good management will be required, coupled with improved technology to ensure water use efficiency.

Higher rainfall areas – wetter underdeveloped south:

- Challenges are largely non-water/climate – being primarily institutional and infrastructural in nature.
- Increased water resource availability introduces potential for increased productive use of water (particularly for agriculture).
- Increased intensity of extreme events (floods and cyclones) can have very significant detrimental effect through crop damage.

	**Education/gender**	**Semi-arid centre and coastal areas**	**Weak negative impact**
		Wetter underdeveloped south	**Positive impact**

Semi-arid centre and coastal areas:

- Negative impacts could be felt directly and indirectly if variable rainfall and extreme weather increase poverty, food insecurity, health problems and energy insecurity, and destroy infrastructure.

Higher rainfall areas – wetter underdeveloped south:

- These MDGs are not likely to be negatively impacted, and increased productive use of water and other natural resources could even improve them. Current constraints are institutional and infrastructural.

	Health	Semi-arid centre and coastal areas	Strong negative impact
		Wetter underdeveloped south	Strong negative impact

Semi-arid centre and coastal areas:

- Flooding increases the risk of spreading waterborne diseases, particularly linked to poor water supply and sanitation.
- Under hotter and humid conditions (especially after flooding) there is increased risk of malaria.
- Poor water supply and sanitation impact particularly on HIV/AIDS and other patients.
- Direct health effects of floods.
- Indirect effects through poverty and hunger, infrastructure destruction and reduced availability of natural resource.

Higher rainfall areas – wetter underdeveloped south:

- Flooding increases the risk of spreading waterborne diseases, particularly linked to poor water supply and sanitation.
- There is increased risk of malaria, under hotter and humid conditions (especially after flooding).
- Effect of poor water supply and sanitation on HIV/AIDS and other patients.
- Direct health effects of cyclones (exposure, lightning, etc).
- Indirect effects through poverty and hunger, infrastructure destruction, and reduced availability of natural resources.

	Environmental sustainability	Semi-arid centre and coastal areas	Strong negative impact
		Wetter underdeveloped south	Positive impact

Semi-arid centre and coastal areas:

- Estuarine effects will be severe through reduced water availability, deteriorating water quality (organic runoff, land-degradation, siltation), flow modulation (reduced low intensity floods – flushing) owing to abstraction, sea level rise, over-exploitation.
- Salt-water intrusion in shallow coastal groundwater aquifers will result in significant damage to coastal forest belt, wetland systems and agriculture.
- Flood damage on the coast will increase.
- Flood damage to riparian environments – is the tipping point where reduced overall water availability does not enable rehabilitation following flood damage.
- Increased reliance on natural resources will drive unsustainable harvesting of marine and terrestrial resources.
- Indirect effects on policy and enforcement through poverty, hunger, health and infrastructure effects.

Higher rainfall areas – wetter underdeveloped south:

- Increased forest productivity resulting from CO_2 fertilisation, moderate warming and high rainfall (if spread evenly). Increased supply of biomass for energy. Risk of wildfires lower than in the semi-arid central regions.
- Rising temperature may have effect on vulnerable aquatic ecosystem, although temperature changes not as severe due to coastal location.
- Ecosystem damage through floods and cyclone activity.
- Increased water resources will support aquatic ecosystems and probably negate the effects of rising temperature and flood/cyclone damage.
- Increased groundwater will offset some of the effects of sea level rise on coastal aquifers and aquifer-dependent ecosystems.

	Water supply and sanitation	Semi-arid centre and coastal areas	Strong negative impact
		Wetter underdeveloped south	Weak negative impact

- Semi-arid centre and coastal areas:
- Salt-water intrusion into coastal groundwater aquifers will have profound effects on the numerous shallow well water collection systems along the coast.
- Floods may damage infrastructure.
- Failing infrastructure, particularly during floods, may increase surface water contamination and increase risk of water borne disease from un-protected water sources.
- Wash-off of pollution from peri-urban and informal settlements will increase, increasing pollutant load on rivers.
- Response is significant investment in infrastructure, protection of infrastructure, appropriate technology and maintenance/refurbishment (institutional and financial capacity issue).

