



Climate Change Municipal Adaptation Plan Health and Water

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eThekwini Municipality

Municipal Adaptation Plan Health and Water

16 November 2009

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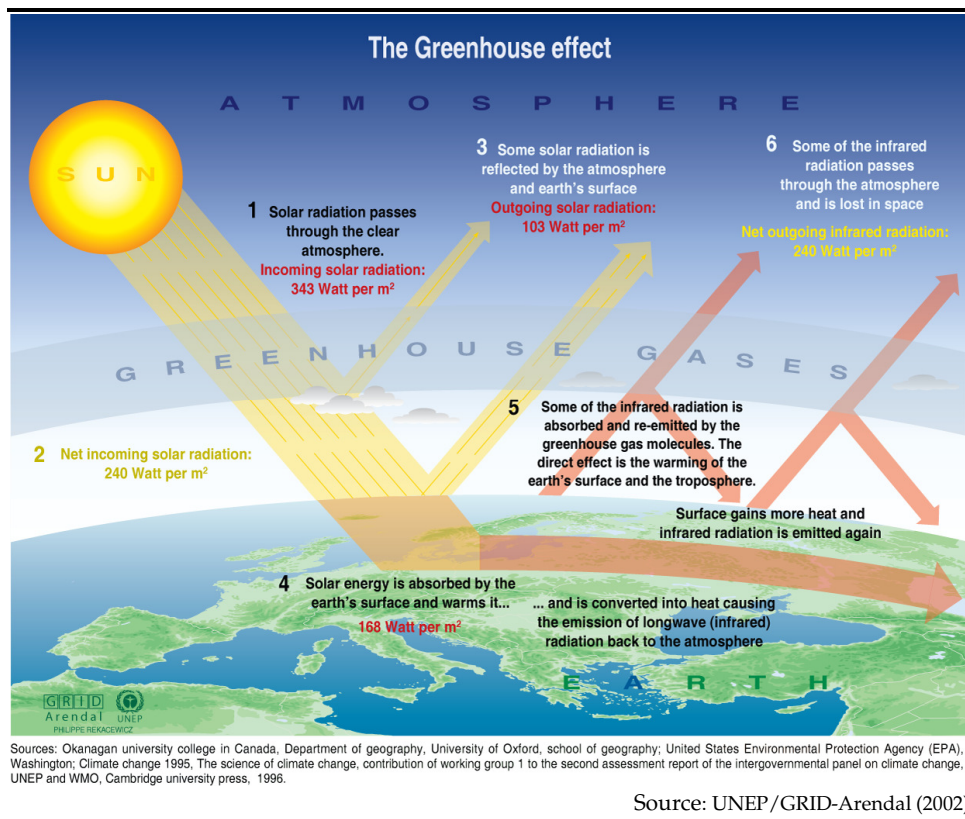
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Human-induced climate change is one of the most complex and serious challenges confronting the world today. The burning of fossil fuels to generate energy, the release of carbon from soil into the atmosphere when land is ploughed, the mining of calcium carbonate for cement production, the release of methane from farm animals and landfills, the emission of industrial gases, and the deforestation of regions that sequester atmospheric carbon dioxide (CO₂) all increase the concentration of atmospheric greenhouse gases (GHGs). This in turn increases the retention of solar radiation within the atmosphere, raises the temperature and destabilises the global climate system (see Figure 1.1).

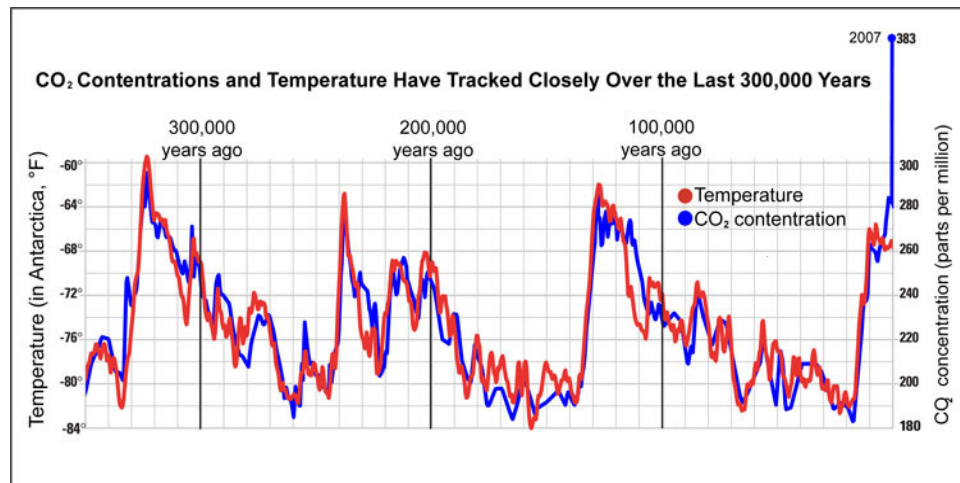
Figure 1.1 Illustration of the Greenhouse Effect



