

Handbook on Adaptive Management Strategies and Options for the Water Sector in South Africa under Climate Change

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PREAMBLE

Climate change has been identified as one of South Africa's future threats on the country's path towards a sustainable and equitable development of society. Juxtaposed with this are land use changes which often amplify flow variability as a result of management practices. Furthermore, there remain disparities in water availability and access to water for many of the country's people, and these could well be amplified by climate change. Impacts of climate change and enhanced climate variability are thus now added to an already stressed water situation. It is crucial, therefore, in light of projected amplification of the effects of climate variability and climate change on hydrological responses, to increase the ability to respond to change. Adaptations, and hence adaptive capacity, call for the ability of responsiveness as well as a continual uptake of new information into decision making processes in order to evaluate the negative effects and potential benefits from climate change. This

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should be viewed as a practical aid in mainstreaming climate change issues into decision making. It constitutes one of three documents making up the final reports of WRC project K5/1843 titled ***An Evaluation of the Sensitivity of Socio-Economic Activities to Climate Change in Climatically Divergent South African Catchments***.

Please note that sections of this handbook are taken in their entirety or in parts from the following sources:

- Schulze, R.E. 2011. Climate Proofing the South African Water Sector 2: An Initial Study on Practical Suggestions for Adaptation to Climate Change. *In: Schulze, R.E. A 2011 Perspective on Climate Change and the South African Water Sector*. Water Research Commission, Pretoria, RSA, WRC Report 1843/2/12, Chapter 9.3, 309-364.
- Stuart-Hill, S. I. and Herrfahrdt-Pähle, E. 2011. A Framework to Mainstream Climate Change into Decision Making Processes of South African Water Managers. German Development Institute, Bonn, Germany.

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Why a Handbook?

Climate change has been identified in South Africa's Second National Communication to the UN Framework Convention on Climate Change (DEA, 2010) as one of the country's threats on its path towards sustainable development in future and an equitable society. Climate change is not expected to have a uniform impact across the country, and is projected to be accompanied by increased variability in precipitation and temperature.

Taking current knowledge to a new level, updating it and making it more relevant as well as usable for water managers in their decision making processes, was the major goal of WRC project K5/1843, of which this handbook forms one component. Reduction of existing and anticipated vulnerability of societies, the economy and the environment under a changing future can only be achieved through appropriate adaptation strategies. Consequently, a transition into a pro-active and an adaptive management approach is imperative.

Hopefully, with this Handbook an awareness will be created not only of potential impacts of climate change, but also of the role that each one of us plays in the water sector. Furthermore, this Handbook aims at introducing a potential pathway and process which empowers the water sector and individuals within it to act in the face of climate change by adapting timeously and adequately.

With projected impacts on drought, flooding, evaporation, storm surges, melting ice caps and sea-level rise, the hydrological cycle is one component of the Earth's system that will be most affected by climate change. Many of the impacts of climate change, including its effects on climate variability, will manifest themselves on the availability of, and demand on, water resources. Areas affected will include the functioning and operation of existing water infrastructure, such as structural flood defences, drainage and irrigation systems, as well as vital services provided by natural ecosystems. Water is therefore seen as the primary medium through which climate change impacts will be felt by people, ecosystems and economies.

Climate change presents serious water-related risks. Therefore it calls for global, regional and local responses that need to be

designed in an integrated and adaptive manner in order to provide sustainable and relevant solutions for our country. To achieve this, everyone active in the water sector needs to become involved and bring their knowledge and expertise to the table. This has to go in parallel with an appropriate evaluation of South Africa's finite water resources, a forward looking learning approach and a better understanding of the complex feedbacks that characterise the catchment hydrological cycle.

So, You Think that You are Not Part of the Water Sector?

Well, rethink: ARE YOU USING WATER ON A DAY-TO-DAY BASIS? IS WATER A RESOURCE THAT YOUR BUSINESS IS USING, AND HENCE YOUR PRODUCT OR SERVICE IS DEPENDING ON? If you have answered one of these questions with a YES – and even if only half heartedly so – then you are part of the water sector and this Handbook is for YOU!

What Does Climate Change Imply for South Africa and What is Adaptive Management?

Impacts of climate change resulting in the need for adaptation hold particular significance for South Africa for a number of reasons (Schulze 2005; 2007; 2011):

- South Africa is already subjected to a high risk climate with a low conversion of rainfall to runoff and very high year-to-year variability;
- Any changes in rainfall are amplified by hydrological responses, e.g. a 10% change in rainfall can result in up to a 20-30% change in runoff;
- Many fragile ecosystems (both terrestrial and aquatic) are directly or indirectly dependent on water;
- Climate change does not occur over clean, virgin catchments ... it is superimposed onto existing, already stressed catchments on which land degradation can further amplifies climate change impacts;
- A large proportion of South Africa's population is impoverished, subjected to the vagaries of climate and are hence vulnerable to any changes in climate;
- Water related infrastructure has a typical design life of 50-100 years, i.e. well into the era of increasing climate change impacts;
- Water quality in South Africa has deteriorated and is getting poorer. Significantly, with a 2-3°C increase in temperature most chemical reactions will speed up markedly;
- Given the link between climate change, hydrological responses, land use and economic development, climate change can play out very differently at the local level, implying that adaptation also becomes a local issue.

All these factors create vulnerability, not only for the poor, but across all sectors in South Africa. Our country is a land of great diversity, in its landscapes, flora and fauna, but also within its people and economy we find huge discrepancies manifesting themselves in poverty vs. wealth, rural vs. urban, industrialised vs. undeveloped areas, subsistence farming vs. agribusiness etc. The upshot of this is that climate change impacts will create local, regional and sectoral "winners" and "losers".

In order to consider not only the variations in vulnerabilities resulting from historic and current inequalities, but also the dynamics that unfold from growth and development in our country, we need to be adaptive when managing these challenges and creating relevant solutions. We need to learn to be responsive and innovative within our working environment. Adaptive management practices will cater for this as long as the following issues (Allen and Stankey, 2009) are included:

- **Understanding the context is critical.** This reinforces the importance of a broad-based, inclusive and participatory structure as part of any adaptive management enterprise – without this it is difficult to develop a comprehensive grasp of the scope and detail of context.
- **Honest, public articulation of what it means to undertake adaptive management.** Adaptive management needs to be seen as something more than “making it up as we go”, or “business as usual”. It is critical that policy makers and practitioners move beyond rhetoric and engage in explicit discussions that are purposeful and deliberate, are characterised by careful documentation processes, and are designed to promote learning that translates into action.
- **Purposeful and deliberate.** Effective adaptive management begins with the framing of good questions. Only then can problems (in our case climate change impacts) be clarified and framed in a way that ensures that subsequent management actions are relevant and useful. This suggests that the simple depiction “plan-act-monitor-evaluate” needs to include a continuous process of feedbacks, leading to a reformulation of problems, tactics and strategies.
- **Careful documentation.** Good documentation, including systematic monitoring, is necessary to facilitate examination and analysis of data, and for sharing the lessons learned and any new knowledge gained with other practitioners, including those who will make decisions in the future.
- **Promote ongoing learning processes that translate into action.** Organisations need to acknowledge that organisational commitment, the will to act, as well as a capacity to act, is crucial in the process.
- **Supporting the “right” people is critical.** People who bring enthusiasm and energy to the climate change adaptation

debate, who have established respect and trust among their colleagues and who have a commitment to change and the capacity to cope with ambiguity and uncertainty, are essential. Such leadership is not always at the top of the organisational hierarchy. Indeed, advocates and champions are needed at multiple levels in any organisation as well as from internal and external sources.

In the South African context it is vital to overcome the current lack of integration and coordination between all relevant organisations.

A Summary of Key Take-Home Messages

During the study on “A 2011 Perspective on Climate Change and the South African Water Sector” (Schulze, 2011) a number of key general findings came to the fore. These are summarised below.

- There is no doubt that climate change poses new challenges to water resource managers in South Africa. The climatically determined future is certainly not all “gloom and doom, however, as some authoritative spokespersons would have it, but neither do the results of the study suggest, as certain water strategists argue, that “everything is under control” in the water sector in regard to climate change.
- Some areas within South Africa are likely to become “winners” in light of certain projected changes and new water related opportunities will arise, while other areas are likely to become “losers” in the sense that more water related stresses are likely to be experienced. “Hotspots” of concern which were identified time and again in the assessments of impacts were the southwest of the country, the west coast and, to a lesser extent, the extreme north of South Africa (examples in **Figure 1**).

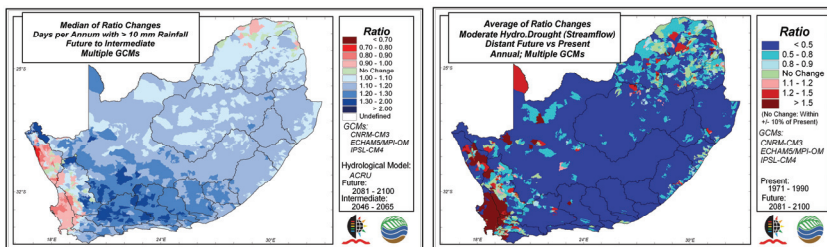


Figure 1 Examples of the southwest being a “hotspot” of concern to water resource management under conditions of projected climate change, based on output from multiple GCMs. On the left are ratio changes between the more distant future (2071-2100) and the intermediate future (2046-2065) of days per annum with runoff producing rainfall of > 10 mm per day while on the right ratio changes between distant future and present (1971-1990) hydrological droughts of moderate severity are shown

- Results from analyses of ratios of change, based on output from multiple GCMs used as input to the ACRU model (Schulze, 1995), show that patterns of change across South Africa are

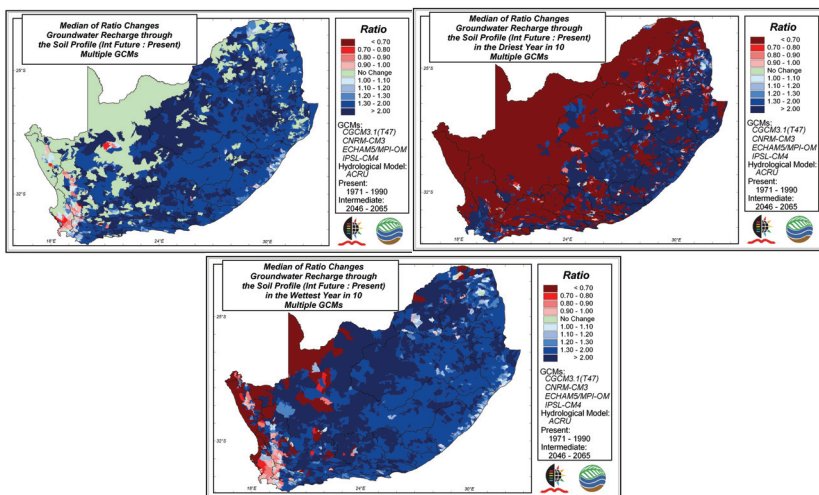


Figure 2 Example of patterns of change being different between average, dry and wet years: Medians of ratio changes of intermediate future to present recharge of water through the soil profile into the groundwater store in a year of median recharge (top left), the year with the lowest recharge in 10 years (top right) and the year with the highest recharge in 10 years (bottom), derived with the ACRU model from output of multiple GCMs

often projected to differ between future “average year” conditions vs. future 1 in 10 year wet or 1 in 10 year dry conditions (e.g. in the cases of projected changes in stormflow, baseflow, sediment yield or net irrigation requirements). An example is given in **Figure 2**. Some changes were found to be positive, others were found to be potentially more detrimental, and this finding will place an added challenge to future water management.

- Another finding was that the transitional zone between the winter and summer rainfall area (**Figure 3**, top left) in the western interior of South Africa appears to be an area of high sensitivity and of inconsistent change (as illustrated by the low index of consistency of change between the five GCMs in **Figure 3**, top right), with frequently the highest ratios of change occurring there. This was observed, for example, in the case of projected changes to stormflows, peak discharge (**Figure 3**, bottom) and design streamflows.

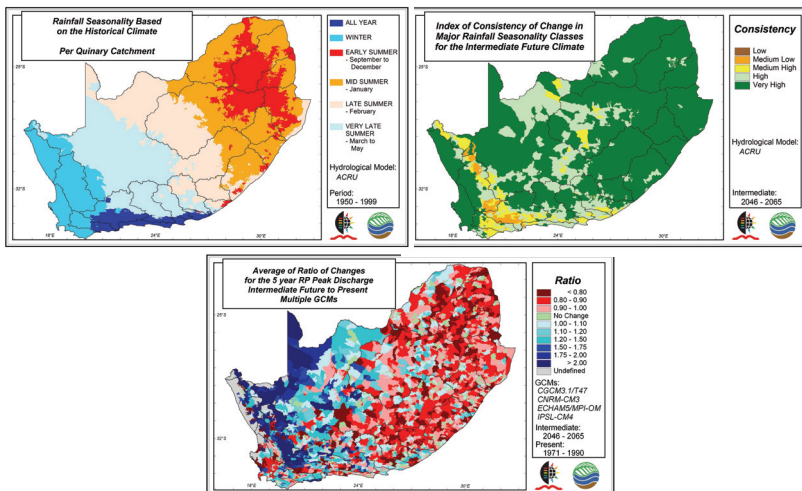


Figure 3 Example of the transitional zone between the winter and summer rainfall area (top left) being an area of inconsistent change between GCMs (top right) and of high sensitivity to climate change (bottom) by the low index of consistency of change between the five GCMs used (top right), with frequently the highest ratios of change occurring there. This was observed, for example, in the case of projected changes to stormflows, peak discharge (**Figure 3**, bottom) and design streamflows.

- An intensification (both + and -), and associated expansion in area, was frequently shown for patterns of change in the relatively short period of 35 years from the intermediate future (2046-2065) to the more distant future (2081-2100), illustrating an acceleration and amplification of impacts into the second half of the century when compared with the relatively long 75 year period between the present (1971-1990) and the intermediate future. The high sensitivity of this later period was evident in the climate change assessments of, *inter alia*, accumulated streamflows (**Figure 4**), thresholds of streamflows exceeded, meteorological droughts, net irrigation requirements and deep percolation losses from irrigated lands.
- In general the results showed an increase in the year-to-year variability of hydrological responses into the future, often a quite substantial increase, especially when inter-annual variability was expressed in absolute terms by the standard deviation

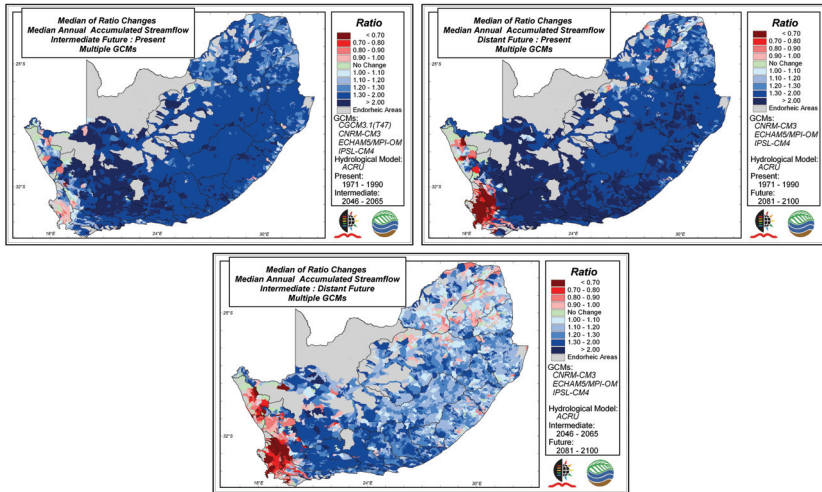


Figure 4 Example of the intensification of change in the latter part of this century by comparing ratios of change derived from multiple GCMs of median annual streamflows between the 75 year time period from the intermediate future and present (top left), the 110 year period from the more distant future and present (top right) and the 35 year period between the more distant and intermediate future (bottom)

(**Figure 5**). The increase in variability also tended to be higher into the more distant future than between the intermediate future and present. Where both the standard deviation and the coefficient of variation (a relative indicator of variability) were shown to increase, those areas were considered to be particularly sensitive to climate change. Examples of increases in variability included changes in rainfall, to stormflows, accumulated streamflows and to sediment yields.