Higher rainfall areas – wetter underdeveloped south:

- Water, groundwater and surface water will increase.
- Damage to infrastructure by floods and cyclones will increase.
- Relatively low population density reduces risk of floods affecting water quality through pollution runoff – effect of assimilation and dilution.

9. Zambia: Projected impact of climate change on the MDGs

Table 8: The expected possible impact of climate change on the trajectory of achieving the MDGs in Zambia. A brief narrative of the water-, food security-, health- and energy-related drivers is included.

KEY:	Possible impact of climate change on the trajectory of achieving the MDGs			
	Positive impact	No/small impact	Weak negative impact	Strong negative impact

	**Poverty**	**Drier south**	**Strong negative impact**
		Wetter north	**Weak negative impact**

- Primary effect through increased uncertainty of rainfed agriculture – shorter rainy season, reduced annual rainfall, greater variability intra-seasonally and increased risk of early rainy season dry spells increase the risk of crop failure in rainfed production.
- This effect is compounded by institutional weakness with poor distribution of information, technology and services.
- Indigenous knowledge systems may be a hindrance, as fundamental climate shifts may undermine traditional rules such as onset of rains, ideal planting conditions, crop varieties and agricultural practices.
- Effect on hydropower may be significant, although much of the flow in the main-stem rivers is generated in the north where increased rainfall and runoff is anticipated.
- Economic stress may be experienced as water resources available for productive means diminish in southern and central regions. This is not as severe owing to abundant resources in the main-stem rivers (perennial rivers).
- **A key response is the development of infrastructure and institutions – the latter are particularly important given the transboundary and connected nature of the Zambezi basin.**
- Significant institutional cooperation and collaboration around key water resources infrastructure (primarily hydropower infrastructure, but also flood management) is already seen and will strengthen.

	**Hunger**	**Drier south**	**Strong negative impact**
		Wetter north	**Weak negative impact**

- Primary effect through increased uncertainty of rainfed agriculture – shorter rainy season, reduced annual rainfall, greater variability intra-seasonally and increased risk of early rainy season dry spells increase the risk of crop failure in rainfed production.
- This effect is compounded by institutional weakness with poor distribution of information, technology and services.
- Indigenous knowledge systems may be a hindrance, as fundamental climate shifts may undermine traditional rules such as onset of rains, ideal planting conditions, crop varieties and agricultural practices.
- Environmental degradation (aquatic ecosystems and wetlands) will undermine the ability to rely on natural resource harvesting (including fishing) as alternative food sources.
- An important adaptation strategy is to move away from rainfed agriculture in the high-risk environments (southern and central regions) towards irrigation (small-scale or large scale irrigation).
- **Key response is the development of irrigation infrastructure linked to improvement of the resource through impoundment infrastructure (dams) to capture rainy-season runoff.**
- Development of key institutions to ensure adequate water and good management, coupled with improved technology to ensure water use efficiency.

	**Education/gender**	**Drier south**	**Weak negative impact**
		Wetter north	**No/small impact**

- These MDGs are not likely to be greatly impacted, although indirect negative impacts could be felt if variable rainfall and extreme weather increase poverty, food insecurity, health problems and energy insecurity, and destroy infrastructure.
- This is a particular risk in the semi-arid southern and central regions.
- On the other hand, these negatives could be reduced by increasing annual rainfall available for productive use in the northern regions.

	Health	**Drier south**	**Strong negative impact**
		Wetter north	**Strong negative impact**

- Flooding increases the risk of spreading waterborne diseases, particularly linked to poor water supply and sanitation, and unprotected water sources.
- Droughts increase risk of waterborne diseases as reliance on diminishing water sources increases and contamination potential of unimproved sources increases (human or livestock related).
- There is increased risk of malaria, under hotter and humid conditions (especially after flooding).
- Effects of poor water supply and sanitation on HIV/AIDS and other patients will increase.
- Indirect effects through poverty and hunger, infrastructure destruction and reduced availability of natural resource.