The earth's atmosphere has always contained GHGs, and their trapping of heat within the atmosphere is responsible for the ambient temperatures under which communities and economies have developed. The concentration of these greenhouse gases in the atmosphere has always varied naturally as a result of complex cause and effect feedback cycles within the long-term carbon cycle affected by photosynthesis and respiration of plants, weathering of

silicates and organic carbon, ocean circulation and precipitation. Temperature and atmospheric CO₂ are intricately linked in this system and *Figure 1.2* illustrates this relationship as determined through the analysis of ice core records. The natural variations can be attributed to astronomical processes affecting the distance and angle (and therefore temperature) of the Earth in relation to the Sun.

Figure 1.2 Ice core records showing temperature and carbon dioxide variations over the past 350,000 years



South West Climate Network (2009)

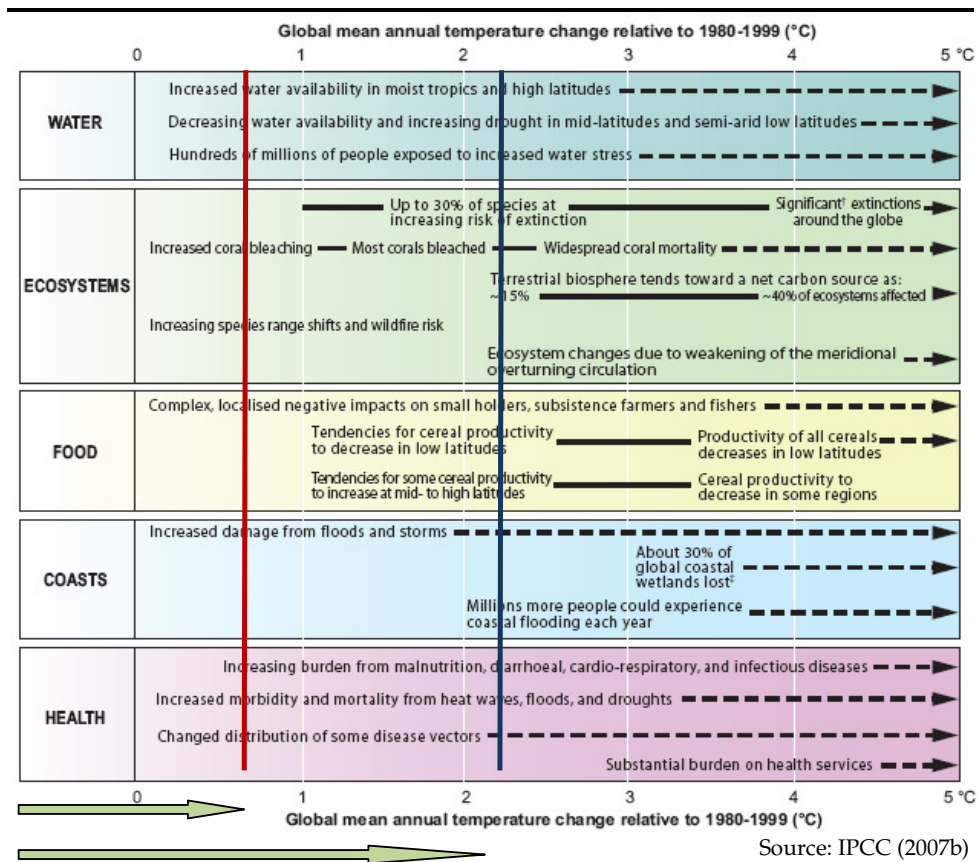
Since the beginning of the Industrial Revolution, the levels of GHGs have increased rapidly as a result of human activities, and particularly due to the burning of fossil fuels. Global GHG emissions from human activity increased by 70% between 1970 and 2004. Current levels of CO₂ in the atmosphere are higher than they have been over the past 400,000 years (*Figure 1.2*) and “exceed by far” the natural range over the past 650,000 years (IPCC, 2007a). The current rate of increase in CO₂ concentrations (1.9 ppm per year) is unprecedented in the past 200 years (IPCC, 2007a). At the same time, the 100 year linear terrestrial temperature trend (1905-2005) has increased by 0.74 °C (0.56-0.92°C range) and 13 of the last 14 years rank among the 14 warmest years since instrumental records became available in 1850 (IPCC, 2007a). In February 2007, the Intergovernmental Panel on Climate Change (IPCC), which is made up of 2500 scientists from 130 countries, reported that it was “very likely” or 90% probable that human activities were the main cause of global warming in the past 50 years (IPCC, 2007a).