- Patterns of change into the future of certain hydrological variables are not always smooth across South Africa. Often strong gradients of change over very short distances were shown from the analyses, sometimes even changing sign from increases to decreases over short distances. Examples of this were found in evaluations of changes in baseflows, stormflows and surface runoff losses from irrigated areas (**Figure 6**).
- Some components of the hydrological system were found to be more sensitive to climate change than others, sometimes

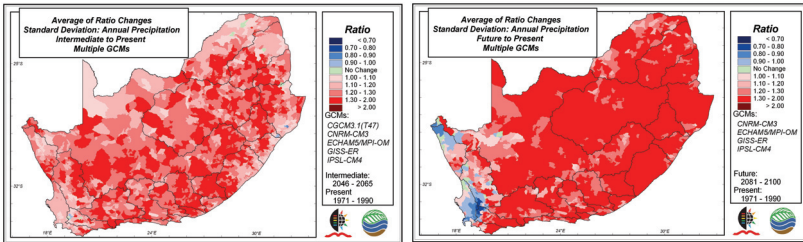


Figure 5 Example of increases in the variability of annual precipitation under projected future climates, derived from multiple GCMs, with variability **generally** increasing more into the distant future (right)

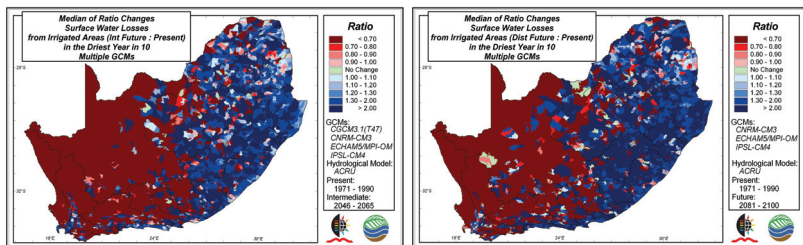


Figure 6 Example of abrupt changes with changes over short distances, including changes in sign, taken from ratio changes of surface water losses from irrigated areas between the intermediate future and present (left) and more distant future and present (right), derived with the ACRU model from output of multiple GCMs

displaying a doubling or more, or a halving or more, of change into the future. Examples of sensitive components identified in this study were changes to baseflows, hydrological droughts and surface runoff losses from irrigated lands (**Figure 6**).

- From an engineering perspective, an important finding was that projected spatial changes to design rainfall and design streamflows vary with return period (**Figure 7**) rather than with critical duration, and this should be factored into future hydraulic designs.
- A strong amplification / intensification was shown when changes in rainfall parameters were compared with equivalent changes in runoff responses, highlighting again the high sensitivity of changes in rainfall in the hydrological cycle. Examples of this amplification include a comparison of hydrological drought (more sensitive) vs. meteorological drought (less sensitive) for the same duration and level of severity, as well as of design

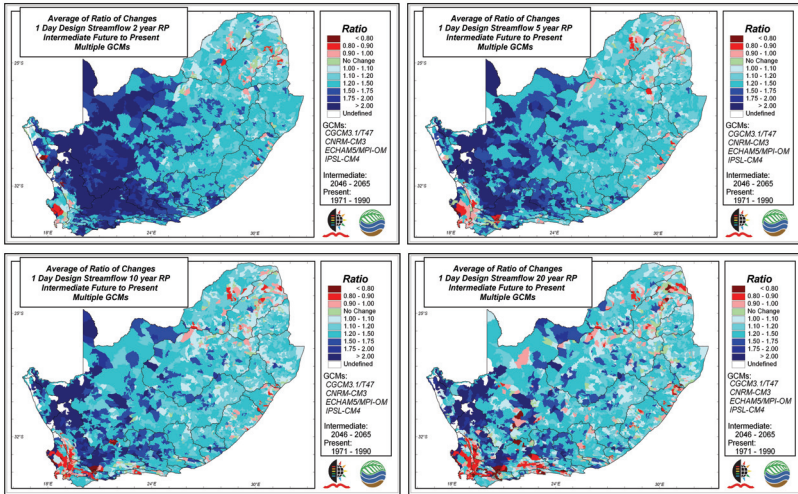


Figure 7 Averages of ratio changes of intermediate future to present one day design streamflows for the 2 year return period (top left), as well as the 5 (top right), 10 (bottom left) and 20 year return period (bottom right), derived with the *ACRU* model from output of multiple GCMs, illustrating that changes in design streamflows (and also design rainfall) vary with return period

streamflows vs. design rainfall for the same duration and return period (**Figure 8**).

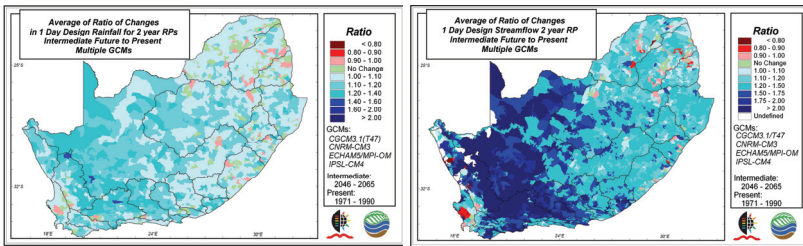


Figure 8 Comparison of averages of ratio changes from the present into the intermediate future between design rainfalls (left) and design streamflows (right) for the identical duration and return period, derived with the *ACRU* model from output of multiple GCMs, illustrating the amplification when changes in rainfall parameters are compared to equivalent changes in streamflow responses

This study by Schulze (2011) has also identified the need for assessing climate change impacts in hydrological responses from more GCMs than those used here, for a wider range of emissions scenarios to be considered and for periods longer than 20 year time slices of projected climates to be used, in order to achieve higher confidence in results.

Why Should YOU Act?

Adaptation activities themselves mostly take place within peoples' daily lives and therefore mostly in a local context (e.g. Adger, 2001). In order to make knowledge and choices for adaptation available on a local level, adaptation must be included on a governance and long-term planning scale. The local context is extremely complex as it is simultaneously embedded in social relations (Senge and Schrammer, 2001). Gaining a holistic view of adaptation can only be achieved by participation which can give insight into the *status quo* of peoples' perceptions, needs, and vulnerabilities.

Consequently, stakeholder engagement is seen as vital for adaptive water management

- first, as a means of jointly framing the priority issues and questions to be addressed,
- secondly, as a means of collaborative sense-making leading to joint agreement of appropriate solutions and
- thirdly, and perhaps most importantly, as a mechanism for building ownership of the implementation of these solutions.

Learning to do adaptive management is thus not only about a different, more experimental approach to management, but also about broadening the number and diversity of players involved, to embrace partnership and to apply networked approaches. This is where all players in the water sector from all levels need to get involved. No change, no improvement can be achieved when we carry on with business as usual. The severity of our water problems today will only be exacerbated in a future under climate change. So we all need to decide: Is it time to act? Do I want to be part of the "losers" or "winners"?

YOUR Window of Opportunity to Act

Some models of change highlight the importance of windows of opportunity for introducing new practices. The period around the development and agreement of South Africa's National Water Act in the 1990s can be seen as one such window of opportunity. Climate change introduces a new window of opportunity for the development of new management practices with a strong focus on adaptive management.

Let's have a closer look at this:



WHAT DOES THIS MEAN FOR YOU?

The world is now locked into a pattern of change, and the opportunity for preventing any warming has passed (IPCC, 2007). Societies must respond both by minimizing any further warming (through mitigation to reduce the concentrations of greenhouse gases in the atmosphere) and by finding ways to adapting the impacts that warming is projected to bring (some would argue is already bringing), including shifting precipitation regimes, more frequent and severe extreme weather events and sea-level rise. Adaptation policy is a crucial means by which to prepare to deal with the unavoidable impacts of climate change.

Climate change adaptation reinforces the need for integrated water management approaches, including systems approaches.

Climate change adaptation highlights the need to move beyond current approaches to risk management and to take uncertainties and unknowns into account, rather than simply trying to reduce them.

Climate change adaptation places a new emphasis on vulnerabilities. This includes the vulnerabilities both of ecosystems and the critical services these provide, and also of vulnerable groups of

Climate change adaptation reinforces the need for innovative, collaborative and adaptive management approaches, with experimental and social learning approaches as a cornerstone, and where these break down, preparedness to manage water conflicts.

Climate change adaptation requires both top down and bottom up responses, and strong leadership from all sectors of society, including government, business and civil society.

Climate change pushes us to act now and to find a “walkable” path into the future. In South Africa we have a unique set of laws and policies that offer manifold **regulatory windows of opportunities** through which to become involved and act. These include:

... the National Water Resource Strategy and its updates

The first National Water Resource Strategy was published in 2004 (DWA, 2004) and the second is to be completed in 2011. The regular updates of the NWRS provide an important opportunity not only to highlight the increased significance of IWRM, but more specifically can bring to the fore collaborative and adaptive management approaches in the context of climate change adaptation as and when our understanding of projected impacts of climate change improves. The NWRS paves our way forward in managing with our water resources.

... the development of Catchment Management Strategies

Two catchment management strategies (CMSs) have now (2011) been developed – in the Inkomati (ICMA, 2010) and the Breede (Enright, personal communication). Both should be reviewed in light of climate change adaptation issues as we understand these at present, and should be reviewed again in future when new climate change information is available. Those catchments where a Catchment Management Agency (CMA) is currently absent, this Handbook could be utilised for integrating and mainstreaming climate change into the decision processes of the CMA and the resulting CMS.

... the water allocation reform

Water Allocation Reform (WAR) is a stated priority of the DWA and a toolkit to support the WAR process has been produced (DWA, 2007). Catchment Management Strategies are a key mechanism for agreeing to more equitable water allocation, but in the absence of CMAs, the WAR process can be undertaken by the DWA. Drawing on the framework provided later in this Handbook, recommendations could be developed for ways in which the WAR toolkit could be updated to take account of climate change adaptation.

... the identification of climate hotspots and initiating plans of action

Cape Town and Durban, for example, are both currently participating in an ICLEI Africa-led project “Sub-Saharan Cities: A Six City

Network to Pioneer Climate Adaptation through Participation Research and Local Action” while further north within the country the Shared Rivers Initiative is researching the institutional barriers to benefiting from sharing and how these might be overcome (Pollard and du Toit, 2010). These cases show that action can be taken without national government or provinces pushing for adaptation. Find YOUR niche!

Additionally, there are **policy windows** that open up and offer an opportunity to act. Such windows, described by Vennix (1996), can be very influential as the topic of such a policy window is not only paid serious attention to by parliament or the presidency, but they may result in a state where decisions are planned and are then taken. Regretfully such windows of opportunity open up infrequently and they often only stay open for a short period of time, so initiative has to be taken as soon as they open. Currently such open policy windows include:

...capacity building

The transformation agenda of South Africa places huge emphasis on the need for skills development and overall human capacity building. Expert interviews have shown that overall in South Africa sufficient capacity probably exists, but certain types of capacity are seen to be in short supply by different experts. Hence, one needs to be clear about the type of capacity building required (be it political¹, professional², implementation³ or compliance⁴ capacity), as tailored actions are needed for different human resource skills tools to be sharpened.

... reducing illegal water abstractions

Expert interviews by the senior author as well as workshops held during the course of this project have shown a growing concern in regard to illegal water abstractions. This pushes issues of law

¹ Are there influential champions for the reform, can the reform produce results within a politically relevant time-scale, can ministries with different perspectives on water be brought on board or isolated?

² Are there the professional skills needed to draft legislation, provide regulation or adjudication, provide conflict resolution etc.?

³ Do the agencies charged with implementing the technical and, financial tasks at hand have the human resources necessary to fulfil the task?

⁴ Many of the tools are designed to change water use behaviour; do users have the knowledge and ability to respond?

enforcement and monitoring higher up the agenda. Furthermore, illegal abstractions impact significantly on water availability which can potentially compromise any environmental goods and services provided by the catchment.

... curbing deteriorating water quality

Although water quality issues exist throughout the country, there are currently two hotspots of concern: the mining areas in Gauteng and various catchments in the Western Cape. The latter, from which a wide variety of agricultural products are exported into the European market, have to adhere to European quality standards. Deteriorating water quality reflects in the product's quality. This is becoming increasingly problematic as product quality is starting to borderline on minimum quality standards.

... enhancing ecosystem services to aid the second economy

There is now significant interest across a number of state departments in developing payment schemes for ecosystem services (PES) that directly benefit poor and vulnerable communities and contribute both to resource protection / restoration and sustainable livelihoods. The development of such schemes is being considered on a watershed basis. Pilot studies have been undertaken in several catchments (e.g. Maloti Drakensberg Transfrontier Project 2008; Blignaut *et al.*, 2008, 2010; Lankford *et al.*, 2010; Mander *et al.*, 2010) and some already factor climate change adaptation into their analyses.

...promoting biodiversity when development is planned

Healthy, biodiverse catchment areas play a vital role in maintaining and increasing the resilience of ecological communities and society to climate change and in reducing climate related risks and vulnerabilities. For disaster risk management and managing other climatically determined extreme events the riparian zone is an indispensable asset that needs to be preserved.

... appreciating the importance of the water-energy-food security nexus

The production of food relies strongly on the availability of sufficient water – in both quantity AND quality. South Africa has a highly technological commercial agriculture sector with significant areas under irrigation. Approximately 60% of South Africa's water

resources go to irrigation. Furthermore, the access to food is influenced by multiple factors not well understood. However, it is estimated that 39% of South Africa's population is vulnerable to food insecurity.

Finding your window of opportunity is crucial to starting a process of adaptive management and designing adaptation activities or strategies, especially those related to climate change.

Define YOUR Role in the Water Sector and What YOU may have to Adapt to

A crucial starting point is to know your role in the water sector. The key question is: IN WHICH CONTEXT ARE YOU ACTING AND MAKING DECISIONS?

Here we will introduce you to some recommendations for actors in the South African water related sectors, based on ideas first used in Appleton *et al.* (2003) and then elaborated upon by Schulze (2005; 2011). The cross references in the third column of the tables which follow lead you to the publication titled ***A 2011 Perspective on Climate Change and the South African Water Sector*** (Schulze, 2011), another product of WRC project K5/1843. The maps you will find in that document can be used as a starting point in the information and knowledge creation. This, in turn, sets you up for the next section of this handbook, when creating a process to include climate change into decision making processes and finally designing adaptation activities or strategies.

1. Who needs to adapt within the South African water related sector?

Decide which water related sector you are part of or are representing, e.g.

- *National Water Planners (e.g. Department of Water Affairs, DWA)*
- *Regional Water Planners (e.g. Catchment Management Agencies, CMAs)*
- *Bulk Water Suppliers (e.g. Umgeni Water)*
- *Water User Associations / Irrigation Boards (e.g. Pongola Irrigation Board)*
- *Municipalities*
- *Disaster Risk Management*
- *Rainfed Agriculture, including Livestock Activities*
- *Irrigated Agriculture*
- *Insurance Industry*
- *Road Transport Sector*
- *Thermal Electric Power Industry (e.g. Eskom)*
- *Hydro-Electric Power*
- *Poor Rural Communities*
- *Informal Urban Communities*
- *Individual Households*
- *Aquatic Ecosystems (e.g. estuaries, wetlands, buffers, environmental flows)*
- *Terrestrial Ecosystems (e.g. biodiversity, land degradation, fire, alien invasive plants)*

2. What do we need to adapt to, or cope with?

The sectors listed under point 1 above make up the wider water community in South Africa. Those who manage water will need to cope with, and adapt to, a range of changes which are foreseen in regard to climate drivers and the hydrological responses to the changes of those drivers. Anticipated changes to the following are considered in this initial study, noting that the list below is not exhaustive and that the distinction between what are considered drivers and what are seen as responses is not always clear-cut. References to Chapters in Schulze (2011) and to other Reports on where to find some information on projected impacts in South Africa are also provided.

a. Drivers: Changes in...

- Enhanced Evaporation – Ch 4.1, 4.2, 8.1

- Heat Waves – See Schulze and Kunz (2010; Ch 3.4)
- Water Temperature – See Barichiev *et al.* (2010a; Ch 13 and 14)
- Thresholds of Rainfall Exceeded – Ch 3.6
- Design Precipitation – Short Duration (5 min-24 h) – Ch 7.1
- Design Precipitation – Long Duration (1-7 days) – Ch 7.2

b. Responses: Changes in...