	Environmental sustainability	**Drier south**	**Strong negative impact**
		Wetter north	**Weak negative impact**

- Climate adaptation practices may result in detrimental downstream aquatic ecosystem impacts – dams, irrigation schemes, etc.
- Increasing temperature will affect vulnerable aquatic species.
- Reducing drainage network and shrinking flow duration in seasonal rivers in the southern and central regions will have significant effects on riparian woodlands – dramatic floods could result in tipping points shifting rivers into new hydro-ecological states from which recovery is not possible.
- Effects are most severe off the main-stem rivers, as main-stem flows probably maintained through increased runoff in north (excluding the effect of infrastructure on flow modulation).
- Positive impacts on forest growth and regeneration, with increased net primary productivity resulting from CO_2 fertilisation, moderate warming and increased rainfall at times in the north (if spread evenly) will increase the supply of biomass for energy. However, this could be offset by greater frequency and intensity of wildfires.
- High temperatures, CO_2 fertilisation and nutrients washed off during flood events will drive eutrophication and proliferation of aquatic invasive species (particularly water hyacinth).
- Indirect effects through deepening poverty and hunger, and increased natural resource degradation as a livelihood strategy will increase.
- **Key response is careful incorporation of environmental objectives and considerations in adaptation planning, including the development of 'green infrastructure' and the establishment of strong institutions to manage natural resources.**

	Water supply and sanitation	**Drier south**	**Strong negative impact**
		Wetter north	**Weak negative impact**

- The effect will be most severe in southern and central regions, where reliance on surface water sources will be stressed by the contracted rainy season, reduced duration of flow in seasonal rivers and reduced groundwater sources.
- Adequate water in the Zambezi basin as a whole will unlikely affect the urban supply systems, except where urban supply is not from main-stem sources but from local runoff or groundwater (e.g. Lusaka).
- Response is development of improved water sources in rural areas (including groundwater sources) and, particularly, water resources infrastructure to service rural and urban areas in southern and central regions.

10. Discussion of case studies

This analysis has highlighted much common vulnerability across political boundaries, which reflects shared biophysical and socioeconomic contexts. On the other hand, most countries show marked gradients of vulnerability within their own boundaries. Both offer opportunities for responding to climate change. Table 9 summarises the vulnerability to regressing on current progress towards achieving the MDGs for all four countries.

Table 9: Synopsis of the possible impact of climate change on the trajectory of achieving the MDGs in all four case study countries

KEY:	Possible positive impact	No/very small impact	Possibly feasible	Possible stronger negative impact

Country/sub-region	Poverty	Hunger	Education/ gender	Health	Environmental sustainability	Water supply and sanitation
Malawi						
Mozambique (south)						
Mozambique (north)						
Tanzania (central)						
Tanzania (other)						
Zambia (south)						
Zambia (north)						

10.1 Common vulnerabilities

Common vulnerabilities provide opportunities for countries within the region to work together much more closely on identifying solutions and learning best practice from one another. Economies of scale can provide greater efficiencies in rolling out programmes and attracting additional financial support. However, this depends on the nature of cooperative agreements, for example SADC policies.

10.1.1 Extreme poverty (MDG1)

National poverty reduction strategies and programmes are showing clear signs of success in Malawi and Mozambique, albeit off a low base. On the other hand, Tanzania and Zambia are struggling to make inroads and are unlikely to achieve on poverty targets by 2015, due to sluggish growth in the agricultural sector and inability to keep up with the food needs of a growing population. In all cases, however, climate change impacts on livelihood assets (health, access to water, homes and infrastructure), and on food security (crop and livestock losses, failure to access lands during flooding, breakdown in distribution systems). This could place strain on further economic growth and progress on poverty reduction. The more arid areas within countries (subregions 2b and 4) are particularly at risk since water resource availability, which is so central to livelihoods and socio-economic development, will come under increasing pressure. Where increases in rainfall are projected (parts of subregion 3), negative impacts on the MDG trajectories could potentially be mitigated and constrained, given a strengthening of policies and institutions.