The rate of current climate change makes it difficult for plants and animals to adapt or evolve in response to the changing conditions as they have done in the past. It also creates the potential for feedback effects to compound each other, further accelerating climate change. Feedbacks can amplify or dampen the temperature response to the immediate climate forcing, and have a

profound impact on localised climate impacts. For example, as global average temperature increases, tropospheric water vapour (a GHG) concentrations increase. Water vapour changes represent the largest feedback affecting equilibrium climate sensitivity and are now better accounted for by the IPCC scientists than previously. Similarly, warming reduces terrestrial and ocean uptake of atmospheric CO₂, although the extent of this feedback effect varies markedly among models (IPCC, 2007a).

What is not contested, is that climate change has already begun to affect physical and biological systems, including people, and that current concentrations of GHGs (which are still increasing at an accelerating rate) commit the world to at least 2°C warming and probably 2.4 °C (Watson, 2009), and hence continued environmental change. Both the Millennium Ecosystem Assessment and the IPCC Fourth Assessment Report, outline the effects of global climate change, including more frequent extreme weather events, rising sea levels, water shortages, threats to food security, disease and other health effects. These effects in relation to global temperatures and their severity are outlined in *Figure 1.3*.

Figure 1.3 *The impact of rising temperatures on natural systems*



On average the world is currently 0.74°C warmer than it was 100 years ago which implies that the physical and biological changes identified by the IPCC that appear to the left of the red line (at 0.74°C) in *Figure 1.3* are already taking

place (IPCC, 2007b). Current concentrations of GHGs in the atmosphere almost certainly commit the world to a 2.2°C temperature rise by 2050, implying that the changes to the left of the purple line are inevitable and need to be planned for.

A combination of weak governance structures, poverty and large numbers of people with a direct dependence on the natural environment for their livelihoods, exposes Africa in particular to the detrimental effects of climate change. At the very least, climate change is expected to negatively affect South Africa's efforts to redress poverty and inequality. More pessimistic scenarios suggest that climate change will necessitate economic reform and a relocation of human settlements (Diamond, 2005; Hansen, 2007; Forum for the Future, 2008).

The need to switch to alternative energy sources is urgent. But even if every country were to cease the emission of greenhouse gases from fossil fuels this year, the global climate would continue warming until at least the end of the century due to built-in momentum in the current climate system (IPCC, 2007a).

1.2

CLIMATE CHANGE VULNERABILITIES AND THE NEED FOR ADAPTATION

Changes in the climate manifest themselves via a disturbance in global weather patterns (e.g. distribution of rain). Typically, but not exclusively, the intensity and frequency of existing weather such as storms and droughts increases. Predicting the consequences of climate change is not an exact science. The IPCC reports that cold days, cold nights and frost has become less frequent over most land areas, while hot days and hot nights have become more frequent (IPCC, 2007a). It also reports that heatwaves appear to have become more frequent, while the proportion of total rainfall from heavy falls has increased and sea levels have risen at sites worldwide since 1975.

In order to understand the impact of climate change, however, it is necessary to appreciate both the biophysical impacts of altered weather patterns and the social and institutional implications of these changes. Climate change impacts are seldom discrete. Changes in precipitation affect:

- access to potable drinking water and the spreading of disease (e.g. malaria, cholera and dengue fever);
- the range of these diseases is affected by changing temperatures and humidity;
- The impact of disease and altered precipitation affects the distribution of rural populations which in turn impacts demand for potable drinking water.
- At the same time , rising sea levels contribute to coastal erosion, flooding of coastal communities and salination of groundwater reserves; while
- warmer nights affect the growth habits of a wide range of crops and necessitate changes in the production of food and fibre.