- Soil Moisture – Ch 4.2
- Groundwater Recharge – Ch 5.3
- Thresholds of Streamflows Exceeded – Ch 5.5
- Flash Floods – Ch 5.6, 7.1
- Regional Floods – Ch 5.2, 5.4, 7.3
- Design Streamflow Volumes – Ch 7.3
- Design Peak Discharge – Ch 5.6
- Agricultural Droughts – Ch 4.2, 6.1, 6.2, 8.2
- Hydrological Droughts – Ch 5.5, 6.1, 6.2, 8.1, 8.2
- Surface Water Supply – Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4
- Transboundary Flows (Quantity and quality) – Ch 5.4, 5.5, 5.7, 6.2, 7.2, 7.3, 8.1, 8.2, 8.3
- Groundwater Supply – Not addressed in Schulze (2011)
- Water Quality – Sediments – Ch 5.7
- Water Quality – Chemical – Ch 8.3
- Water Quality – Biological – Not addressed in Schulze (2011)
- Environmental Flows – See Barichiev *et al.* (2010b; Ch 12)
- Storm Surges – Not addressed in Schulze (2011)
- Sea Level Rise – Not addressed in Schulze (2011)

3. What categories can we identify in order to adapt to climate change in the South African water related sector?

a. Technological and Structural Considerations

- Storage and Reticulation
 - Surface Water (e.g. large reservoirs; small reservoirs)
 - Groundwater (e.g. artificial recharge; borehole drilling; sand dams)
 - System Maintenance (e.g. supply leakage control; irrigation equipment maintenance; irrigation canal leakage / losses)
 - Rainwater Harvesting
 - Water Re-use / Recycling
- Water Quality and Quantity Monitoring Systems
- Desalination
- Flood / Storm Surge Control

- Structures (i.e. dams, spillways, stormwater systems, levees, sand bags, wave breaks, vegetative planting)
- Early Warning Systems
 - Near Real-Time (Hours to one day)
 - Short-Term (Days to weeks)
 - Medium-Term (Month to season)
 - Long-Term (Years to decades)
- Communication of Forecasts to End Users
 - Awareness Creation at Higher Decision Making Level
 - Awareness Creation at Operational Level (e.g. Municipal wastewater treatment, i.e. WWT)
 - Training at Middle Management Level
 - Training at Local Level (e.g. Municipal WWT operators)
- Operations / System Improvements (e.g. reservoir operating rules; retrofitting existing structures; irrigation scheduling; wastewater treatment works; sanitation)
- Water Demand Management
- Indigenous Coping Strategies
- Precipitation Enhancement
- b. *Knowledge / Skills / Participation Issues*
 - Research and Development
 - Efficient Technologies
 - Upgrading of Climate Models (e.g. improvements to downscaling / RCM; fine scale information provision relevant to local water managers)
 - Improve Forecast Skill / Dissemination
 - Development of Drought Resistant Crops
 - Development of Risk Maps / Floodlines
 - Communication, Training, Dissemination
 - Awareness Creation at Higher Decision Making Level
 - Awareness Creation at Operational Level (e.g. Municipal wastewater treatment, i.e. WWT)
 - Training at Middle Management Level
 - Training at Local Level (e.g. Municipal WWT operators)
 - Knowledge Management to Influence Decision Making (e.g. synthesising; re-assessing; sectorising)
 - Participatory Approach in Decision-Making
 - Establishment of Inter-Departmental Learning Platforms (e.g. task teams)
 - Establishment of an Integrated Communication System (e.g. trends, priorities, activities, risks)

- Creation of Ongoing Learning and Communication Platforms between Main Water Users (e.g. WRC Reference Group meetings)
- c. **Policy Instruments**
 - International Conventions (e.g. UNFCCC)
 - International Water Agreements
 - International Trade
 - National Water Master Plans (e.g. National Water Act of 1998; Water Services Act of 1997; National Water Resource Strategy of 2004, 2011; Water for Growth and Development Framework of 2009; Catchment Management Strategies; Estuary Management Plans)
 - Other National Master Plans (e.g. National Environmental Management Act; Conservation of Agricultural Resources Act; Integrated Development Plans)
 - Provincial Strategies (e.g. Provincial Growth and Development Strategies; Provincial Water Reconciliation Strategies)
 - Local Strategies (e.g. Municipal Bye-Laws)
 - Disaster Management Policies / Action Plans
- d. **Risk Sharing / Spreading**
 - Private Sector Strategies
 - Insurance (e.g. primary insurers; re-insurance; micro-insurance)
 - Banks (e.g. development; private; micro-lenders)
 - Stock Exchange
 - Public Sector Strategies
 - Drought and Flood Relief by Government
- e. **Change of Use / Activity / Location**
 - Land Use Measures (e.g. conservation structures; adaptive spatial planning; tillage practices; use of organic fertilizers; alien invasive clearing activities)
 - Crop Changes
 - Resettlement
 - Maintenance or Re-establishment of Natural Capital (e.g. wetlands, estuaries, buffers etc)

4. **Choose what you need to focus on**

Refer to the relevant table and look at the sub-section (column 1) and the corresponding hydrological responses (column 2). Make your choice what you need to focus on, or alternatively develop a set of corresponding priorities.

5. *Gain further insights*

Check in Schulze 2011 and other relevant literature and available data in order to gain insight into the impacts of climate change and broaden your knowledge base.

6. *Identify vulnerabilities*

Use the Population Census (e.g. 2001; 2011) or other socio-economic information you have available to identify vulnerabilities.

7. *Start a stakeholder process*

Armed with the above you can start a stakeholder process that creates the interdisciplinary environment required to drive a successful process as described in the next section. Your process outcome will allow you to design relevant and sustainable adaptation activities, as is described in the examples given in the last section of this Handbook.

Modus Operandi

The 17 tables developed by Schulze (2011) and given below are self-standing, as in practice each of the different sectors considered here are likely to evaluate their sector-specific table by itself, without necessarily cross-referencing to tables on other sectors. For this reason also, each of the tables (which are of different lengths) starts on a separate page. It is anticipated that individual sectors will debate and elaborate on the contents of their specific table and that in follow-up workshops the tables will be amended, expanded and improved upon. At this juncture no explanations are given as to which drivers and responses have been included in a specific table; this is likely to happen at sector-specific workshops at a later stage. Cross-reference is also made in the third column to Chapters from Schulze (2011) in which more information can be gleaned and impacts maps obtained, as well as to some other sources of information. These cross-references are not exhaustive and will be added to in future.

Table 1 Adaptation recommendations for the National Water Planning sector (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
- Storage and Reticulation - Surface Water - Large Reservoirs - Early Warning Systems - Short-Term (Days to Weeks) - Medium-Term (Month to Season) - Long-Term (Years to Decades) - Operations / System Improvements - Reservoir Operations Rules - Water Demand Management	- Regional Floods - Hydrological Droughts - Surface Water Supply - Storm Surges - Transboundary Flows - Environmental Flows - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak discharge - Enhanced Evaporation - Threshold Streamflows - Regional Floods - Hydrological Droughts - Agricultural Droughts - DDF - Streamflows - DDF - Peak Discharge - Water Quality - Chem - Water Quality - Biol - Hydrological Droughts - Agricultural Droughts - Surface Water Supply - Groundwater Recharge - Regional Floods - Hydrological Droughts - Surface Water Supply - Groundwater Recharge - Water Quality - Seds - Water Quality - Chem - Regional Floods - Hydrological Droughts - DDF - Peak Discharge - DDF - Streamflows - Water Temperature - Water Quality - Chem - Water Quality - Biol - Agricultural Droughts	Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Not in Report Ch 5.4, 5.5, 5.7, 6.2, 7.3, 8.2, 8.3 See Barichievsky <i>et al.</i> (2010b) Ch 7.2 Ch 7.3 Ch 5.6 Ch 4.1, 4.2, 8.1 Ch 5.5 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.3 Ch 5.6 Ch 8.3 Not in Report Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.7 Ch 8.3 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.6 Ch 7.3 See Barichievsky <i>et al.</i> (2010a) Ch 8.3 Not in Report Ch 4.2, 6.1, 6.2, 8.2

Hydrological Droughts			Ch 5.5, 6.1, 6.2, 8.1, 8.2
KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES	
• Research and Development - Efficient Technologies - Upgrading of Climate Models ▫ Improvements to Downscaling / RCMs - Improvement of Forecast Skill / Dissemination • Development of Risk Maps / Floodlines • Communication / Training / Dissemination - Awareness Creation at Higher-Decision Making Level • Participatory Approach in Decision-Making - Establishment of Inter-Departmental Learning Platforms - Establishment of Integrated Communication Systems	• All • All • All • All • Regional Floods - Flash Floods - Hydrological Droughts - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Peak Discharge - Sea Level Rise - Storm Surges • All • All • All	Ch 7.2, 7.3 Ch 5.6, 7.1 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 7.1 Ch 7.2 Ch 5.6 Not in Report Not in Report	
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES	
• International Conventions (e.g. UNFCCC) • International Water Agreements • National Water Master Plans - National Water Act of 1998 - National Water Resource Strategy • Other National Master Plans - National Environmental Management Act	• All • All • All • All • Environmental Flows	See Barichievsky <i>et al.</i> (2010b)	

- Conservation of Agricultural Resources Act • Disaster Management Policies / Plans	• Water Quality - Seds - Water Quality - Chem • Flash Floods - Regional Floods - Agricultural Droughts - Hydrological Droughts	Ch 5.7 Ch 8.3 Ch 5.6, 7.1 Ch 5.2, 5.4, 7.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN ...	CROSS REFERENCES
• Private Sector Strategies - Banks ▫ Development	• All	
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN ...	CROSS REFERENCES
• Land Use Measures - Adaptive Spatial Planning	• Flash Floods - Regional Floods - DDF - Streamflows - Surface Water Supply - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol - Sea Level Rise - Storm Surges	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.3 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.7 Ch 8.3 Not in Report Not in Report Not in Report

Table 2 Adaptation recommendations for Regional Water Planners, CMAs (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
- Storage and Reticulation - Surface Water - Large Reservoirs - Small Reservoirs - Groundwater - Artificial Recharge - Borehole Drilling - Sand Dams - Water Re-use / Recycling - Flood / Storm Surge	- Regional Floods - Agricultural Droughts - Hydrological Droughts - Transboundary Flows - Surface Water Supply - DDF - Streamflows - Threshold Streamflows - Enhanced Evaporation - Water Quality - Chem - Water Quality - Biol - Water Temperature - Storm Surges - Flash Floods - Agricultural Droughts - Hydrological Droughts - Surface Water Supply - Threshold Streamflows - Enhanced Evaporation - Water Quality - Chem - Water Quality - Biol - Water Temperature - DDF - Rainfall : Short - DDF - Streamflows - DDF - Peak Discharge - Hydrological Droughts - Groundwater Recharge - Hydrological Droughts - Agricultural Droughts - Groundwater Recharge - Flash Floods - Hydrological Droughts - Groundwater Supply - Enhanced Evaporation - Hydrological Droughts - Agricultural Droughts - Surface Water Supply - Water Quality - Seds - Water Quality - Chem	- Ch 7.2, 7.3 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 5.4, 5.5, 5.7, 6.2, 7.3, 8.2, 8.3 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 7.3 - Ch 5.5 - Ch 4.1, 4.2, 8.1 - Ch 8.3 - Not in Report - See Barichievsky <i>et al.</i> (2010a) - Not in Report - Ch 5.6, 7.1 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 5.5 - Ch 4.1, 4.2, 8.1 - Ch 8.3 - Not in Report - See Barichievsky <i>et al.</i> (2010a) - Ch 7.1 - Ch 7.3 - Ch 5.6 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 5.3 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.3 - Ch 5.6, 7.1 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Not in Report - Ch 4.1, 4.2, 8.1 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 5.7 - Ch 8.3

Control		
- Structures (e.g. Dams, spillways, stormwater systems, levees, wave breaks, vegetation)	- Flash Floods - Regional Floods - Sea Level Rise - Storm Surges	Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report Not in Report
- Early Warning Systems - Short-Term (Days to Weeks)	- Flash Floods - Regional Floods - Hydrological Droughts - Agricultural Droughts - DDF - Rainfall : Long - DDF - Peak Discharge - DDF - Streamflows - Environmental Flows - Water Quality - Seds	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.2 Ch 5.6 Ch 7.3 See Barichiev <i>et al.</i> (2010b) Ch 5.7
- Medium-Term (Month to Season)	- Hydrological Droughts - Agricultural Droughts - Surface Water Supply - Groundwater Supply - Environmental Flows	Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Not in Report See Barichiev <i>et al.</i> (2010b)
- Long-Term (Years to Decades)	- Hydrological Droughts - Surface Water Supply - Groundwater Supply	Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Not in Report
Communication of Forecasts to End Users	- Flash Floods - Regional Floods - Hydrological Droughts - Agricultural Droughts - Storm Surges	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Not in Report
- Water Quality and Quantity Monitoring Systems - Operations / System Improvements - Reservoir Operations Rules	All	
Retrofitting Existing Structures	- Flash Floods - Regional Floods - Agricultural Droughts - Hydrological Droughts - DDF - Rainfall : Short - DDF - Rainfall : Long - DDF - Streamflows - DDF - Peak Discharge - Surface Water Supply	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4
	Flash Floods	Ch 5.6, 7.1

Water Demand Management	Regional Floods Sea Level Rise Storm Surges Surface Water Supply Groundwater Recharge Agricultural Droughts Hydrological Droughts Environmental Flows Sea Level Rise Surface Water Supply Groundwater Recharge Water Quality - Sediments Water Quality - Chemicals	Ch 7.2, 7.3 Not in Report Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 See Barichev <i>et al.</i> (2010b) Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.7 Ch 8.3
KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN ...	CROSS REFERENCES
- Research and Development - Efficient Technologies - Upgrading of Climate Models - Improvements to Downscaling / RCMs - Fine Scale Information Provision Relevant to Local Water Managers - Improvement of Forecast Skill / Dissemination - Development of Risk Maps / Floodlines - Communication / Training / Dissemination - Awareness Creation at Higher Decision Making Level - Awareness Creation at Operational Level - Participatory Approach in Decision-Making - Establishment of Interdepartmental Learning Platforms (e.g. Task teams) - Establishment of an Integrated Communication System (Trends, priorities, activities, risks)	- All - All - All - All - Flash Floods Regional Floods Hydrological Droughts Sea Level Rise Storm Surges - All - All - All - All	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Not in Report

- Creation of Ongoing Learning and Communication Platforms between Main Water Users	• All	
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN ...	CROSS REFERENCES
• International Water Agreements • National Water Master Plans - National Water Act of 1998 - National Water Resource Strategy of 2004, 2011 - Catchment Management Strategies (CMS) - Estuary Management Plans • Provincial Strategies - Provincial Growth and Development Strategies - Provincial Water Reconciliation Strategies • Disaster Management Policies / Plans	• All • All • All • All • All • All • All • All	
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN ...	CROSS REFERENCES
• Private Sector Strategies - Banks ▫ Development	• All	
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN ...	CROSS REFERENCES
• Land Use Measures - Adaptive Spatial Planning - Alien Invasive Clearing Activities • Maintaining or Re-establishment of Natural Capital (e.g. wetlands, buffers etc)	• Flash Floods - Regional Floods - DDF - Streamflows - Environmental Flows - Surface Water Supply - Water Quality - Seds - Water Quality - Chem - Sea Level Rise - Storm Surges • Surface Water Supply • Flash Floods	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.3 See Barichiev <i>et al.</i> (2010b) Surface Water Supply Ch 5.7 Ch 8.3 Not in Report Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.6, 7.1

	Regional Floods Water Quality - Seds Water Quality - Chem Water Quality - Biol	Ch 5.2, 5.4, 7.3 Ch 5.7 Ch 8.3 Not in Report
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Table 3 Adaptation recommendations for Bulk Water Suppliers, e.g. Umgeni Water (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN ...	CROSS REFERENCES TO SCHULZE (2011)
• Storage and Reticulation - Surface Water ▫ Large Reservoirs ▫ Small Reservoirs - Groundwater ▫ Artificial Recharge ▫ Borehole Drilling ▫ Sand Dams - System Maintenance ▫ Supply Leakage Control - Rainwater Harvesting	• Regional Floods - Agricultural Droughts - Hydrological Droughts - Surface Water Supply - Enhanced Evaporation - Threshold Streamflows - Water Temperature - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge - Storm Surges • Surface Water Supply - Hydrological Droughts - DDF - Rainfall: Short - DDF - Streamflows - DDF - Peak Discharge - Enhanced Evaporation - Threshold Streamflows - Water Temperature • Hydrological Droughts - Groundwater Recharge • Hydrological Droughts - Agricultural Droughts - Groundwater Recharge • Flash Floods - Enhanced Evaporation - Hydrological Droughts - Surface Water Supply - Groundwater Recharge • Hydrological Droughts - Surface Water Supply - Water Quality - Chem • Rainfall Thresholds - Hydrological Droughts - Agricultural Droughts - Surface Water Supply	Ch 7.2, 7.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 4.1, 4.2, 8.1 Ch 5.5 See Barichievsky <i>et al.</i> (2010a) Ch 5.7 Ch 8.3 Not in Report Ch 7.2 Ch 7.3 Ch 5.6 Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 7.1 Ch 7.3 Ch 5.6 Ch 4.1, 4.2, 8.1 Ch 5.5 See Barichievsky <i>et al.</i> (2010a) Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.3 Ch 5.6, 7.1 Ch 4.1, 4.2, 8.1 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 8.3 Ch 3.6 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4