10.1.2 Hunger (MDG1)

The expected impacts of climate change on the trajectories for hunger reduction are similar to those for poverty. In all four countries, agriculture, food security and poverty are inextricably linked. When crops fail because of drought or are destroyed by floods, pests or diseases, both poverty and hunger take hold. Lack of alternative income sources exacerbates the hunger situation since people are unable to purchase sufficient food. The impacts are expected to be more serious in the semi-arid regions of each country, but the wetter regions could be buffered by improved conditions for farming, given the required technological and institutional support.

Increased poverty and hunger affect education and gender equality. A women's group in the Chimwavi village, Salima district of Malawi.

10.1.3 Education/gender equality (MDG2, MDG3)

Increased poverty and hunger affect education and gender equality, as children are taken out of school because of a lack of cash. Both children and women's time and labour is diverted to household tasks and alternative income-generating (or even survivalist) tasks. The quality of the education is also compromised for those who stay at school with hunger severely affecting learning ability. Climate extremes such as storms and floods impair access to schools as well as off-farm employment for women.

Children and women are also more severely impacted than other population sectors by disaster-driven displacement and migration. Climate-related disasters impact more heavily on female-headed households, particularly those living in extreme poverty. Although these risks are to be taken seriously, they are unlikely to significantly derail current efforts and successes (driven by national priorities and strategies) towards providing access to education for all and eliminating gender disparities.

10.1.4 Health (MDG4, MDG5, MDG6)

The health targets are proving very difficult to achieve across all four countries. The burden of disease in the region is such that even small increases in disease pressure, linked to a changing climate, would severely impact on an already weak public health care system. Women and children are particularly vulnerable to climate change related impacts on water- and vector-borne diseases such as cholera and malaria, especially during and after floods. These impacts include increased heat-related mortality, declining quantity and quality of drinking water, threatened food security and increased malnutrition, and impaired access to essential health services. Concerted efforts to reduce child mortality are paying dividends in all four countries, with each expected to reach or go beyond their MDG4 target. *In three of the four countries,* improvements in the maternal mortality rates (MDG5) are too low, while *the fourth* country is not making progress. Although climatic and climate-related hazards to health are only one of many drivers of maternal health and survival, an increase in these risks would have serious repercussions (on the achievement of these MDGs).

10.1.5 Environmental sustainability (MDG7)

Environmental sustainability will become increasingly more difficult to achieve in the lower rainfall areas of the region. Water resources, which play a critical role in all components of ecosystem services (provisioning, regulating, supporting and cultural services) are expected to decrease in more arid areas. In addition, the continuing high rates of deforestation will lead to further losses of biodiversity, soil and other ecosystem services. Driven by increasing population pressure, this signals a steady erosion of basic support systems for the majority of livelihoods. Loss of ecosystem regulating services increases vulnerability to floods and droughts. All four countries have, or are planning to develop, lucrative nature-based tourism sectors. The impacts of climate change-driven land transformation, poaching and biodiversity loss could be a huge setback for this sector. All four countries are currently not making any (or sufficient) progress on the environmental indicators, and many do not have satisfactory systems in place for data collection and monitoring. Nevertheless, opportunities for greater success lie in some of the higher rainfall areas and those which are projected to experience wetter climates (parts of subregion 3). Greater water supplies and primary productivity which could be accessed for human needs and productive use could benefit these areas, although currently they suffer from lack of infrastructure.

10.1.6 Water supply and sanitation (MDG7)

The potential climate change impacts vary widely, depending on current policy successes and investments, and existing and future water resources. Emerging water supply constraints in some areas could make future progress on this indicator more difficult and costly. Countries which are on track on this indicator and could experience higher rainfall, such as Malawi, may benefit. But areas of similarly high rainfall but current severe lack of infrastructure, such as northern Mozambique, will have to substantially increase investment to make better progress on this indicator. The potentially severe impacts of extreme storms and floods on water and sanitation infrastructure are a critical unknown – they could set back progress by many years.