Not all climate change impacts are expected to be adverse. Longer growing seasons, more intense run-off leading to water impounding opportunities and milder winter climates present new opportunities for agriculture, tourism and water management. Generally, it is anticipated that climate change will create “winners and losers”. The over-riding concern is that the low income and marginalised communities are poorly equipped and can least afford to adapt to these changes. In many instances it is these communities that are most vulnerable to the impacts of climate change. In the context of South Africa’s efforts to reduce inequality and poverty, climate change that is not countered with effective adaptation, has the potential to hinder development efforts.

South Africans have always had to adapt to changing environmental and social conditions. In some ways this equips the country well to deal with future climate induced changes, and planned adaptation efforts should build on existing coping mechanisms. Given the complexity and pace of climate change impacts, however, local authorities such as eThekweni Municipality will be called upon to provide unprecedented support to existing adaptation efforts and to formulate unprecedented responses to existing and new threats. It is the need for planned, and in some cases pre-emptive, adaptation responses that the Municipality has a particular responsibility.

The clear need is for eThekweni Municipality to concurrently switch to non-fossil fuel based energy sources and develop responses to climate change impacts. Preparedness, and the ability to cope with adverse consequences and respond to new opportunities can radically reduce the costs that are associated with climate change⁽¹⁾. Given the complexity of impacts it can, however, be difficult for local authorities such as eThekweni Municipality to formulate appropriate responses.

Whilst it is important to research and raise awareness as to the types of climate change impacts that are likely in Durban, it is not possible to predict the nature and precise timing of every impact that will be encountered. The approach taken in this plan is to reduce vulnerability to a wide range of climate uncertainties and associated impacts by providing information and preparing institutions and communities. Necessarily this involves a process – it is not a once off deliverable. It is not possible to perfectly predict how, where and when climate change impacts will manifest in Durban and it is not possible to ‘climate proof’ the city. The outcome of this adaptation planning process will be a municipality that is prepared and has the ability to adapt well to the changes that it encounters i.e. that is ‘climate smart’.

The principles of good climate adaptation practice are only just beginning to emerge. EThekweni Municipality is at the forefront of a rapidly evolving

(1) In the United Kingdom, for example, it is estimated that appropriate human and institutional responses to sea level rise and flooding could reduce the associated cost of climate change by 27-fold relative to the business-as-usual scenario (King, 2007).

discipline, through commissioning the Municipal Adaptation Plan. What is already clear, however, is that successful climate change adaptation:

- requires climate change to be integrated into existing strategies and decision making processes in order to ensure long term sustainable development – few new perspectives and analytical tools relating only to climate change are required;
- involves the provision of information required to inform decisions, recognising that different stakeholders often have competing goals and processes;
- is a multi-lateral and participatory process. Autonomous action is likely to lead to adaptation that is more harmful than helpful (maladaptation);
- involves actions at multiple scales. Local actions are ultimately required to implement climate change responses and are most effective when supported by an enabling legislative, financial and institutional environment at the provincial and national level, as well as being informed by local and international research;
- preserves the integrity of the environment and the flow of resources and processes from ecosystems providing additional options and buffers;
- involves institutional and social responses as these tend to be of a lower cost and are a pre-requisite for responding to physical and biological impacts;
- should, given the uncertainty over future climate impacts, retain as many adaptation options as possible, and place a premium on flexibility and responsiveness in institutional and programme design. Adaptation options that lock-in technologies or reduce the set of adaptation options should be considered less attractive than those that do not; and
- prioritises responses that do not, themselves, increase the emissions of greenhouse gases (Downing et al., 2008).