- Water Re-use/Recycling • Desalination • Early Warning Systems - Near Real-Time (Hours to Days) - Short-Term (Days to Weeks) - Medium-Term (Month to Season) - Long-Term (Years to Decades) • Communication of Forecasts to End Users • Water Quality and Quality Monitoring Systems • Operations / System Improvements - Reservoir Operations Rules	Groundwater Recharge • Hydrological Droughts - Agricultural Droughts - Surface Water Supply • Hydrological Droughts - Surface Water Supply • Flash Floods - DDF - Rainfall: Short - DDF - Peak Discharge - Regional Floods - Environmental Flows - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol • Regional Floods - Hydrological Droughts - Agricultural Droughts - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge • Hydrological Droughts - Surface Water Supply - Groundwater Recharge - Enhanced Evaporation - Environmental Flows • Hydrological Droughts - Surface Water Supply - Groundwater Recharge - Enhanced Evaporation • Flash Floods - Regional Floods - Surface Water Supply - Hydrological Droughts - Agricultural Droughts - Storm Surges • All • Flash Floods - Regional Floods - Agricultural Droughts - DDF - Stormflows - DDF - Peak Discharge	Ch 5.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.6, 7.1 Ch 7.2 Ch 5.6 Ch 7.2, 7.3 See Barichiev <i>et al.</i> (2010b) Ch 5.7 Ch 8.3 Not in Report Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.2 Ch 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 4.1, 4.2, 8.1 See Barichiev <i>et al.</i> (2010b) Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 4.1, 4.2, 8.1 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.3 Ch 5.6
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- Retrofitting Existing Structures • Water Demand Management	Water Temperature Water Quality - Chem Water Quality - Biol Hydrological Droughts • Flash Floods Regional Floods DDF - Rainfall: Short DDF - Rainfall: Long DDF - Peak Discharge Sea Level Rise Storm Surges Surface Water Supply Groundwater Supply • Agricultural Droughts Hydrological Droughts Sea Level Rise Surface Water Supply Groundwater Recharge Water Quality - Chem	See Barichievsky <i>et al.</i> (2010a) Ch 8.3 Not in Report Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.2 Ch 5.6 Not in Report Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Not in Report Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch8.3
KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN ...	CROSS REFERENCES
• Research and Development - Efficient Technologies - Upgrading of Climate Models ▫ Improvements to Downscaling / RCMs ▫ Fine Scale Information Provision Relevant to Local Water Managers - Improvement of Forecast Skill / Dissemination • Communications, Training and Dissemination - Awareness Creation at Higher Decision-Making Level - Training at Middle Management • Participatory Approach in Decision-Making - Establishment of an Integrated Communication System (trends, priorities, activities, risks)	• All • All • All • All • All • All • All	

- Creation of Ongoing Learning and Communication Platforms between Main Water Users	• All	
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• International Conventions (e.g. UNFCCC) • International Water Agreements • National Water Master Plans - National Water Act of 1998 - National Water Research Strategy • Provincial Strategies - Provincial Growth and Development Strategies - Provincial Reconciliation Plans • Disaster Management Policies / Plans	• All • All • All • All • All • All	
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Private Sector Strategies - Stock Exchange	• All	
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Land Use Measures - Adaptive Spatial Planning • Resettlement	• Flash Floods - Regional Floods - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge - Surface Water Supply - Environmental Flows - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol - Sea Level Rise - Storm Surges • Flash Floods - Regional Floods - Hydrological Droughts - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Streamflows	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 See Barichievy <i>et al.</i> (2010b) Ch 5.7 Ch 8.3 Not in Report Not in Report Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 7.1 Ch 7.2 Ch 7.3

	DDF - Peak Discharge Water Quality - Biol Sea Level Rise Storm Surges	Ch 5.6 Not in Report Not in Report Not in Report
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Table 4 Adaptation recommendations for Water User Associations / Irrigation Boards (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
• Storage and Reticulation - Surface Water ▫ Large Reservoirs ▫ Small Reservoirs - Groundwater ▫ Artificial Recharge ▫ Borehole Drilling ▫ Sand Dams - Water Re-use / Recycling • Flood / Storm Surge Control	• Regional Floods - Agricultural Droughts - Hydrological Droughts - Surface Water Supply - DDF - Streamflows - Threshold Streamflows - Enhanced Evaporation - Water Quality - Chem - Water Quality - Biol - Water Temperature • Flash Floods - Agricultural Droughts - Hydrological Droughts - Surface Water Supply - Threshold Streamflows - Enhanced Evaporation - Water Quality - Chem - Water Quality - Biol - Water Temperature - DDF - Rainfall : Short - DDF - Stormflows - DDF - Peak Discharge • Hydrological Droughts - Groundwater Recharge - Groundwater Supply • Hydrological Droughts - Agricultural Droughts - Groundwater Recharge - Groundwater Supply • Flash Floods - Hydrological Droughts - Groundwater Supply - Enhanced Evaporation • Hydrological Droughts - Agricultural Droughts - Surface Water Supply - Water Quality - Seds - Water Quality - Chem	Ch 7.2, 7.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 7.3 Ch 5.5 Ch 4.1, 4.2, 8.1 Ch 8.3 Not in Report See Barichievsky <i>et al.</i> (2010a) Ch 5.6, 7.1 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5 Ch 4.1, 4.2, 8.1 Ch 8.3 Not in Report See Barichievsky <i>et al.</i> (2010a) Ch 7.1 Ch 7.3 Ch 5.6 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.3 Not in Report Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.3 Not in Report Ch 5.6, 7.1 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Ch 4.1, 4.2, 8.1 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.7 Ch 8.3

- Structures (e.g. Dams, spillways, stormwater systems, levees, wave breaks, vegetation) • Early Warning Systems - Short-Term (Days to Weeks) - Medium-Term (Month to Season) - Long-Term (Years to Decades) • Communication of Forecasts to End Users • Water Quality and Quantity Monitoring Systems • Operations / System Improvements - Reservoir Operations Rules - Retrofitting Existing Structures	• Flash Floods Regional Floods Sea Level Rise Storm Surges • Flash Floods Regional Floods Hydrological Droughts Agricultural Droughts Threshold Rainfalls Threshold Streamflows Environmental Flows Water Quality - Seds • Hydrological Droughts Agricultural Droughts Surface Water Supply Groundwater Supply Environmental Flows • Hydrological Droughts Surface Water Supply Groundwater Supply • Flash Floods Regional Floods Hydrological Droughts Agricultural Droughts Threshold Rainfalls Threshold Streamflows Storm Surges • All • Flash Floods Regional Floods Agricultural Droughts Hydrological Droughts Threshold Rainfalls Threshold Streamflows Surface Water Supply • Flash Floods Regional Floods Sea Level Rise	Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 3.6 Ch 5.5 See Barichiev <i>et al.</i> (2010b) Ch 5.7 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Not in Report See Barichiev <i>et al.</i> (2010b) Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 3.6 Ch 5.5 Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 3.6 Ch 5.5 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report
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Water Demand Management	Storm Surges Surface Water Supply Groundwater Recharge Agricultural Droughts Hydrological Droughts Environmental Flows Surface Water Supply Groundwater Recharge Water Quality - Seds Water Quality - Chem	Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 See Barichievy <i>et al.</i> (2010b) Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.7 Ch 8.3
KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
- Research and Development - Efficient Technologies - Upgrading of Climate Models - Improvements to Downscaling / RCMs - Fine Scale Information Provision Relevant Managers - Improvement of Forecast Skill / Dissemination - Development of Risk Maps / Floodlines - Communication / Training / Dissemination - Awareness Creation at Higher Decision Making Level - Awareness Creation at Operational Level - Participatory Approach in Decision-Making - Establishment of Interdepartmental Learning Platforms (e.g. Task teams) - Establishment of an Integrated Communication System (Trends, priorities, activities, risks) - Creation of Ongoing Learning and Communication Platforms between	- All - All - All - All - Flash Floods Regional Floods Hydrological Droughts Sea Level Rise Storm Surges - All - All - All - All	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Not in Report

Main Water Users	• All	
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• National Water Master Plans - National Water Act of 1998 - National Water Resource Strategy of 2004, 2011 - Catchment Management Strategies - River Management Plans • Provincial Strategies - Provincial Growth and Development Strategies - Provincial Water Reconciliation Strategies • Local Strategies - Municipal Bye-Laws • Disaster Management Policies / Plans	• All • All • All • All • All • All • All • All	
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Private Sector Strategies - Banks ▫ Development	• All	
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Land Use Measures - Adaptive Spatial Planning - Alien Invasive Clearing Activities • Maintaining or Re-establishment of Natural Capital (e.g. wetlands, buffers etc)	• Flash Floods - Regional Floods - DDF - Rainfall: Long - DDF - Streamflows - Environmental Flows - Surface Water Supply - Water Quality - Seds - Water Quality - Chem - Sea Level Rise - Storm Surges • Surface Water Supply • Flash Floods - Surface Water Supply - Regional Floods - Water Quality - Seds	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.2 Ch 7.3 See Barichievy <i>et al.</i> (2010b) Surface Water Supply Ch 5.7 Ch 8.3 Not in Report Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.6, 7.1 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.2, 5.4, 7.3 Ch 5.7

	Water Quality - Chem Water Quality - Biol	Ch 8.3 Not in Report
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Table 5 Adaptation recommendations for Municipalities (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
• Storage and Reticulation - Surface Water ▫ Large Reservoirs ▫ Small Reservoirs - Groundwater ▫ Artificial Recharge ▫ Borehole Drilling ▫ Sand Dams - System Maintenance ▫ Supply Leakage Control - Rainwater Harvesting - Water Re-use / Recycling	• Enhanced Evaporation - Water Temperature - DDF - Stormflows - DDF - Peak Discharge - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol - Regional Floods - Hydrological Droughts - Surface Water Supply - Storm Surges • Surface Water Supply - Hydrological Droughts - DDF - Rainfall: Short - DDF - Streamflows - DDF - Peak Discharge - Enhanced Evaporation - Threshold Streamflows - Water Temperature • Hydrological Droughts - Groundwater Recharge • Hydrological Droughts - Agricultural Droughts - Groundwater Recharge • Flash Floods - Hydrological Droughts - Groundwater Supply • Hydrological Droughts - Surface Water Supply - Water Quality - Chem • Rainfall Thresholds - Hydrological Droughts - Agricultural Droughts - Surface Water Supply - Groundwater Recharge • Hydrological Droughts - Agricultural Droughts - Surface Water Supply	Ch 4.1, 4.2, 8.1 See Barichiev <i>et al.</i> (2010a) Ch 7.3 Ch 5.6 Ch 5.7 Ch 8.3 Not in Report Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 7.1 Ch 7.3 Ch 5.6 Ch 4.1, 4.2, 8.1 Ch 5.5 See Barichiev <i>et al.</i> (2010a) Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.3 Ch 5.6, 7.1 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 8.3 Ch 3.6 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Not in Report

• Desalination • Flood / Storm Surge Control - Structures (e.g. Dams, spillways, stormwater systems, levees, wave breaks, vegetation) • Early Warning Systems - Near Real-Time (Hours to Days) - Short-Term (Days to Weeks) - Medium-Term (Month to Season) - Long-Term (Years to Decades) • Communication of Forecasts to End Users - Awareness Creation at Operational Level - Training at Local Level	• Groundwater Supply • Hydrological Droughts • Surface Water Supply • Flash Floods • Regional Floods • Sea Level Rise • Storm Surges • Flash Floods • Regional Floods • DDF - Rainfall: Short • DDF - Rainfall: Long • DDF - Stormflows • DDF - Peak Discharge • Water Quality - Chem • Water Quality - Biol • Regional Floods • Hydrological Droughts • Agricultural Droughts • DDF - Rainfall: Long • DDF - Streamflows • DDF - Peak Discharge • Streamflow Thresholds • Water Quality - Chem • Water Quality - Biol • Hydrological Droughts • Agricultural Droughts • Surface Water Supply • Groundwater Recharge • Hydrological Droughts • Surface Water Supply • Groundwater Supply • Flash Floods • Regional Floods • Hydrological Droughts • Agricultural Droughts • Sea Level Rise • Storm Surges • Flash Floods • Regional Floods	Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6 Ch 8.3 Not in Report Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.2 Ch 7.3 Ch 5.6 Ch 5.5 Ch 8.3 Not in Report Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Not in Report Not in Report Ch 5.6, 7.1 Ch 5.2, 5.4, 7.3 Not in Report
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• Water Quality and Quantity Monitoring Systems • Operations / System Improvements - Reservoir Operations Rules - Retrofitting Existing Structures • Water Demand Management	Storm Surges • All • Flash Floods Regional Floods Hydrological Droughts Environmental Flows • Flash Floods Regional Floods DDF - Rainfall: Short DDF - Streamflows DDF - Peak Discharge Sea Level Rise Storm Surges Surface Water Supply Groundwater Recharge • Agricultural Droughts Hydrological Droughts Surface Water Supply Groundwater Recharge Water Quality - Chem Water Quality - Biol	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 See Barichiev <i>et al.</i> (2010b) Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.3 Ch 5.6 Not in Report Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 8.3 Not in Report
KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Research and Development - Efficient Technologies - Upgrading of Climate Models ▫ Fine Scale Information Provision Relevant to Local Water Managers - Improvement of Forecast Skill / Dissemination • Communication / Training / Dissemination - Awareness Creation at Operations Level (e.g. Senior Municipal Officials re. budget allocation and future special planning) - Training at Middle Management Level - Training at Local Level (e.g. Municipal WWT)	• All • All • All • All • All	

- operators) - Participatory Approach in Decision-Making - Establishment of Inter-Departmental Learning Platforms - Establishment of Integrated Communications Systems - Creation of Ongoing Learning and communication Platforms between Main Water Users	- All - All - All - All	
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
- National Water Master Plans - National Water Act of 1998 - National Water Resource Strategy - Water Services Act of 1997 - Catchment Management Strategies - River Management Plans - Other National Strategies - Integrated Development Plans - Provincial Strategies - Provincial Growth and Development Strategies - Local Strategies - Municipal Bye-Laws - Disaster Management Policies / Plans	- All - All - All - All - All - All - All - All - All	
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
- Private Sector Strategies - Insurance - Re-Insurance	- Regional Floods - Flash Floods	Ch 7.2, 7.3 Ch 5.6, 7.1
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
- Land Use Measures - Conservation Structures	- Flash Floods - Regional Floods - DDF - Rainfall: Short - DDF - Streamflows - DDF - Peak Discharge	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7/3 Ch 5.6

- Adaptive Spatial Planning - Alien Invasive Clearing Activities • Resettlement • Maintaining or Re-establishment of Natural Capital (e.g. wetlands, buffers etc)	Sea Level Rise Storm Surges Agricultural Droughts • Flash Floods Regional Floods DDF - Rainfall: Short DDF - Rainfall: Long DDF - Streamflow DDF - Peak Discharge Sea Level Rise Storm Surges • Surface Water Supply • Flash Floods Regional Floods Rainfall Thresholds DDF - Rainfall: Short DDF - Rainfall: Long DDF - Streamflows DDF - Peak Discharge • Flash Floods Regional Floods Water Quality - Seds Water Quality - Chem Water Quality - Biol	Not in Report Not in Report Ch 4.2, 6.1, 6.2, 8.2 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6 Not in Report Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.6, 7.1 Ch 5.2, 5.4, 7.3 Ch 3.6 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6 Ch 5.6, 7.1 Ch 5.2, 5.4, 7.3 Ch 5.7 Ch 8.3 Not in Report
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Table 6 Adaptation recommendations for Disaster Risk Management (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
- Storage and Reticulation - Surface Water - Large Reservoirs - Small Reservoirs - Groundwater - Artificial Recharge - Flood / Storm Surge Control - Structures (e.g. Dams, spillways, stormwater systems, levees, wave breaks, vegetation) - Early Warning Systems - Near Real-Time (Hours to Days) - Short-Term (Days to Weeks)	- Flash Floods - Regional Floods - Threshold Streamflows - DDF - Streamflows - DDF - Peak Discharge - Hydrological Droughts - Surface Water Supply - Storm Surges - Hydrological Droughts - DDF - Rainfall: Short - DDF - Streamflows - DDF - Peak Discharge - Threshold Rainfall - Threshold Streamflows - Hydrological Droughts - Groundwater Recharge - Flash Floods - Regional Floods - Storm Surges - Flash Floods - Regional Floods - Threshold Streamflows - Soil Moisture - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol - Regional Floods - Hydrological Droughts - Agricultural Droughts - Flash Floods	- Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 5.5 - Ch 7.3 - Ch 5.6 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Not in Report - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 7.1 - Ch 7.3 - Ch 5.6 - Ch 3.6 - Ch 5.5 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 5.3 - Ch 5.6, 7.1 - Ch 7.2, 7.3 - Not in Report - Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 5.5 - Ch 4.2 - Ch 7.1 - Ch 7.2 - Ch 7.3 - Ch 5.6 - Ch 5.7 - Ch 8.3 - Not in Report - Ch 7.2, 7.3 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.6, 7.1