10.2 Differential vulnerabilities

Vulnerability is not evenly distributed across the region, or even across a country. The drier parts of each country (subregions 2b and 4) are more vulnerable than the wetter parts (subregion 3). The complexities associated with predicted higher annual or seasonal rainfall should not be underestimated. If spread evenly and used productively, higher rainfall can give impetus to the achievement of development goals. If, on the other hand, the rainfall comes as more intense downpours, with high rates of runoff and flooding, it is more likely to be damaging. It is to be expected that both scenarios will occur within a pattern of increasing inter-annual variability, and the potential developmental benefits of 'good rainfall years' will only be realised (and be able to mitigate the 'bad years') if infrastructural and institutional capacities and good governance at all levels are in place to manage water resources optimally.

Exposure to sea level rise, salt water intrusion, and increasing frequencies and/or intensities of coastal storm surges and cyclones along the eastern shores of the region, bring with them particular challenges. Their impacts are potentially catastrophic and measures to deal with them will be extremely costly, thus placing great strain on these countries' financial resources and prospects for growth and development. Well planned and resourced disaster risk reduction and response strategies are essential for long-term mitigation of these threats.

Regions with high population densities and high population growth rates are particularly vulnerable (subregion 3a). Although endowed with reasonably high rainfall, Malawi is facing (and will continue to do so) developmental challenges associated with pressure on ecosystem services, as population numbers and densities steadily rise.

A key response by every country will be to sustainably capitalise on potential benefits to generate employment, growth and income in less vulnerable parts of the country, whilst providing safety nets in the more vulnerable areas. It is to be expected that continued rapid urbanisation will occur throughout the region and demand greater focused attention to the provision of livelihoods and essential services in towns and cities.

Food security is increasingly being recognised as a regional issue.
Vendors at a local market in Chokwe, Gaza Province, Mozambique.

11. Summary discussion of MDGs and climate change

The analysis showed that climate is one of many drivers of development and consequently an additional burden in the achievement of the MDGs in southern Africa. Many of the expected impacts from climate change will be common to the whole region, whereas others will differ between and within countries, depending on national circumstances and specific biophysical and socioeconomic contexts. Overall, adaptive capacity will rest on these circumstances in combination with national investment priorities, capacitation of local institutions, good local governance and accountability, and development of supportive infrastructure such as transport networks.

11.1 Regional dependencies

In seeming conflict with the country-based MDG approach, water supply is based on rainfall not just within national boundaries, but also within the entire watershed. The major hydropower facilities in the region are on river basins that cover several riparian countries. For example, the hydropower plants in Mozambique will be impacted by rainfall in the upper reaches of the Zambezi (Econ Pöyry, 2009).

The Southern African Power Pool (SAPP) is a good example of a regional dependency that could be used to offset the impacts of regional climate challenges. Power generated in a region where sufficient rainfall occurs to give reliable river flows and generating capacity could be transmitted to those regions where droughts have reduced generating capacity. The management of the SAPP and the internal trading of electricity could enable the whole region to rely on a shared resource and enhance regional integration. There are continuing discussions, for example, on hydropower projects on the Congo River and in Zambia, Mozambique and Malawi. However, for political stability and sovereignty reasons, it is unlikely that countries will import more than a small proportion of their total electricity demands.