Whilst climate change scientists now acknowledge that it is not possible to avoid climate change through mitigation efforts, what is less frequently acknowledged is that adaptation efforts, too, are not able to negate all impacts. At a workshop in Zurich in July 2009, Martin Parry from IPCC Working Group 2 used the term “climate change residual risk” to describe those unavoidable climate change impacts that cannot be adapted against due to technical or financial barriers, and suggested that this residual may be very large. The implication is that alongside mitigation efforts, and as part of their adaptation strategies, local authorities should be planning to cope with managed resettlements, environmental refugees, increasing insurance losses and greater demands on disaster relief resources.

eThekwini Municipality has recognised the need to develop climate change adaptation plans to allow Durban to continue to function and develop effectively and sustainably. This in itself represents an important step in the adaptation process.

eThekwini Municipality has set up a Municipal Climate Protection Programme, which is endorsed by Durban's Integrated Development Plan under Plan 1, Programme 6. The Municipal Climate Protection Programme can be divided into four phases; Phase 1 was the assessment of local climate change impacts; Phase 2 was the Headline Adaptation Strategy which highlighted key interventions required by the municipality to adapt to climate change. Phase 3 involves the development of a tool which will allow for the simulation, evaluation and comparison of strategic development in the city in the context of climate change and Phase 4 is the mainstreaming of climate change concerns into city planning and development. The Headline Adaptation Strategy (Phase 2) identified potential impacts on public health (e.g. heat stress and extended disease ranges) and water supply (e.g. reduced water availability and flooding). Hence, the health and water sectors have been recognised as two key sectors that will be severely impacted by climate change and therefore require urgent attention.

In 2008 eThekwini Municipality's Environmental Management Department (EMD) commissioned Environmental Resources Management Southern Africa (Pty) Ltd (ERM) to take the role of Project Co-ordinator in facilitating the development of Municipal Climate Change Adaptation Plans (Municipal Adaptation Plans) for the municipality's health and water sectors under the Municipal Climate Change Protection Program.

Under the direction of the EMD, ERM worked with health and water department representatives to identify adaptation measures and the most effective means of implementation in light of projected climate change.

The Terms of Reference for this project stated that the Municipal Adaptation Plan should:

- include detailed action plans that will maintain or improve the functioning of municipal systems, departments, services, and infrastructure related to health and water as the local climate changes;
- contain clear phases and timelines for roll out of action plans;
- be developed with approval by municipal departments and key stakeholder groups that will be responsible for plan implementation;

- be based upon the most up-to-date and localised predictions of climate change and its impacts for the eThekweni Municipality over the next 50 to 100 years;
- show consideration to the simultaneous effort of the Municipality to mitigate climate change by reducing its greenhouse gas emissions;
- be cognisant of other local and international experience and best practise in the field of climate change adaptation;
- receive council approval; and
- be ready for implementation by the end of the planning phase.

1.4 *ERM'S APPROACH TO DEVELOPING THE MUNICIPAL ADAPTATION PLAN*

ERM developed this Municipal Adaptation Plan (MAP) with a strong focus on participation. This ensures local level buy-in and capacity building which are critical to the successful implementation of the Municipal Adaptation Plan.

Anton Cartwright, a climate change adaptation expert at the Stockholm Environment Institute (SEI), has supported ERM on this project. He has attended Project Steering Committee meetings and provided expert input and advice during development of the Municipal Adaptation Plan.

The need for a detailed adaptation plan is seen by eThekweni Municipality as a prerequisite for action. The Headline Climate Change Adaptation Strategy was prepared in response to the initial vulnerability analysis which highlighted the fact that most municipal line functions were likely to be negatively impacted by climate change. Although the strategy examined sectoral vulnerabilities and identified adaptation options these were too generalised to prompt action.

This MAP seeks to provide the required detail in the form of the types of responses that are likely to prove successful, who should be collaborating with whom, and what decisions should be taken, by whom, and with what information. The document does focus on specific actions, but places greater emphasis on the institutional prerequisites for effective decision making and actions in the context of adaptation. What the document cannot do is perfectly predict climate change impacts and prescribe specific responses to these impacts. This is not a function of imperfect science or a poorly researched study, but the direct result of the nature of climate change. In this sense the Municipal Adaptation Plan did not set out to “climate proof” the city and the municipality’s activities. It is however possible to better understand the types of risk that climate change is likely to impose on Durban and to support planning decisions - some specific to climate change and some that were going to have to be taken anyway - that will reduce the cost of climate change impacts in Durban.

Institutions and communities that monitor changes, are flexible and have responsive strategies will be better placed to deal with the wide range of difficult to predict climate change contingencies. The aim with this approach is to support climate resilient development characterised by choices of infrastructure, technology, legislation and socio-institutional capacity¹ that will serve eThekweni Municipality well under future climates.