- Medium-Term (Month to Season) • Communication of Forecasts to End Users • Operations / System Improvements - Reservoir Operations Rules - Retrofitting Existing Structures • Precipitation Enhancement	Threshold Streamflows Soil Moisture DDF - Rainfall: Long DDF - Streamflows DDF - Peak Discharge Water Quality - Seds Water Quality - Chem Water Quality - Biol • Hydrological Droughts Agricultural Droughts Surface Water Supply Groundwater Recharge • Flash Floods Regional Floods Threshold Streamflows Hydrological Droughts Agricultural Droughts Water Quality - Seds Water Quality - Chem Water Quality - Biol Storm Surges • Flash Floods Regional Floods Threshold Streamflows DDF - Streamflows DDF - Peak Discharge Hydrological Droughts • Flash Floods Regional Floods DDF - Rainfall: Short DDF - Rainfall: Long DDF - Streamflows DDF - Peak Discharge Sea Level Rise Storm Surges Surface Water Supply Groundwater Recharge • Agricultural Droughts Threshold Rainfalls Threshold Streamflows	Ch 5.5 Ch 4.2 Ch 7.2 Ch 7.3 Ch 5.6 Ch 5.7 Ch 8.3 Not in Report Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.7 Ch 8.3 Not in Report Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5 Ch 7.3 Ch 5.6 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6 Not in Report Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 3.6 Ch 5.5
KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Research and Development - Efficient Technologies	• All	

RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Private Sector Strategies - Insurance ▫ Primary Insurers ▫ Re-Insurance ▫ Micro-Insurance - Banks ▫ Development ▫ Private ▫ Micro-Lenders	• Agricultural Droughts - Hydrological Droughts - Regional Floods - Flash Floods - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Stormflows - DDF - Peak Discharge • Regional Floods - Flash Floods - Agricultural Droughts - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Stormflows - DDF - Peak Discharge • Flash Floods - Regional Floods - Agricultural Droughts • Agricultural Droughts - Regional Floods - Flash Floods • Agricultural Droughts - Flash Floods - Regional Floods	- Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 7.2, 7.3 - Ch 5.6, 7.1 - Ch 7.1 - Ch 7.2 - Ch 7.3 - Ch 5.6 - Ch 7.2, 7.3 - Ch 5.6, 7.1 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 7.1 - Ch 7.2 - Ch 7.3 - Ch 5.6 - Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.6, 7.1 - Ch 7.2, 7.3
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Land Use Measures - Adaptive Spatial Planning - Alien Invasive Plant Clearance • Maintenance & Re-establishment of Natural Capital (Buffer zones, wetlands etc.)	• Flash Floods - Regional Floods - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge - Sea Level Rise - Storm Surges • Surface Water Supply • Threshold Streamflows - DDF - Streamflows - DDF - Peak Discharge - Water Quality - Seds	- Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 7.1 - Ch 7.2 - Ch 7.3 - Ch 5.6 - Not in Report - Not in Report - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 5.5 - Ch 7.3 - Ch 5.6 - Ch 5.7

	Water Quality - Chem Water Quality - Biol	Ch 8.3 Not in Report
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Table 7 Adaptation recommendations for Dryland Agriculture, including Livestock Activities (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
• Storage and Reticulation - Surface Water ▫ Small Reservoirs - Groundwater ▫ Borehole Drilling ▫ Sand Dams • Rainwater Harvesting • Flood / Storm Surge Control - Structures (e.g. Dams, spillways, stormwater systems, levees, wave breaks, vegetation) • Early Warning Systems - Near Real-Time (Hours to Days)	• Flash Floods Enhanced Evaporation DDF - Rainfall: Short DDF - Streamflows DDF - Peak Discharge Threshold Streamflows Water Temperature Water Quality - Sed Water Quality - Chem Water Quality - Biol Agricultural Droughts Hydrological Droughts Surface Water Supply • Hydrological Drought Agricultural Drought Groundwater Recharge • Flash Floods Hydrological Droughts Groundwater Supply Enhanced Evaporation Threshold Streamflows • Hydrological Droughts Agricultural Droughts Threshold Rainfalls Surface Water Supply Groundwater Recharge • Flash Floods Regional Floods Sea Level Rise Storm Surges • Flash Floods Regional Floods Soil Moisture Threshold Rainfalls	Ch 5.6, 7.1 Ch 4.1, 4.2, 8.1 Ch 7.1 Ch 7.3 Ch 5.6 Ch 5.5 See Barichievy <i>et al.</i> (2010a) Ch 5.7 Ch 8.3 Not in Report Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.3 Ch 5.6, 7.1 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Ch 4.1, 4.2, 8.1 Ch 5.5 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 3.6 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 4.2 Ch 3.6

- Short-Term (Days to Weeks) - Medium-Term (Month to Season) - Long-Term (Years to Decades) • Communication of Forecasts to End Users • Indigenous Coping Strategies • Precipitation Enhancement	Threshold Streamflows • Regional Floods Hydrological Droughts Agricultural Droughts Heat Waves Threshold Rainfalls Threshold Streamflows • Hydrological Droughts Agricultural Droughts Surface Water Supply Groundwater Recharge • Hydrological Droughts Surface Water Supply Groundwater Recharge • Flash Floods Regional Floods Hydrological Droughts Agricultural Droughts Heat Waves Threshold Rainfalls Soil Moisture Storm Surges • Flash Floods Regional Floods Agricultural Droughts Agricultural Droughts	Ch 5.5 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 See Schulze and Kunz (2010) Ch 3.6 Ch 5.5 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 See Schulze and Kunz (2010) Ch 3.6 Ch 4.2 Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 4.2, 6.1, 6.2, 8.2
KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Research and Development - Efficient Technologies - Upgrading of Climate Models ▫ Fine Scale Information Provision Relevant to Local Water Managers - Improvement of Forecast Skill / Dissemination	• Agricultural Droughts Regional Floods • Agricultural Droughts DDF - Rainfall: Short Heat Waves • Agricultural Droughts Regional Floods Heat Waves Soil Moisture Threshold Rainfalls	Ch 4.2, 6.1, 6.2, 8.2 Ch 7.2, 7.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.1 See Schulze and Kunz (2010) Ch 4.2, 6.1, 6.2, 8.2 Ch 7.2, 7.3 See Schulze and Kunz (2010) Ch 4.2 Ch 3.6

- Development of Drought Resistant Crops • Communication, Training, Dissemination - Awareness Creation at Operational Level - Training at Local Level • Participatory Approach in Decision-Making - Creation of Ongoing Learning and Communication Platforms	• Agricultural Droughts Heat Waves Soil Moisture • Agricultural Droughts Regional Floods Heat Waves Soil Moisture • Agricultural Droughts Regional Floods Heat Waves Soil Moisture • Agricultural Droughts Regional Floods Heat Waves Soil Moisture	Ch 4.2, 6.1, 6.2, 8.2 See Schulze and Kunz (2010) Ch 4.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.2, 7.3 See Schulze and Kunz (2010) Ch 4.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.2, 7.3 See Schulze and Kunz (2010) Ch 4.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.2, 7.3 See Schulze and Kunz (2010) Ch 4.2
POLICY INSTRUMENTS ADAPTING TO CHANGES IN . . . CROSS REFERENCES		
• International Trade • Other National Strategies - National Environmental Management Plan - Conservation of Agricultural Resources Act	• Agricultural Droughts • All • All	Ch 4.2, 6.1, 6.2, 8.2
RISK SHARING / SPREADING ADAPTING TO CHANGES IN . . . CROSS REFERENCES		
• Private Sector Strategies - Insurance ▫ Primary Insurers ▫ Micro-Insurance - Banks ▫ Private ▫ Micro-Lenders	• Agricultural Droughts Hydrological Droughts Regional Floods Flash Floods • Flash Floods Regional Floods Agricultural Droughts • Agricultural Droughts DDF - Rainfall: Short DDF - Streamflows DDF - Peak Discharge Heat Waves Regional Floods Flash Floods • Agricultural Droughts	Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 7.2, 7.3 Ch 5.6, 7.1 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.1 Ch 7.3 Ch 5.6 See Schulze and Kunz (2010) Ch 7.2, 7.3 Ch 5.6, 7.1 Ch 4.2, 6.1, 6.2, 8.2

	Flash Floods Regional Floods	Ch 5.6, 7.1 Ch 7.2, 7.3
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
- Land Use Measures - Conservation Structures - Adaptive Spatial Planning - Tillage Practices - Use of Organic (instead of chemical) Fertilizers - Alien Invasive Clearing Activities - Crop Change - Resettlement	- DDF - Rainfall: Short DDF - Streamflows DDF - Peak Discharge Flash Floods Regional Floods Storm Surges Agricultural Droughts - Flash Floods Regional Floods Water Quality - Seds Water Quality - Chem Sea Level Rise Storm Surges Agricultural Droughts Heat Waves Thresholds - Rainfall Soil Moisture - Soil Moisture Agricultural Droughts - Surface Water Supply Heat Waves Threshold Rainfalls Agricultural Droughts - Threshold Rainfalls Soil Moisture Agricultural Droughts Regional Floods	- Ch 7.1 Ch 7.3 Ch 5.6 Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.7 Ch 8.3 Not in Report Not in Report Ch 4.2, 6.1, 6.2, 8.2 See Schulze and Kunz (2010) Ch 3.6 Ch 4.2 - Ch 4.2 Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 See Schulze and Kunz (2010) Ch 3.6 Ch 4.2, 6.1, 6.2, 8.2 Ch 3.6 Ch 4.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.2, 7.3

Table 8 Adaptation recommendations for Irrigated Agriculture (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
• Storage and Reticulation - Surface Water ▫ Large Reservoirs ▫ Small Reservoirs - Groundwater ▫ Artificial Recharge ▫ Borehole Drilling - System Maintenance ▫ Irrigation Equipment Maintenance ▫ Irrigation Canal Leakage / Losses • Water Quality and Quantity Monitoring Systems • Early Warning Systems - Short-Term (Days to	• Regional Floods - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge - Agricultural Droughts - Hydrological Droughts - Enhanced Evaporation - Water Temperature - Water Quality - Seds - Water Quality - Chem - Surface Water Supply • Flash Floods - DDF - Rainfall: Short - DDF - Streamflows - DDF - Peak Discharge - Enhanced Evaporation - Water Temperature - Water Quality - Seds - Water Quality - Chem - Agricultural Droughts - Hydrological Droughts - Surface Water Supply • Hydrological Droughts - Groundwater Recharge - Groundwater Supply • Groundwater Supply - Groundwater Recharge • Agricultural Droughts - Water Quality - Seds - Water Quality - Chem • Agricultural Droughts - Enhanced Evaporation - Water Temperature • All	Ch 7.2, 7.3 Ch 7.2 Ch 7.3 Ch 5.6 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2 See Barichievy <i>et al.</i> (2010a) Ch 5.7 Ch 8.3 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.6, 7.1 Ch 7.1 Ch 7.3 Ch 5.6 Ch 4.1, 4.2, 8.1 See Barichievy <i>et al.</i> (2010a) Ch 5.7 Ch 8.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.3 Not in Report Not in Report Ch 5.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.7 Ch 8.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 4.1, 4.2, 8.1 See Barichievy <i>et al.</i> (2010a)

Weeks) - Medium-Term (Month to Season) - Communication of Forecasts to End Users • Operations / System Improvements - Reservoir Operations Rules - Irrigation Scheduling • Precipitation Enhancement	• Heat Waves Threshold Rainfalls Surface Water Supply Regional Floods Hydrological Droughts Agricultural Droughts • Hydrological Droughts Agricultural Droughts Surface Water Supply Groundwater Recharge • Flash Floods Regional Floods Hydrological Droughts Agricultural Droughts Heat Waves Threshold Rainfalls • Flash Floods Regional Floods Water Quality - Seds Water Quality - Chem Water Temperature Agricultural Droughts Hydrological Droughts • Threshold Rainfalls Soil Moisture Agricultural Droughts • Agricultural Droughts	See Schulze and Kunz (2010) Ch 3.6 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 See Schulze and Kunz (2010) Ch 3.6 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.7 Ch 8.3 See Barichievy <i>et al.</i> (2010a) Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 3.6 Ch 4.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 4.2, 6.1, 6.2, 8.2
KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Research and Development - Efficient Technologies - Upgrading of Climate Models ▫ Fine Scale Information Provision Relevant to Local Water Managers - Improvement of Forecast Skill / Dissemination - Development of Drought Resistant Crops • Communication / Training /	• All • All • All • Heat Waves Soil Moisture Agricultural Droughts	See Schulze and Kunz (2010) Ch 4.2 Ch 4.2, 6.1, 6.2, 8.2

Dissemination - Awareness Creation at Operational Level • Participatory Approach in Decision-Making - Creation of Ongoing Learning and Communication Platforms	• Heat Waves Soil Moisture Threshold Rainfalls Surface Water Supply Agricultural Droughts • All	See Schulze and Kunz (2010) Ch 4.2 Ch 3.6 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 4.2, 6.1, 6.2, 8.2
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• International Water Agreements • International Trade • National Water Master Plans - National Water Resource Strategy of 2004, 2011 - Catchment Management Strategy • Other National Strategies - National Environmental Management Plan - Conservation of Agricultural Resources Act	• Surface Water Supply Water Quality - Seds Water Quality - Chem • Agricultural Droughts • • All • Agricultural Droughts Hydrological Droughts Surface Water Supply Water Quality - Seds Water Quality -Chem • All • All	Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.7 Ch 8.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.7 Ch 8.3
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Private Sector Strategies - Insurance ▫ Primary Insurers ▫ Micro-Insurance - Banks ▫ Development ▫ Private	• Agricultural Droughts Hydrological Droughts Flash Floods Regional Floods • Flash Floods Regional Floods Agricultural Droughts • Surface Water Supply Agricultural Droughts • Agricultural Droughts Flash Floods	Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 4.2, 6.1, 6.2, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.6, 7.1

	Regional Floods	Ch 7.2, 7.3
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
- Land Use Measures - Conservation Structures - Adaptive Spatial Planning - Tillage Practices - Use of Organic (instead of chemical) Fertilizers - Crop Change	- Flash Floods - Regional Floods - DDF - Rainfall: Short - DDF - Streamflows - Threshold Rainfalls - Agricultural Droughts - Flash Floods - Regional Floods - Surface Water Supply - Agricultural Droughts - Enhanced Evaporation - Soil Moisture - Soil Moisture - Agricultural Droughts - Heat Waves - Soil Moisture	- Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 7.1 - Ch 7.3 - Ch 3.6 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 4.1, 4.2, 8.1 - Ch 4.2 - Ch 4.2 - Ch 4.2, 6.1, 6.2, 8.2 - See Schulze and Kunz (2010) - Ch 4.2