Related to the interlinked power sharing, river basin management is an increasingly important task. This has resulted in several cross-boundary commissions being established, for example the Interim Zambezi Watercourse Commission (ZAMCOM). Managing the freshwater impacts of climate change in southern Africa is fundamentally a development challenge within a changing climate (Pegram *et al.*, 2009). Even without climate change, much of the region's water resources are facing threats from overuse, pollution, and/or degradation. The existing capacity to adapt at different scale is uneven across the region, and is limited in areas of high vulnerability. Building resilience at all levels must therefore be the priority for adaptation to water-climate changes. This provides greater impetus for the adoption of good water resources management approaches that are widely accepted and reflected in policy and strategies across the region. The SADC Protocol on Shared Watercourses provides a strong foundation. While climate change poses significant challenges to water resources and transboundary water management across the region, it also provides opportunities and a strong imperative to address many of the developmental challenges facing the region (Pegram *et al.*, 2009). The work of the various River Basin Commissions in guiding equitable transboundary water resource management has gained urgency.

Food security is clearly a household level and national issue, but is also increasingly being recognised as a regional problem associated with poor market linkages and barriers to transboundary trade (de Wit, 2009). Southern Africa faces many challenges to its current agricultural and trade policies and strategies. Despite progress at policy level with regard to more liberalised trade both within SADC and between SADC and other regional economic communities (SACU, COMESA, EAC) it has as yet not contributed notably to declining undernourishment. Barriers to cross-border trade include export and import regulations, exorbitant taxes, border delays, poor transport infrastructure and high costs of transport. Regional trade must be a preferred response option to absorbing the shock of highly volatile domestic prices which can be triggered by supply deficits (de Wit, 2009). In addition, a robust regional agricultural policy, currently under development for both SADC and COMESA, should incorporate strategies for dealing with the impacts of climate change.

Other inter-regional dependencies are also being constructed. A SADC-wide standardisation and approvals of pharmaceuticals and drugs is being formulated. Cross-border flows of pharmaceuticals will be made easier, especially from South Africa which has the technical means to evaluate pharmaceutical efficacy and safety.

The threat of climate change thus provides a strong imperative for improved regional cooperation. MDG8 (global partnership for development) acquires additional urgency when seen in the light of future climate change. Additional finance from national budgets, international donors and lenders, and the private sector is required to deal with the added pressure. A key aspect is to engage the private sector in stimulating local and regional level partnerships (UN, 2008).

11.2 Global issues

The global financial crisis which began in 2008 has resulted in sharp reductions in projected Gross Domestic Product (GDP) growth rates. This is especially true for developing countries, with GDP growth being slashed to one quarter of that before the financial crisis occurred (World Bank, 2009). In sub-Saharan Africa particularly, growth is projected to have slowed to 1.7% in 2009 from 6.7% in 2006–2007, illustrating the momentous impact the crisis has had on post millennium development and growth in the region.

The UN progress report on MDGs (UN, 2009) found that the economic crisis had resulted in an additional 35 million people falling into extreme poverty, and the number of chronically malnourished reaching one billion. Progress toward MDG1, which aims to reduce by half the number of people suffering from hunger and extreme poverty, was in effect almost completely reversed in 2008 as a result of the rising food prices. In addition, it was estimated that the slow economic growth resulting from the financial crisis (in 2008) may cause between 200 000 to 400 000 additional infant deaths per year towards the MDG target year of 2015 (World Bank, 2009). The compounded impact of a shrinking economy, global contraction, and the ongoing economic crisis, results in unpredictable impacts and difficult scenarios. These make prediction very difficult when overlaying current and future climate trends. Experience indicates that the economic contraction resulting from the financial crisis will be large in terms of the impact on the MDGs, which are highly unlikely to be achieved at the current level of target. Climate induced stressor events, such as recent wild fires in Russia and unprecedented high and sustained summer temperatures, resulted in an export ban on wheat, stimulating price hikes in some regions. The knock-on effect of this in vulnerable poor communities where up to 80% of the household income is spent on food is further increases in breadth and depth of malnourishment.

These trends illustrate the importance of a broad approach when considering context-specific impacts, and when analysing climate change in the region; macro-economic influences and globalised political alliances filter through to regional and local government and thus play an influential role in the relationship and impact between climate change and the MDGs.