(1) “Socio-institutional capacity” in this context refers to the capacity of people and institutions (including legislation, government and civil society programmes and cultural norms) to individually and collectively support effective climate change responses.

2.1**INTRODUCTION**

An increase in global surface temperature leads to changes in atmospheric circulation and sea levels, which in turn alters rainfall patterns and increases the intensity of storms. Durban already faces challenges associated with water availability and storms, but the nature and occurrence of these events is likely to change with altered climates.

The impact of these direct, physical, climate risks have multiple, interlinked, secondary and tertiary effects including effects on social and institutional arrangements. Water availability and quality, and health (including food security) have been identified as potentially being critically affected by climate change in Durban.

The institutions central to the responses to these challenges within eThekweni Municipality are:

- Water Sector Water and Sanitation;
Coastal, Storm water and Catchment Management; and
Coastal Policy.
- Health Sector Environmental Health;
Clinical Health;
Social Development (food security); and
Communicable Disease Control.

In addition to the health and water sectors, the Disaster Management Department is affected through the need to respond to emergency situations.

Responses by the respective institutions need not be specific to that institution. On the contrary, the best adaptation responses are likely to be shared between institutions and departments and provide solutions to a range of threats.

As part of eThekweni Municipality's Municipal Climate Protection Programme, Golder Associates is currently undertaking a detailed impact assessment exercise to identify potential climate change vulnerabilities in the Durban region. This mapping is based on current work by Roland Schulze, Darryn Knoesen and others at the School of Bioresources Engineering and Environmental Hydrology at the University of KwaZulu Natal. Much of this work is still under development and the projections discussed below are based on draft reports and previously published papers. The information available has been sufficient for the purposes of this project and future revisions of this plan should incorporate updated data.

2.2 WATER AVAILABILITY

2.2.1 *Projected change due to climate change*

Mean annual precipitation for the Durban region is projected to increase in light of climate change (Knoesen et al, 2009). There is also projected to be an increase in the intensity of extreme precipitation events. The University of KwaZulu Natal has undertaken an extensive modelling exercise of hydrological and climate change projections⁽¹⁾ for the Water Research Commission. Initial results from this modelling suggest the following projected effects:

- an increase in mean annual rainfall of 10-20% by mid century (2045-2065) and 30-100% by the end of the century (2100);
- an increase in the number of days with more than 10mm rain of 10-30% by mid century and 30-100% by the end of the century;
- no real change in rainfall amounts for short and long duration events;
- an increase in mean annual evaporation (estimated through measurement of transpiration in crops) of 5-10% by mid century and 20-25% by the end of the century; and
- no real change in the frequency and intensity of droughts. (Knoesen et al, 2009).

Further detailed analysis at the quinary catchment level in KwaZulu Natal will provide a more accurate indication of the situation in the region. Increased precipitation events are likely to lead to higher average runoff and stream flow (due to higher overland flow and reduced infiltration) (Umgeni Water, 2008). This could potentially provide the means for replenishment of dams and the ecological reserve. However an increase in evaporation, due to the increase in temperature, is likely to result in a decrease in water availability (Golder Associates, 2008). Lower infiltration and high energy runoff could furthermore have an effect on individual water systems and ecosystems.

It should be noted that these projections are based on the output of one model (ECHAM)⁽¹⁾. Additional interpretation using additional downscaled models should be considered to provide a range of scenarios and effective risk assessment. This work is still in progress.

2.2.2 *Consequence and vulnerability*

The population of Durban is increasing, and existing demand for water is already placing strain on water supply systems. Water demand is projected to exceed system yield, even with the development of Spring Grove Dam (on the Mooi River in the KwaZulu Natal Midlands) in the short to medium term, and

(1) Modelling was based on the A2 SRES future emission scenario from the Intergovernmental Panel on Climate Change (IPCC) which assumes high end carbon dioxide emissions growth. This was downscaled using the ECHAM Global Climate Model developed by the Max Planck Institute for Meteorology. See: <http://sedac.ciesin.columbia.edu/ddc/sres/index.html>

particularly post 2016 (DWAF, 2008). In the face of new settlements, higher precipitation is a potentially valuable change, creating the opportunity for house-level rainwater harvesting and potentially swelling groundwater stocks and the ecological reserve. Provided additional water can be captured, purified and allocated, the available water for human and economic use could increase. Where this is not the case, more intense precipitation will result in greater incidences of water contamination and either higher water treatment costs or the need for greater resources to manage water-borne diseases.