Table 9 Adaptation recommendations for the Insurance Industry (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
• Early Warning Systems - Near Real-Time (Hours to Days) - Short-Term (Days to Weeks) - Medium-Term (Month to Season) - Long-Term (Years to Decades) • Communication of Forecasts to End Users	• Flash Floods - Regional Floods - DDF - Rainfall: Short - DDF - Streamflows - DDF - Peak Discharge - Heat Waves - Threshold Rainfalls - Threshold Streamflows • Regional Floods - Agricultural Droughts - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge - Heat Waves - Threshold Rainfalls - Threshold Streamflows • Agricultural Droughts • Regional Floods • Flash Floods - Threshold Rainfalls - Threshold Streamflows - Heat Waves - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Peak Discharge - Regional Floods - Hydrological Droughts - Agricultural Droughts • Agricultural Droughts • Agricultural Droughts - Hydrological Droughts	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.3 Ch 5.6 See Schulze and Kunz (2010) Ch 3.6 Ch 5.5 Ch 7.2, 7.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.2 Ch 7.3 Ch 5.6 See Schulze and Kunz (2010) Ch 3.6 Ch 5.5 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.2, 7.3 Ch 5.6, 7.1 Ch 3.6 Ch 5.5 See Schulze and Kunz (2010) Ch 7.1 Ch 7.2 Ch 5.6 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2

KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Research and Development - Efficient Technologies - Upgrading Climate Models ▫ Fine Scale Information Provision Relevant to Local Water Managers - Improvement of Forecast Skill / Dissemination • Development of Risk Maps / Floodlines • Communication. Training , Dissemination - Awareness Creation at Higher Decision-Making Level	• All • All • All • Flash Floods Regional Floods DDF - Rainfall: Short DDF - Rainfall: Long DDF - Streamflows DDF - Peak Discharge Hydrological Droughts Sea Level Rise Storm Surges • Flash Floods Regional Floods DDF - Rainfall: Short DDF - Rainfall: Long DDF - Streamflows DDF - Peak Discharge Hydrological Droughts Agricultural Droughts Heat Waves	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 See Schulze and Kunz (2010)
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Disaster Management Policies / Plans	• All	
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Private Sector Strategies - Insurance ▫ Primary Insurers	• Agricultural Droughts Hydrological Droughts DDF - Rainfall: Short DDF - Rainfall: Long DDF - Streamflows DDF - Peak Discharge	Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6

Table 10 Adaptation recommendations for the Road Transport Sector (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
• Flood / Storm Surge Control - Structures (i.e. Levees, Sand Bags, Wave Breaks, Planting) • Early Warning Systems - Near Real-Time (Hours to Days) - Short-Term (Days to Weeks) - Long-Term (Years to Decades) • Communication of Forecasts to End Users	• Flash Floods - Regional Floods - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge - Threshold Rainfalls - Threshold Streamflows - Sea Level Rise - Storm Surges • Flash Floods - Regional Floods - Threshold Rainfalls - Threshold Streamflows • Flash Floods - Regional Floods - Threshold Rainfalls - Threshold Streamflows • Regional Floods - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge - Threshold Rainfalls - Threshold Streamflows • Flash Floods - Regional Floods - Storm Surges - Threshold Rainfalls - Threshold Streamflows	- Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 7.1 - Ch 7.2 - Ch 7.3 - Ch 5.6 - Ch 3.6 - Ch 5.5 - Not in Report - Not in Report - Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 3.6 - Ch 5.5 - Ch 7.2, 7.3 - Ch 5.6, 7.1 - Ch 3.6 - Ch 5.5 - Ch 7.2, 7.3 - Ch 7.1 - Ch 7.2 - Ch 7.3 - Ch 5.6 - Ch 3.6 - Ch 5.5 - Ch 5.6, 7.1 - Ch 7.2, 7.3 - Not in Report - Ch 3.6 - Ch 5.5
KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Research and		

Development - Improvement of Forecast Skill / Dissemination • Development of Risk Maps / Floodlines • Communication / Training / Dissemination - Awareness Creation at Higher Decision-Making Level - Awareness Creation at Operational Level • Participatory Approach in Decision-Making - Establishment of an Integrated Communication System	• Flash Floods Regional Floods Storm Surges • Flash Floods Regional Floods DDF - Rainfall: Short DDF - Rainfall: Long DDF - Streamflows DDF - Peak Discharge Sea Level Rise Storm surges • Flash Floods Regional Floods DDF - Rainfall: Short DDF - Rainfall: Long DDF - Streamflows DDF - Peak Discharge Threshold Rainfalls Threshold Streamflows Sea Level Rise Storm Surges • Flash Floods Regional Floods DDF - Rainfall: Short DDF - Rainfall: Long DDF - Streamflows DDF - Peak Discharge Threshold Rainfalls Threshold Streamflows Sea Level Rise Storm Surges • Flash Floods Regional Floods Sea Level Rise Storm Surges	Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6 Not in Report Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6 Ch 3.6 Ch 5.5 Not in Report Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6 Ch 3.6 Ch 5.5 Not in Report Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report Not in Report
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Disaster Management Policies / Plans	• Flash Floods	Ch 5.6, 7.1

	Regional Floods	Ch 7.2, 7.3
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
- Private Sector Strategies - Insurance - Primary Insurers - Re-Insurance	- Flash Floods - Regional Floods - Threshold Rainfalls - Threshold Streamflows - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge - Flash Floods - Regional Floods	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.6 Ch 3.6 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6 Ch 5.6, 7.1 Ch 7.2, 7.3
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
- Land Use Measures - Adaptive Spatial Planning - Resettlement	- Flash Floods - Regional Floods - Sea Level Rise - Storm Surges - Flash Floods - Regional Floods - Sea Level Rise	Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report

Table 11 Adaptation recommendations for the Thermal Electric Power Industry (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
• Storage and Reticulation - Surface Water ▫ Large Reservoirs • Early Warning Systems - Near Real-Time (Hours to Days) - Short-Term (Days to Weeks) - Medium-Term (Month to Season) - Long-Term (Years to Decades) • Communication of Forecasts to End Users • Operations / System Improvements - Reservoir Operations Rules	• Surface Water Supply Threshold Streamflows DDF - Streamflows DDF - Peak Discharge • DDF - Rainfall: Short Flash Floods Threshold Rainfalls Threshold Streamflows Soil Moisture Regional Floods • DDF - Rainfall: Short DDF - Rainfall: Long Threshold Rainfalls Threshold Streamflows Soil Moisture Regional Floods Hydrological Droughts • Hydrological Droughts Surface Water Supply • Hydrological Droughts Surface Water Supply • Flash Floods Regional Floods DDF - Rainfall: Short DDF - Rainfall: Long Threshold Rainfalls Soil Moisture Hydrological Droughts Storm Surges • Regional Floods Hydrological Droughts Threshold Streamflows Surface Water Supply	Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5 Ch 7.3 Ch 5.6 Ch 7.1 Ch 5.6, 7.1 Ch 3.6 Ch 5.5 Ch 4.2 Ch 7.1, 7.2 Ch 7.1 Ch 7.2 Ch 3.6 Ch 5.5 Ch 4.2 Ch 7.1, 7.2 Ch 7.1, 7.2 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.2 Ch 3.6 Ch 4.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.5 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4

KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Research and Development - Efficient Technologies - Upgrading of Climate Models ▫ Improvements to Downscaling / RCMs ▫ Fine Scale Information Provision Relevant to Local Water Managers - Improvement of Forecast Skill / Dissemination • Communication, Training, Dissemination - Awareness Creation at Higher Decision-Making Level - Awareness Creation at Operational Level • Participatory Approach in Decision-Making - Establishment of Interdepartmental Learning Platforms (e.g. task teams) - Establishment of an Integrated Communication System (trends, priorities, activities, risks) - Creation of Ongoing Learning and Communication Platforms	• All • All • All • All • All • All • All • All • All • All • All	
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• National Water Master Plans - National Water Act of 1998 - National Water Resource Strategy of 2004, 2011 • Disaster Management Policies / Plans	• All • All • All	
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Private Sector Strategies - Banks ▫ Development • Public Sector Strategies	• All • All	

CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
- Land Use Measures - Adaptive Spatial Planning - Resettlement	- Flash Floods - Regional Floods - Soil Moisture - DDF - Rainfall: Short - Sea Level rise - Storm Surges - Regional Floods - Hydrological Droughts - Soil Moisture - Storm Surges - Sea Level Rise - Water Quality - Seds	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 4.2 Ch 7.1 Not in Report Not in Report Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2 Not in Report Not in Report Ch 5.7

Table 12 Adaptation recommendations for the Hydro-Electric Power Industry (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
• Storage and Reticulation - Surface Water ▫ Large Reservoirs • Early Warning Systems - Near Real-Time (Hours to Days) - Short-Term (Days to Weeks) - Medium-Term (Month to Season) - Long-Term (Years to Decades) • Communication of Forecasts to End Users • Operations / System Improvements - Reservoir Operations Rules	• Surface Water Supply Threshold Streamflows • Regional Floods Water Quality - Seds • DDF - Rainfall: Long Surface Water Supply Regional Floods Hydrological Droughts Water Quality: Seds Threshold Streamflows • Hydrological Droughts Surface Water Supply • Hydrological Droughts Surface Water Supply • Regional Floods Hydrological Droughts Storm Surges • Flash Floods Regional Floods Threshold Streamflows Water Quality - Seds Hydrological Droughts	Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5 Ch 7.2, 7.3 Ch 5.7 Ch 7.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.7 Ch 5.5 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5 Ch 5.7 Ch 5.5, 6.1, 6.2, 8.1, 8.2
KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Research and Development - Efficient Technologies - Upgrading of Climate Models ▫ Improvements to Downscaling / RCMs ▫ Fine Scale Information	• All • All • All	

Provision Relevant to Local Water Managers - Improvement of Forecast Skill / Dissemination • Participatory Approach in Decision-Making	• All • All	
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• National Water Master Plans - National Water Act of 1998 - National Water Resource Strategy of 2004, 2011 • Disaster Management Policies / Plans	• All • All • All	
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Private Sector Strategies - Banks ▫ Development	• All	
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Land Use Measures - Adaptive Spatial Planning • Resettlement	• Flash Floods • Regional Floods • Regional Floods • Hydrological Droughts • DDF - Stormflows • DDF - Peak Discharge	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 7.3 Ch 5.6

Table 13 Adaptation recommendations for Poor Rural Communities
(Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
• Storage and Reticulation - Surface Water ▫ Small Reservoirs - Groundwater ▫ Borehole Drilling • Rainwater Harvesting • Early Warning Systems - Short-Term (Days to Weeks) - Medium-Term (Month to Season) • Indigenous Coping Strategies	• Flash Floods - Agricultural Droughts - Hydrological Droughts - Surface Water Supply - Enhanced Evaporation - DDF - Streamflows - DDF - Peak Discharge - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol • Hydrological Droughts - Agricultural Droughts - Groundwater Recharge - Groundwater Supply • Hydrological Droughts - Agricultural Droughts - Threshold Rainfalls - Soil Moisture - Surface Water Supply • Heat Waves - Enhanced Evaporation - Soil Moisture - Threshold Rainfalls • Hydrological Droughts - Agricultural Droughts - Surface Water Supply - Groundwater Recharge - Groundwater Supply - Threshold Rainfalls - Soil Moisture • Flash Floods - Regional Floods - Soil Moisture - Hydrological Droughts - Storm Surges - Surface Water Supply	Ch 5.6, 7.1 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 4.2 Ch 7.3 Ch 5.6 Ch 5.7 Ch 8.3 Not in Report Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.3 Not in Report Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 3.6 Ch 4.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 See Schulze and Kunz (2010) Ch 4.1, 4.2, 8.1 Ch 4.2 Ch 3.6 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.3 Not in Report Ch 3.6 Ch 4.2 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 4.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4

KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Research and Development - Development of Drought Resistant Crops • Participatory Approach in Decision-Making	• Agricultural Droughts Soil Moisture • All	Ch 4.2, 6.1, 6.2, 8.2 Ch 4.2
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Other National Master Plans - Conservation of Agricultural Resources Act - Integrated Development Plans	• All • All	
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Private Sector Strategies - Insurance ▫ Micro-Insurance - Banks ▫ Micro-Lenders	• Flash Floods Regional Floods Heat Waves Threshold Rainfalls Agricultural Droughts • Agricultural Droughts Heat Waves Threshold Rainfalls Soil Moisture Flash Floods Regional Floods	Ch 5.6, 7.1 Ch 7.2, 7.3 See Schulze and Kunz (2010) Ch 3.6 Ch 4.2, 6.1, 6.2, 8.2 Ch 4.2, 6.1, 6.2, 8.2 See Schulze and Kunz (2010) Ch 3.6 Ch 4.2 Ch 5.6, 7.1 Ch 7.2, 7.3
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Land Use Measures - Conservation Structures - Tillage Practices • Crop Change • Resettlement	• Flash Floods Regional Floods Storm Surges Agricultural Droughts • Agricultural Droughts Enhanced Evaporation Soil Moisture • Agricultural Droughts Enhanced Evaporation Soil Moisture • Regional Floods Agricultural Droughts Hydrological Droughts Sea Level Rise Water Quality - Biol	Ch 5.6, 7.1 Ch 7.2, 7.3 Not in Report Ch 4.2, 6.1, 6.2, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 4.1, 4.2, 8.1 Ch 4.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 4.1, 4.2, 8.1 Ch 4.2 Ch 7.2, 7.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Not in Report

Table 14 Adaptation recommendations for Informal Urban Communities (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
• Storage and Reticulation - Surface Water ▫ Large Reservoirs - Groundwater ▫ Borehole Drilling - System Maintenance ▫ Supply Leakage Control - Rainwater Harvesting - Water Re-use / Recycling • Water Quality and Quantity Monitoring Systems • Flood / Storm Surge Control - Structures (e.g. Dams, spillways, stormwater systems, levees, wave breaks, vegetation) • Early Warning Systems - Near Real-Time (Hours to Days) - Short-Term (Days to Weeks)	• Enhanced Evaporation Surface Water Supply Hydrological Droughts Water Quality - SedS Water Quality - Chem Water Quality - Biol • Groundwater Storage Groundwater Recharge Water Quality -Chem • Surface Water Supply • Surface Water Supply Threshold Rainfalls • Surface Water Supply Water Quality - Chem Water Quality - Biol • All • Threshold Streamflows DDF - Streamflows DDF - Peak Discharge • Flash Floods Threshold Streamflows Soil Moisture DDF - Rainfall: Short DDF - Streamflows DDF - Peak Discharge • Threshold Rainfalls Threshold Streamflows DDF - Rainfall: Long	Ch 4.1, 4.2, 8.1 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.7 Ch 8.3 Not in Report Not in Report Ch 5.3 Ch 8.3 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 3.6 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 8.3 Not in Report Ch 5.5 Ch 7.3 Ch 5.6 Ch 5.6, 7.1 Ch 5.5 Ch 4.2 Ch 7.1 Ch 7.3 Ch 5.6 Ch 3.6 Ch 5.5 Ch 7.2

- Medium-Term (Month to Season) • Communication of Forecasts to End Users - Awareness Creation at Higher Decision Making Level - Training at Local Level (e.g. Municipal WWT operators) • Operations / System Improvements - Retrofitting Existing Structures - Irrigation Scheduling • Water Demand Management • Indigenous Coping Strategies	DDF - Streamflows • Surface Water Supply • All • All • Surface Water Supply DDF - Streamflows DDF - Peak Discharge • All • All	Ch 7.3 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 7.3 Ch 5.6
KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Research and Development - Efficient Technologies - Upgrading of Climate Models ▫ Fine Scale Information Provision Relevant to Local Water Managers - Improvement of Forecast Skill / Dissemination • Development of Risk Maps / Floodlines • Communication, Training, Dissemination - Awareness Creation at Higher Decision Making Level - Awareness Creation at Operational Level (e.g. Municipal WWT) - Training at Middle Management Level - Training at Local Level (e.g. Municipal WWT)	• All • All • Threshold Rainfalls Threshold Streamflows Flash Floods • Regional Floods DDF - Streamflows DDF - Peak Discharge • All • All • All	 Ch 3.6 Ch 5.5 Ch 5.6, 7.1 Ch 5.2, 5.4, 7.3 Ch 7.3 Ch 5.6

- operators) • Participatory Approach in Decision-Making - Creations of Ongoing Learning and Communication Platforms btw. Main Water Users (e.g. WRC Reference Group meetings)	• All • All	
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• National Water Master Plans ▫ Water Services Act of 1997 ▫ National Water Resource Strategy of 2004, 2011 ▫ Water for Growth and Development Framework of 2009 ▫ Catchment Management Strategies • Other National Master Plans ▫ Integrated Development Plans (IDPs) • Provincial Strategies ▫ Provincial Growth and Development Strategies ▫ Provincial Water Reconciliation Strategies • Local Strategies ▫ Municipal Bye-Laws • Disaster Management Policies / Plans	• All • All • All • All • All • All • All • All • All	
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Private Sector Strategies - Insurance - Micro-Insurance - Banks ▫ Development	• Flash Floods - Regional Floods - Threshold Rainfalls - Threshold Streamflows • Surface Water Supply - Hydrological Droughts - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Streamflows	Ch 5.6, 7.1 Ch 5.2, 5.4, 7.3 Ch 3.6 Ch 5.5 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 7.1 Ch 7.2 Ch 7.3