11.3 Beyond 2015

Although progress has been made on certain MDGs, this is unlikely to be rapid enough to offset population growth in many countries, thereby lowering the likelihood that the 2015 target will be met. More importantly than the 2015 deadline, however, is the beyond-2015 trajectory towards further progress in eliminating poverty, hunger and so on, where the impact of climate change is likely to be profound and result in arguably the most significant tangible impacts over the next 20–30 years.

The entrenched political frameworks associated with international climate change negotiations and climate financing, overlaid with the extended time frame of emerging climate impacts, motivate for a shift away from set timelines when assessing the impact of climate change on the MDGs. The setting of a 2015 boundary to achieve the MDGs is not only unrealistic in the context of the southern African region, it is detrimental with regards to creating unintentional policy and investment disincentives, particularly in light of current fiscal constraints in donor countries (UN, 2009). For example, in some countries national health budgets have seen a steady decline as treasuries ever more rely on increasing levels of donor support towards the achievement of the health MDGs. However, such short-term injections are not necessarily in the best interests of long-term development goals and can divert attention from the systemic issues that need to be addressed over longer time frames.

11.4 Consequences of weak mitigation efforts

When considering the southern African region, focused attention should be paid to the potentially disastrous impacts of weak international mitigation efforts. Lack of progress on curbing greenhouse gas emissions will essentially require a doubled effort on adaptation strategies to potentially deal with worst-case climate scenarios, for example a 3˚–4 ˚C temperature increase and possibly worse. In view of these requirements, very little overlap is identified in international guidelines and finance plans from key financing institutions with regards to disbursements needed to address climate change implications under various emissions scenarios and timescales, and create synergies between existing funding. Consequently, domestic capacity in the region to absorb funding needs to be urgently addressed to start filling the gap between adaptation requirements and the lack of international clarity in financing.

It is therefore essential to look for opportunities in the linkages between climate change and (notably) climate governance and the MDGs. Direct threats include the physical impact of climate change and the consequences for adaptation and mitigation requirements. However, it needs to be recognised within the region that opportunities exist to create positive collaboration in both the governance architecture surrounding climate change, such as improved alignment, communication and efficiencies between affected ministries, and that surrounding delivery on the MDGs, as well as existing and emerging financing schemes and dissemination of funds.

11.5 Financing

In line with regional agreements there are already linkages in the existing and emerging financial architecture to both support development towards the MDG indicators and implement climate mitigation and adaptation funding. The financial crisis showed that existing institutions, such as the African Development Bank (AfDB), were able to respond with innovative financing instruments (such as the Emergency Liquidity Facility and the Trade

Finance Initiative) to assist countries (ECA *et al*., 2010). The international climate change negotiations processes have yielded substantial financial pledges from developed countries; however, the key challenge is incorporating absorptive capacity for the LDCs and most vulnerable countries to channel these funds.

Least Developed Countries Fund (LDCF)

All four of the profiled LDC countries examined in the analysis are eligible to receive funds under the Least Developed Countries Fund (LDCF). The fund allows LDC states to apply for money to fund adaptation in two ways; firstly the development of National Adaptation Programmes of Action (NAPAs), which outline a country's adaptation priority projects, and secondly to fund the projects themselves. Not all LDC countries have yet accessed the LDCF for implementation, although all countries have received resources to support the development of NAPAs. The allocation of funds within the LDCF is based on a concept of balanced access, which means that all countries get an equal share of resources. The LDCF currently stands at just over USD 200 million, but when shared between 40+ LDC members, equates to less than UDS 10 million per country.

Adaptation Fund

The Adaptation Fund has been set up under the United Nations Framework Convention on Climate Change (UNFCCC) and is funded by a 2% levy on the sale of Certified Emissions Reductions. These funds are available to all Non-Annex I parties and can be accessed through either a Multilateral Implementing Entity (MIE) or a National Implementing Entity (NIE). To date there are five NIEs (Senegal, South Africa, Benin, Jamaica, and Uruguay) which means that other countries wishing to access this fund must do so through the more traditional route of development agencies. It is hoped that more countries will establish NIEs in the near future, which means that knowledge and capacity, as well as agency fees, remain in-country. Based on current projections, the volumes of resources that will likely be available through the Adaptation Fund are similar to those of the LDCF.