More intense precipitation may also be expected to result in more frequent localised flooding in certain catchments (discussed in *Chapter 2.4*), which could compromise dam safety in areas already prone to flooding and expose poorly planned and informal settlements, particularly high density settlements with significant sealed surface areas. Where storm water systems are not able to cope with the frequency or intensity of floods, pools of stagnant water may provide breeding grounds for mosquitoes and other disease vectors.

In the face of altered rainfall seasonality and distribution, farming - particularly subsistence farming - can be expected to come under increasing strain. This is likely to amplify existing pressures as agricultural productivity and food production could be reduced, and crops and livestock lost through drought, fire or flooding.

Afforested areas and plantations have been located in regions where historic temperature and humidity levels support viable timber yields, and have in turn created specific run-off patterns that are now integral to catchment level water management. Precipitation and run-off changes will have implications for the nature and location of afforested areas, which would in turn feedback to run-off patterns as the water absorbing capacity of the land changes.

Managing water catchment, storage and distribution, across South Africa and KwaZulu Natal, will become more difficult with the significant variation in rainfall. Given the increased variability and uncertainty in the hydrological system, the ideal response would be to incorporate greater reserves and buffer capacity. However, creating and defending this reserve will prove difficult in the light of increasing demand, and competing needs. Periods of particularly extreme dry or wet weather will place pressure and additional costs on municipal health facilities with regard to treatment of physical symptoms (e.g. heat stress, cholera etc) and mental welfare (e.g. depression following loss of property and/or livelihood).

In rural areas, improved water storage and management could be used to extend water access and support rural livelihoods, such as agriculture and small-scale brick-making. This will only be possible if additional precipitation can be impounded and transferred to rural users. Failing this, less reliable water availability could exacerbate the existing struggle for food and clean water, leading to malnutrition, dehydration and an increase in the prevalence

of diseases such as cholera. This would have a particularly severe impact on people with HIV and lead to an increase in AIDS cases. The resultant migration to urban/peri-urban areas in search of work and food will lead to a shift in the geographical distribution of populations, placing additional strain on existing infrastructure, displacing communities and potentially leading to the spread of unrest, crime and social collapse.

2.3 *SEA LEVEL RISE*

2.3.1 *Projected change due to climate change*

Sea levels are already on the increase in the region with sea level in Durban rising at 2.7mm per year between 1970 and 2003 (Mather, 2007).

This rising trend is expected to continue in the light of rising temperature and increased glacial melt. Worldwide research into sea level rise has shown that acceleration in the rate of sea level rise is now evident in some of the longer term records and this is expected to be a global trend.

Several sea level rise scenarios are being considered for Durban. These are a sea level rise of 300mm, 600mm and 1000mm, and are based on (1) a linear trend of current rates; and (2) scenarios with a doubling of the current rate with accelerated ice melt and (3) scenarios with a doubling of the current rate with accelerating ice melt, respectively (Mather 2007).

2.3.2 *Consequence and vulnerability*

The hilly topography of Durban places the majority of the area well above sea level. However, there are a number of key sites at risk of inundation and damage from high seas. Industries at Isipingo, transport hubs (the port and airport), coastal areas (including parts of Durban city centre), beaches and agricultural and ecologically important areas south of the city are likely to be particularly vulnerable.

In the short term, the primary consequence of sea level rise will be amplification of coastal erosion, storm damage and inundation of low-lying areas with the associated impacts as described in *Chapter 2.4* and *Chapter 2.5* below. This will place added pressure on disaster management. Poor coastal infrastructure planning will be exposed as transport, storm water drainage, sewerage and electricity infrastructure is damaged more frequently. The associated loss of coastal heritage value may lead to a decrease in tourism in the region.

Rising sea levels will increase water depth in the inter-tidal zone and salinity in rivers, estuaries and wetlands, which will impact sensitive coastal habitats such as coral reefs, mangroves, and breeding grounds for fish. This in turn will affect fish stocks and the biodiversity and tourist potential of these

habitats. Salinisation of aquifers could reduce fresh water availability and increase pressure on an already stretched water supply system. Rising sea levels are likely to alter the erosion and deposition of sand along the coast and the extent and nature of beaches. This may counteract the impact of increased siltation from flooding but might also lead to the formation of sandbanks, which could be hazardous to shipping or may block drainage channels.