	DDF - Peak Discharge	Ch 5.6
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
- Land Use Measures - Adaptive Spatial Planning - Resettlement	- All - Flash Floods - Regional Floods - Surface Water Supply - DDF - Streamflows - DDF - Peak Discharge	Ch 5.6, 7.1 Ch 5.2, 5.4, 7.3 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 7.3 Ch 5.6

Table 15 Adaptation recommendations for Individual Households
(Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
- Storage and Reticulation - Surface Water - Small Reservoirs - Groundwater - Borehole Drilling - Rainwater Harvesting - Early Warning Systems - Near Real-Time (Hours to Days) - Short-Term (Days to Weeks) - Medium-Term (Month to Season) - Long-Term (Years to Decades) - Communication of	- Agricultural Droughts - Hydrological Droughts - Enhanced Evaporation - Threshold Streamflows - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol - Surface Water Supply - Hydrological Droughts - Agricultural Droughts - Groundwater Recharge - Groundwater Supply - Hydrological Droughts - Agricultural Droughts - Threshold Rainfalls - Soil Moisture - Surface Water Supply - Flash Floods - Regional Floods - Threshold Rainfalls - Soil Moisture - Regional Floods - Hydrological Droughts - Agricultural Droughts - Threshold Rainfalls - Hydrological Droughts - Agricultural Droughts - Surface Water Supply - Groundwater Recharge - Groundwater Supply - Hydrological Droughts - Surface Water Supply - Groundwater Recharge - Groundwater Supply	- Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 4.1, 4.2, 8.1 - Ch 5.5 - Ch 5.7 - Ch 8.3 - Not in Report - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.3 - Not in Report - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 3.6 - Ch 4.2 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 3.6 - Ch 4.2 - Ch 7.2, 7.3 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 3.6 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 5.3 - Not in Report - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 5.3 - Not in Report

Forecasts to End Users Indigenous Coping Strategies	- Flash Floods Regional Floods Threshold Rainfalls Threshold Streamflows Hydrological Droughts Agricultural Droughts - Flash Floods Regional Floods Soil Moisture Agricultural Droughts Hydrological Droughts Surface Water Supply	Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 3.6 Ch 5.5 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 4.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4
KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
- Research and Development - Improve Forecast Skill / Dissemination - Development of Drought Resistant Crops - Participatory Approach in Decision-Making	- All - Agricultural Droughts Soil Moisture - All	Ch 4.2, 6.1, 6.2, 8.2 Ch 4.2
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
Disaster Management Policies / Plans	All	
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
- Private Sector Strategies - Insurance - Primary Insurers - Micro-Insurance - Banks - Private - Micro-Lenders	- Agricultural Droughts Hydrological Droughts Regional Floods Flash Floods - Flash Floods Regional Floods Agricultural Droughts - Agricultural Droughts Regional Floods Flash Floods - Agricultural Droughts Flash Floods Regional Floods	Ch 4.2, 6.1, 6.2, 8.2 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 7.2, 7.3 Ch 5.6, 7.1 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 4.2, 6.1, 6.2, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.2, 7.3 Ch 5.6, 7.1 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.6, 7.1 Ch 7.2, 7.3
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
Resettlement	Regional Floods Hydrological Droughts Water Quality	Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.7, 8.3

Table 16 Adaptation recommendations for Aquatic Ecosystems (Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
• Storage and Reticulation - Surface Water ▫ Large Reservoirs ▫ Small Reservoirs - Groundwater ▫ Sand Dams - Water Re-use / Recycling • Flood / Storm Surge Control - Structures (e.g. Dams, spillways, stormwater systems, levees, wave breaks, vegetation) • Early Warning Systems - Near Real-Time (Hours)	• Enhanced Evaporation - Water Temperature - Threshold Streamflows - DDF - Streamflows - DDF - Peak Discharge - Water Quality - SedS - Water Quality - Chem - Water Quality - Biol - Regional Floods - Hydrological Droughts - Surface Water Supply - Environmental Flows - Storm Surges • Surface Water Supply - Hydrological Droughts - DDF - Streamflows - DDF - Peak Discharge - Enhanced Evaporation - Threshold Streamflows - Water Temperature - Water Quality - Chem - Water Quality - Biol • Flash Floods - Hydrological Droughts • Surface Water Supply - Water Temperature - Water Quality - Chem • Environmental Flows - Flash Floods - Regional Floods - Surface Water Supply - Sea Level Rise - Storm Surges	- Ch 4.1, 4.2, 8.1 - See Barichiev <i>et al.</i> (2010a) - Ch 5.5 - Ch 7.3 - Ch 5.6 - Ch 5.7 - Ch 8.3 - Not in Report - Ch 7.2, 7.3 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - See Barichiev <i>et al.</i> (2010b) - Not in Report - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 7.3 - Ch 5.6 - Ch 4.1, 4.2, 8.1 - Ch 5.5 - See Barichiev <i>et al.</i> (2010a) - Ch 8.3 - Not in Report - Ch 5.6, 7.1 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - See Barichiev <i>et al.</i> (2010a) - Ch 8.3 - See Barichiev <i>et al.</i> (2010b) - Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Not in Report - Not in Report

to Days)	• Environmental Flows - Water Temperature - Flash Floods - Regional Floods - Threshold Streamflows - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge - Water Quality - Sediments - Water Quality - Chemical - Water Quality - Biological	See Barichiev <i>et al.</i> (2010b) See Barichiev <i>et al.</i> (2010a) Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5 Ch 7.2 Ch 7.3 Ch 5.6 Ch 5.7 Ch 8.3 Not in Report
- Short-Term (Days to Weeks)	• Environmental Flows - Water Temperature - Regional Floods - Hydrological Droughts - Agricultural Droughts - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge - Threshold Streamflows - Water Quality - Sediments - Water Quality - Chemical - Water Quality - Biological	See Barichiev <i>et al.</i> (2010b) See Barichiev <i>et al.</i> (2010a) Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 7.2 Ch 7.3 Ch 5.6 Ch 5.5 Ch 5.7 Ch 8.3 Not in Report
- Medium-Term (Month to Season)	• Environmental Flows - Water Temperature - Hydrological Droughts - Agricultural Droughts - Surface Water Supply - Hydrological Droughts - Surface Water Supply	See Barichiev <i>et al.</i> (2010b) See Barichiev <i>et al.</i> (2010a) Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 4.2, 6.1, 6.2, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4
- Long-Term (Years to Decades)	• Environmental Flows - Surface Water Supply - Threshold Streamflows - Flash Floods - Regional Floods - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge - Hydrological Droughts - Sea Level Rise - Storm Surges	See Barichiev <i>et al.</i> (2010b) Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.2 Ch 7.3 Ch 5.6 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Not in Report Not in Report
• Communication of Forecasts to End Users - Awareness Creation at Higher Decision Making Level	• Environmental Flows - Water Temperature - Flash Floods	See Barichiev <i>et al.</i> (2010b) See Barichiev <i>et al.</i> (2010a) Ch 5.6, 7.1

- Awareness Creation at Operational Level - Training at Local Level • Water Quality and Quantity Monitoring Systems • Operations / System Improvements - Reservoir Operations Rules • Water Demand Management	Regional Floods Storm Surges Threshold Streamflows Surface Water Supply Water Quality - Sediments Water Quality - Chemical Water Quality - Biological • All • Flash Floods Regional Floods Hydrological Droughts Environmental Flows Water Temperature Surface Water Supply Threshold Streamflows • All • Environmental Flows Water Temperature Flash Floods Regional Floods Threshold Streamflows Hydrological Droughts DDF - Streamflows DDF - Peak Discharge Sea Level Rise Storm Surges Surface Water Supply • Hydrological Droughts Surface Water Supply Water Quality - Chemical Water Quality - Biological Environmental Flows	Ch 5.2, 5.4, 7.3 Not in Report Ch 5.5 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.7 Ch 8.3 Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 See Barichievsky <i>et al.</i> (2010b) See Barichievsky <i>et al.</i> (2010a) Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5 See Barichievsky <i>et al.</i> (2010b) See Barichievsky <i>et al.</i> (2010a) Ch 5.6, 7.1 Ch 5.2, 5.4, 7.3 Ch 5.5 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 7.3 Ch 5.6 Not in Report Not in Report Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 8.3 Not in Report See Barichievsky <i>et al.</i> (2010b)
KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Research and Development - Upgrading of Climate Models ▫ Fine Scale Information Provision Relevant to Local Water Managers - Improvement of Forecast Skill / Dissemination • Communication / Training / Dissemination	• All • All	

- Awareness Creation at Higher Decision Making Level - Awareness Creation at Operations Level (e.g. Senior Municipal Officials (re. budget allocation and future special planning) - Training at Middle Management Level - Training at Local Level (e.g. Municipal WWT operators) • Participatory Approach in Decision-Making - Establishment of Inter-Departmental Learning Platforms - Establishment of Integrated Communications Systems - Creation of Ongoing Learning and Communication Platforms between Main Water Users	• All • All • All • All • All • All • All	
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• International Conventions (e.g. RAMSAR) • International Agreements • National Water Master Plans - National Water Act of 1998 - National Water Resource Strategy - Water for Growth and Development Framework of 2009 - Catchment Management Strategies - River Management Plans - Estuary Management Plans • Other National Strategies - National Environmental Management Act	• All • Environmental Flows • Environmental Flows • Environmental Flows • Environmental Flows • Environmental Flows • Environmental Flows • Environmental Flows • Environmental Flows • Environmental Flows	See Barichievy <i>et al.</i> (2010b) See Barichievy <i>et al.</i> (2010b) See Barichievy <i>et al.</i> (2010b) See Barichievy <i>et al.</i> (2010b) See Barichievy <i>et al.</i> (2010b) See Barichievy <i>et al.</i> (2010b) See Barichievy <i>et al.</i> (2010b) See Barichievy <i>et al.</i> (2010a) See Barichievy <i>et al.</i> (2010b) See Barichievy <i>et al.</i> (2010b)

- Integrated Development Plans • Provincial Strategies - Provincial Water Reconciliation Strategies • Local Strategies - Municipal Bye-Laws • Disaster Management Policies / Plans	• All • All • All • All	
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Land Use Measures - Conservation Structures - Adaptive Spatial Planning - Alien Invasive Clearing Activities • Resettlement • Maintaining or Re-establishment of Natural Capital (e.g. wetlands, buffers etc)	• Flash Floods - Regional Floods - DDF - Rainfall: Short - DDF - Streamflows - DDF - Peak Discharge - Storm Surges • Flash Floods - Regional Floods - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Streamflow - DDF - Peak Discharge - Threshold Streamflows - Surface Water Supply - Environmental Flows - Sea Level Rise - Storm Surges • Surface Water Supply • Flash Floods - Regional Floods - Rainfall Thresholds - DDF - Rainfall: Short - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge • Flash Floods - Regional Floods - Water Quality - Sediments - Water Quality - Chemical - Water Quality - Biological	- Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 7.1 - Ch 7/3 - Ch 5.6 - Not in Report - Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 7.1 - Ch 7.2 - Ch 7.3 - Ch 5.6 - Ch 5.5 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - See Barichievsky <i>et al.</i> (2010b) - Not in Report - Not in Report - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 5.6, 7.1 - Ch 5.2, 5.4, 7.3 - Ch 3.6 - Ch 7.1 - Ch 7.2 - Ch 7.3 - Ch 5.6 - Ch 5.6, 7.1 - Ch 5.2, 5.4, 7.3 - Ch 5.7 - Ch 8.3 - Not in Report

Table 17 Adaptation recommendations for Terrestrial Ecosystems
(Schulze, 2011)

ENHANCING ADAPTIVE CAPACITY TECHNOLOGICAL AND STRUCTURAL	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES TO SCHULZE (2011)
• Storage and Reticulation - Surface Water ▫ Large Reservoirs ▫ Small Reservoirs • Water Quality and Quantity Monitoring Systems • Early Warning Systems - Near Real-Time (Hours to Days) - Short-Term (Days to Weeks) - Medium-Term (Month to Season)	• Water Quality - Seds - Water Quality - Chem - Water Quality - Biol - Regional Floods - Hydrological Droughts - Surface Water Supply • Surface Water Supply - Hydrological Droughts - DDF - Streamflows - DDF - Peak Discharge - Threshold Streamflows - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol • All • Flash Floods - Regional Floods - Threshold Streamflows - DDF - Streamflows - DDF - Peak Discharge - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol • Environmental Flows - Regional Floods - DDF - Streamflows - DDF - Peak Discharge - Threshold Streamflows - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol • Environmental Flows - Threshold Streamflows - Hydrological Droughts - Agricultural Droughts - Surface Water Supply - Hydrological Droughts	- Ch 5.7 - Ch 8.3 - Not in Report - Ch 7.2, 7.3 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 7.3 - Ch 5.6 - Ch 5.5 - Ch 5.7 - Ch 8.3 - Not in Report - Ch 5.6, 7.1 - Ch 7.2, 7.3 - Ch 5.5 - Ch 7.3 - Ch 5.6 - Ch 5.7 - Ch 8.3 - Not in Report - See Barichiev <i>et al.</i> (2010b) - Ch 7.2, 7.3 - Ch 7.3 - Ch 5.6 - Ch 5.5 - Ch 5.7 - Ch 8.3 - Not in Report - See Barichiev <i>et al.</i> (2010b) - Ch 5.5 - Ch 5.5, 6.1, 6.2, 8.1, 8.2 - Ch 4.2, 6.1, 6.2, 8.2 - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 - Ch 5.5, 6.1, 6.2, 8.1, 8.2

- Long-Term (Years to Decades) • Communication of Forecasts to End Users - Awareness Creation at Higher Decision Making Level - Awareness Creation at Operational Level - Training at Local Level • Water Quality and Quantity Monitoring Systems • Water Demand Management	- Surface Water Supply - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol • Environmental Flows - Surface Water Supply - Threshold Streamflows - Flash Floods - Regional Floods - DDF - Rainfall: Long - DDF - Streamflows - DDF - Peak Discharge - Hydrological Droughts - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol • Environmental Flows - Flash Floods - Regional Floods - Threshold Streamflows - Surface Water Supply - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol • All • Flash Floods - Regional Floods - Hydrological Droughts - Environmental Flows - Surface Water Supply - Threshold Streamflows - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol • All • Hydrological Droughts - Threshold Streamflows - Surface Water Supply - Water Quality - Chem - Water Quality - Biol - Environmental Flows	Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.7 Ch 8.3 Not in Report See Barichievy <i>et al.</i> (2010b) Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5 Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.2 Ch 7.3 Ch 5.6 Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.7 Ch 8.3 Not in Report See Barichievy <i>et al.</i> (2010b) Ch 5.6, 7.1 Ch 5.2, 5.4, 7.3 Ch 5.5 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.7 Ch 8.3 Not in Report Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 5.5, 6.1, 6.2, 8.1, 8.2 See Barichievy <i>et al.</i> (2010b) Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5 Ch 5.7 Ch 8.3 Not in Report Ch 5.5, 6.1, 6.2, 8.1, 8.2 Ch 5.5 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 8.3 Not in Report See Barichievy <i>et al.</i> (2010b)
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KNOWLEDGE / SKILLS / PARTICIPATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Research and Development - Upgrading of Climate Models ▫ Fine Scale Information Provision Relevant to Local Water Managers - Improvement of Forecast Skill / Dissemination • Communication / Training / Dissemination - Awareness Creation at Higher Decision Making Level - Awareness Creation at Operations Level (e.g. Senior Municipal Officials (re. budget allocation and future special planning)) - Training at Middle Management Level - Training at Local Level (e.g. Municipal WWT operators) • Participatory Approach in Decision-Making - Establishment of Inter-Departmental Learning Platforms - Establishment of Integrated Communications Systems - Creation of Ongoing Learning and Communication Platforms between Main Water Users	• All • All • All • All • All • All • All • All	
POLICY INSTRUMENTS	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• International Conventions (Biodiversity Convention) • International Agreements • National Water Master Plans - National Water Act of 1998 - National Water Resource Strategy	• All • All • All • All	

- Water for Growth and Development Framework of 2009 - Catchment Management Strategies - River Management Plans - Estuary Management Plans • Other National Strategies - National Environmental Management Act - Conservation of Agricultural Resources Act - Integrated Development Plans • Provincial Strategies - Provincial Water Reconciliation Strategies • Local Strategies - Municipal Bye-Laws • Disaster Management Policies / Plans	• All • All • All • All • All • All • All • All • All • All	
RISK SHARING / SPREADING	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
CHANGE OF USE / ACTIVITY / LOCATION	ADAPTING TO CHANGES IN . . .	CROSS REFERENCES
• Land Use Measures - Conservation Structures - Adaptive Spatial Planning - Alien Invasive Clearing Activities • Maintaining or Re-	• Flash Floods Regional Floods DDF - Rainfall: Short DDF - Streamflows DDF - Peak Discharge • Flash Floods Regional Floods DDF - Rainfall: Short DDF - Rainfall: Long DDF - Streamflow DDF - Peak Discharge Threshold Streamflows Surface Water Supply Environmental Flows Sea Level Rise Storm Surges • Surface Water Supply Threshold Streamflows	- Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7/3 Ch 5.6 - Ch 5.6, 7.1 Ch 7.2, 7.3 Ch 7.1 Ch 7.2 Ch 7.3 Ch 5.6 Ch 5.5 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Not in Report Not in Report - Ch 5.2, 5.4, 6.1, 6.2, 8.1, 8.4 Ch 5.5

establishment of Natural Capital (e.g. wetlands, buffers etc)	- Flash Floods - Regional Floods - Threshold Streamflows - Water Quality - Seds - Water Quality - Chem - Water Quality - Biol	Ch 5.6, 7.1 Ch 5.2, 5.4, 7.3 Ch 5.5 Ch 5.7 Ch 8.3 Not in Report
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The Process from Here? A Framework for Adaptive Management

Long-term sustainable and conscious adaptation planning (and implementation!) cannot be achieved by YOU as an individual nor does it happen by chance. There is the need for a tailored way to include a process on a day-to-day basis, with as little bureaucratic inertia / interference as possible.