Development initiatives need to move away from dependency on donor programmes or loan campaigns. Phelisanong Project, Pitseng Lesotho.

12. Recommendations

A southern African entity that has the capacity to absorb finance, both focused on development and the MDG indicators, as well as climate financing for mitigation and adaptation, is required. Regional, national and local governments need to be capacitated to devise project and funding proposals to capitalise on emerging and existing opportunities for financing and governance that dovetails both climate change and MDGs, as the four key sectors chosen in this analysis have illustrated.

The political framework, which encompasses regional governments and transboundary institutions, needs to comprehend the overlap between the MDGs and climate change, being especially cognisant of opportunities as well as threats.

Governance structures which embrace the overlaps between climate change and the MDGS, and decentralise initiatives to lower sectors of government as well as non-governmental organisations (NGO), will be essential. Institutions need to continue motivating for a high level of political commitment to the MDGs and an understanding of the impact climate change is likely to have.

Weak climate change mitigation globally, and consequently the increasing likelihood of 'worst case scenarios' means that a robust climate change adaptation policy and project base is needed to ensure that the impact of climate change on the MDGs in southern Africa is minimised.

The impact of global economic forces in the region needs to be recognised, and as such a shift is required in national government thinking that encompasses a broader holistic systems analysis which is complemented by context specific information on key issues that need to be addressed.

The impact of global economic forces has resulted in a change in the development arena, where developed countries are now operating in a tight fiscal space. A paradigm shift is required where development and climate adaptation initiatives need to be driven by domestic treasuries and internal government, which has undergone a learning and capacity building phase. This signifies a key message in terms of move away from dependency on donor programmes or loan campaigns.

An effective, institutionalised monitoring and evaluation (M&E) framework needs to be conceptualised which incorporates the climate change and MDG overlaps which have been shown. This would focus on breaking the barriers to achieving the MDGs in the region which are often attributed to M&E which is not transparent or accountable.

Interventions to increase adaptive capacity at local level should include:

- Strategic investments in infrastructure, for improved water, energy, health and agricultural services, as well as transport and communication networks
- Ensuring investments which build resilience to climate change
- Building and strengthening of market linkages and trade systems; removal of regional trade barriers
- Investments in health systems and improved monitoring and data systems within this sector
- Stimulating agricultural innovation e.g. rainfed cropping, plant and animal genetics (breeding for resilience, alternate crops), plant and animal health, small-scale water harvesting, land use management
- Ecosystem restoration and repair of critical natural capital
- Improved (development) planning, incorporating the continuum of timescales (MDGs, climate change)
- Accessible and implementable policies, and enforcement of legislation
- Improved monitoring and data systems
- Improved infrastructure and systems for effective communication e.g. early warning of extreme weather
- Stronger cooperation between academic, civil society and government

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Acronyms and abbreviations

AfDB	African Development Bank
CC	Climate change
COMESA	Common Market of Eastern and Southern Africa
DRC	Democratic Republic of Congo
EAC	East African Community
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organisation of the United Nations
GCM	Global Circulation Model
GDP	Gross Domestic Product
GHG	Greenhouse gases
ICT	Information and communication technology
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-tropical Convergence Zone
LDC	Least developed countries
M&E	Monitoring and evaluation
MDG	Millennium Development Goal
MIE	Multilateral Implementing Entity
NAPA	National Adaptation Programme of Action
NGO	Non-governmental organisation
NIE	National Implementing Entity
RCCP	Regional Climate Change Programme
SACU	Southern Africa Customs Union
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SRES	Special Report on Emissions Scenarios
SSA	Sub-Saharan Africa
SST	Seas surface temperature
TB	Tuberculosis
UCT	University of Cape Town
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UNSD	United Nations Statistics Division
ZAMCOM	Zambezi Watercourse Commission

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