Having created a broader knowledge base on climate change impacts, a process is now needed to draw on other stakeholders' and champions' expertise to achieve further understanding of arising issues and especially vulnerabilities which may result from climate change.

For above reasons a framework has been designed which is based on the core principles of adaptation, integrated water resource management and social learning. The idea is to make use of the flexibility offered by South Africa's water regulations and enabling the opportunity to fill gaps of implementation in order to enter into a progressive water management era. The framework and its adaptive practices could create momentum to pro-actively counteract negative impacts of climate change and derive benefit from positive impacts, thereby reducing vulnerability specifically in the poverty stricken communities of our society. Consequently, it has to assure appropriate ways of dealing with future impacts of climate change, while simultaneously avoiding maladaptation and it should not rely on automatisms of decision takers, i.e. taking decisions just because they have been informed or believe they know the answers.

What all stakeholders and decision makers need to be aware of is that adaptive management practices, of which the following process is part, introduce change. Change in knowledge, change in the way of thinking and change in management. This might go as far as changing decision taking processes. Changes often pose a threat to people as these changes can be painful. A note of caution thus has to be raised, because resistance may be built up as partakers could feel insecure, despite understanding the need for change and adjustments (TEC GWP, 2004).

Some issues need to be clarified up front:

- The framework is not designed for application at one specific spatial scale, i.e. national, regional, local, catchment, sub-catchment etc., or one specific sector.
- The framework should be organized and, hence, limited on a particular scale or level of government, but needs to actively include and consciously inform other levels and sectors.
- The process within the framework needs to be run repetitively over time. Such adaptive cycles offer the opportunity of incorporating new information, creating new knowledge and implementation. But it is critical that afterwards phases of repose follow in order to consolidate what has been learned and implement accordingly.
- The latter is especially important in gaining predictability and continuity of governance during times of change or in periods after change. This is essential for consistency and reliability in planning.

First, a **common starting point** is vital. Let's call it the safe zone where the individual is empowered to act and has knowledge equity with colleagues and stakeholders. This calls for two tasks: **creating common ground** through knowledge on the hydrological system, understanding of relevant laws and regulations as well as the ability to apply **the laws, and consistency** through implementation and monitoring. The latter builds predictability of governance and avoids injustices.

Secondly, a **joint goal** needs to be laid out. Let's call it the team's vision on adaptation that needs to be tailored to a certain **location or a specific water related sector**. The tasks, however, will be to accept the **vulnerabilities of 'water and society as guiding principles'** in decision making and that the **future will be dynamic** and constantly changing **with manifold uncertainties**.

The process to be implemented is a **pathway**, which in itself is adaptive and iterative. The aim is to create innovative solutions for adaptation to climate change. This **implies internalising flexibility** by thinking within ranges and creating changeable options. The latter assures **robust strategies which** consider, *inter alia*, the uncertainties underlying climate change itself and the **uncertainties related to** development of society and economic growth.

The **process**:

1. Choose a location / water related theme and collate all information (biophysical, economic, societal).
2. Ask an expert for the latest scientific findings on climate change downscaled to a relevant level for decision making. Request information on uncertainties of the projections as well.
3. Choose and invite your champions.
4. Check out the expectations of the champions and jointly create rules of interaction and communication.
5. Jointly gain new information and insight into climate change and its vulnerabilities.
6. Decide what is relevant and needs attention.
7. Develop and prioritise adaptation options.
8. Create indicators for monitoring and assessment.
9. Decide on assessment periods (a minimum of 1 year and a maximum of 5 years has been found to work in practice).
10. Manage and distribute information to other levels and sectors.
11. Deal with feedback from item 9. If necessary, go back to item 5.
12. Implement actions and strategies.
13. Integrate knowledge into day-to-day decision making.
14. Monitor progress of the actions and strategies.
15. Invite your champions and other experts.
16. Jointly assess the outcomes.
17. Jointly evaluate against initial situation.
18. Go back to item 5.

Some key factors for success:

Make use of champions with a wide range of expertise. This variety should break up sectoral thinking. Champions are defined here as

individuals who have institutional memory, are critical thinkers and have shown leadership in the past.

Create relevant participation. Besides stakeholders inside and outside of government, experts such as researchers should play a key role. Contributions from the public are crucial, but need to be assessed carefully in their scope and at what point in time these contributions should be sought before their inputs are implemented. Open public participation should be restricted until trust has been built between the champions and rules have been set and tested, especially in the first few adaptive cycles.

Good governance is also key for the process. Transparency and accountability are especially crucial when creating, implementing, evaluating and revising adaptation strategies.

Adaptation Design

In order to revisit your designs, choose information and databases from official organizations that are being reviewed on a regular basis. Furthermore, be aware of assumptions and uncertainties that might underly these.

One example of new knowledge for tailoring adaptation activities is introduced in this section. This example, and other similar ones, might be informative as they stand, but they hopefully will make you broaden your thinking towards the complexities of the hydrological system when taking socio-economic interactions into consideration.

Example: Rainwater harvesting options under present and projected future climatic conditions (Adapted from Bulcock and Schulze, 2011)

Introduction

Water scarcity in countries such as South Africa places considerable strain on communities which rely directly on rainfall to sustain their livelihoods. Irregularity in timing and distribution of rainfall may leave many communities without access to water for even the most basic daily requirements.

Projected changes in climate in the future may result in even greater irregularities in the availability of water for daily use. Amongst the most vulnerable are poor communities, living in low income houses with little access to services and resources. Over the centuries and throughout Sub-Saharan Africa, indigenous knowledge systems have adapted various ways of collecting and storing water for later use (Rockström, 2000, Mbilinyi *et al.*, 2005). However, the full potential of this type of water supply has not been fully exploited in South Africa to date. It has been suggested that rainwater harvesting (RWH) could be implemented to alleviate the temporal water supply problems and to supplement the conventional water supply systems as demand increasingly grows (Mwenga Kahinda *et al.*, 2005).

RWH collectively refers to all methods used to collect, store and utilize rainfall for domestic and agricultural use (Rockström, 2000; Sutherland and Fenn, 2000). For this research the focus was on

collecting rainfall runoff from the roof surface of a conventional low income RDP house and collected in a water tank. Rainwater yield depends largely on roof size, tank capacity and daily rainfall but also on the daily water requirements of the household. According to FAO, the daily water requirement *per capita* is 50 litres (Gleick, 1996; Diouf, 2007). An assumption of 6 people per house was made, which is slightly higher than most statistics indicate. However, low income households generally have high numbers of people; therefore a conservative figure was taken. RDP houses in South Africa range between 30 and 50m² with an average size of 40m² (**Photo 1**).



Photo 1 An average sized RDP house in South Africa with a roof area of 40 m²

Rainwater tanks are available in various sizes. For the purpose of a baseline study, a medium sized tank of 3 000 litres was used.

Methodology

Daily rainfall data were input and an initial abstraction (*I_a*) of 1 mm, due to evaporation and other losses at the commencement of a rainfall event, was subtracted. The amount of water that can be harvested from the roof is calculated by:

$$\text{Harvested Water (l)} = [\text{rainfall (mm)} - I_a \text{ (mm)}] \times \text{roof size (m}^2\text{)}.$$

Household water requirements were calculated according to FAO specifications.

A model was created which calculated the daily inflows from rainfall into the tank and the daily outflows from the tank for the household requirements. The model calculated the average number of times per year that the tank

- was completely empty,
- filled completely and overflowed,
- fulfilled the daily requirements of the household and still had some water remaining, and
- provided some water for the daily requirement but not enough to fulfil the total need and was emptied as a result.

Results and Discussion

Figure 9 shows that under current climate conditions, the western part of the country, especially over the Karoo, shows little potential for RWH, as the tank is empty more than 300 days of the year. The eastern part of the country shows the greatest potential, with the tank being empty on fewer occasions and fulfilling the daily household needs for more than half of the year.

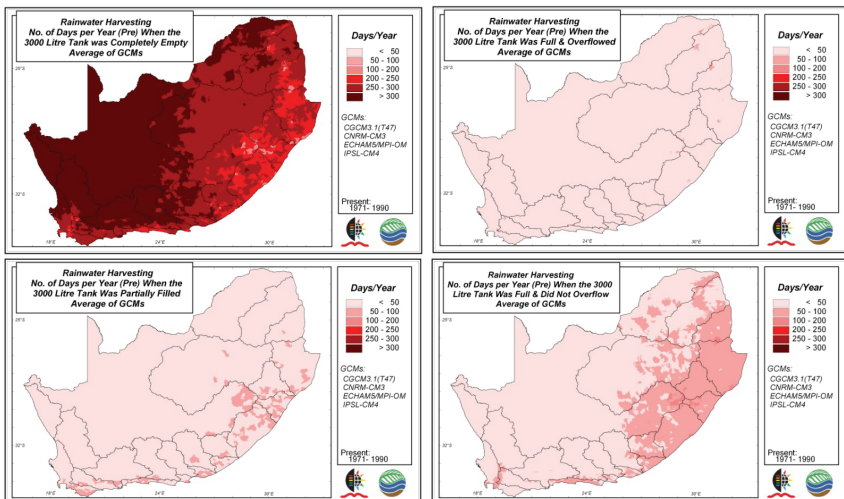


Figure 9 Rainwater harvesting potential under present climate conditions for South Africa

Figure 10 shows that under climate change conditions, potential for rainwater harvesting generally increases across the country, except in the Western Cape. For a majority of the country, the tank will be empty less often and will be able to supply the daily needs of the household in full more often. Of interest is the increase in the number of times that the tank will overflow. This could indicate that in the

future larger tanks should be installed to maximize the amount of water that can be harvested and thereby improve the productivity of the RWH system.

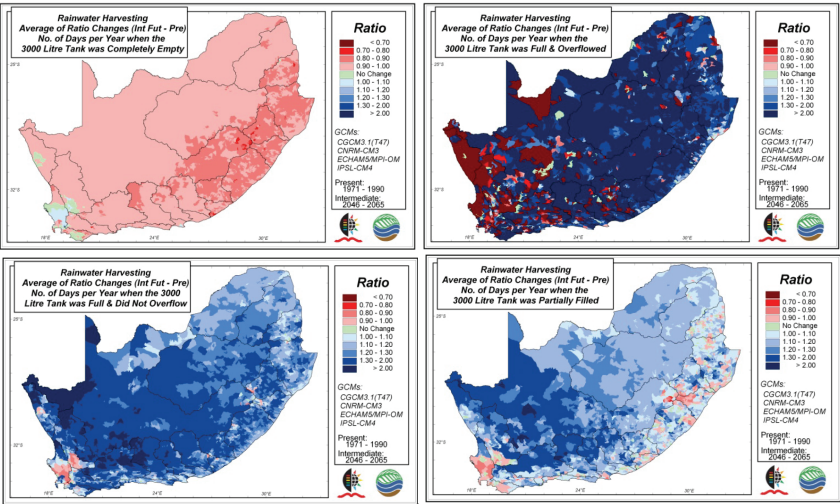


Figure 10 Shifts in rainwater harvesting potential between the intermediate future and present climate scenarios, derived from multiple GCMs

Figure 11 again shows that under more distant future climate change conditions there is an increase in RWH potential across most of South Africa. The marked increase in the number of times that the tank will overflow in the eastern part of the country again supports the notion of increasing tank sizes to best utilize and store collected rainfall.

Figure 12 clearly shows the shift in the latter half of the century whereby the potential of RWH decreases. Increases in the number of the days the tank is dry correspond with decreases in the number of times that the tank is able to supply water to the household. This shows that RWH as a long term solution to alternative water supply is not feasible along the west coast due to the effects of climate change. However, most of the rest of the country may hold potential for RWH to fulfil, or at least supplement, the household requirements, as the thank is often full and there is even an increase in the number of times the tank overflows, suggesting the larger

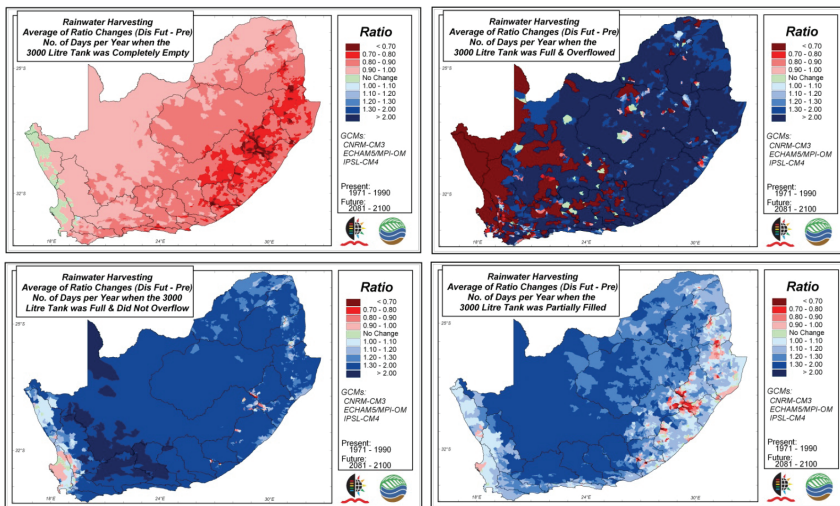


Figure 11 Shifts in rainwater harvesting potential between the more distant future and present climate scenarios, derived from multiple GCMs

tanks may help to exploit this water supply option even more through increased collection and storage.

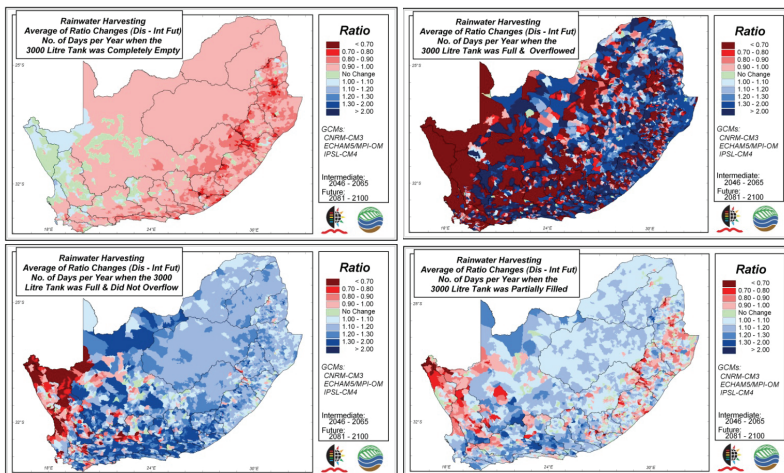


Figure 12 Shifts in rainwater harvesting potential between the more distant and the intermediate climate scenarios, derived from multiple GCMs

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