Where individuals are permitted to make piece-meal, private interventions to protect their property, impacts are typically exacerbated. This is the case when poorly planned sea-walls are erected, rubble is dumped on beaches in an attempt to provide a buffer or privately owned sand-dunes are relocated.

2.4 *FLOODING*

2.4.1 *Projected change due to climate change*

Potential increases in projected sea levels and the intensity of rainfall events for the Durban region could lead to higher runoff and stream flow (due to higher overland flow and reduced infiltration) which could lead to an increase in flooding in flood prone areas. Knoesen et al (2009) modelling suggests a potential increase in flooding through the following:

- an increase in mean annual rainfall of up to 20% by mid century and 30-100% by the end of the century;
- an increase in the number of days with more than 10mm rain of 10-30% by mid century and 30-100% by the end of the century; and
- the change in flood magnitudes for a two year return period varies in the medium term but could potentially double by the end of the century (Knoesen et al, 2009).

2.4.2 *Consequence and vulnerability*

Where increased run-off can be captured, this is a potentially positive development for Durban, providing more water for agricultural and urban users. However, storms and the associated flash floods tend to damage infrastructure, crops and livestock and disrupt economic activity. Since floods are often associated with storms, many of the issues discussed under storm damage below will be relevant to dealing with a flood event.

EThekweni Municipality has, over time, developed a response capacity to both storms and flooding that sees affected communities receive temporary shelter and food, and reconstruction efforts initiated. Under climate change scenarios, the demands on this service will not only increase in frequency, but will come from new locations and take on new dimensions such as the need for new medical treatment, longer term and more extensive accommodation, newly designed and stronger transport infrastructure, and assistance in beginning new livelihood options due to the inappropriateness of past options. Meeting this challenge will have financial implications for Durban

and displace budget allocations from other programmes, which themselves may ameliorate climate change impacts.

Floods disrupt transport infrastructure with flooded and/or washed away roads, railway lines and bridges temporarily preventing access to certain areas for communities (particularly in rural areas). Fast flowing water could cause the failure of sewerage and electricity infrastructure, traffic accidents and wash away vehicles. Restricted mobility of goods and people and disrupted energy and water supplies undermines economic activity, which in some instances leads to outward migration of workers and businesses.

Increased run-off will place pressure on dams and will result in higher levels of erosion which will likely accelerate siltation of dams and the Port of Durban.

Electrical infrastructure could be damaged due to increased storm water flows and increased temperatures. Impacts might include cable sagging, reduced carrying capacity of overhead conductors and underground cables, insulator spray washing programmes affected by drought and heavy rain. Areas of particular risk include the substations at the golf courses adjacent to the Umgeni River; Durban North Substation and Mondi substation (CSIR, 2006).

Basement flooding of housing and commercial properties could damage foundations as well as contents. Durban's humid climate means that damp from flooding could take some time to dry out and lead to the growth of mould in buildings. This mould could lead to health conditions (e.g. respiratory disorders) in some members of the population.

Inundation of low lying areas and flooding of properties is likely to result in the displacement of populations from their homes for varying periods of time resulting in the need for emergency accommodation in the short, medium and in some cases long term.

Informal settlements are particularly vulnerable due to the poor construction of houses and the large numbers of people living in close quarters. With a potential increase in urbanisation as a result of climate change, the number of people at risk will rise.

Increasing urbanisation is likely to lead to an accelerated sealing of surfaces leading to increased surface water run-off and flooding. This will increase pressure on existing drainage systems.

Overflow of storm water drains into the sewerage network and damage to sewerage pipes leads to contamination of flood waters. This in turn could lead to the spread of waterborne diseases and higher levels of contamination which will increase the demand for water purification. For example, *E.coli* levels are particularly high after flood events in the Umgeni River.

Rural communities could become cut off, preventing support from emergency services and increasing the risk of disease if no clean water is available.

Emotional trauma following the loss of possessions, homes, livelihoods and potentially friends and family could lead to the breakdown of family and social structures. This would further increase stress and hamper people's ability to recover and return to normal life following a flood event.

Floods have both a positive and negative impact on malaria and the net impact is unclear. Fast flowing water would flush out stream channels (of water hyacinth and other vegetation) resulting in a reduction in mosquito breeding habitats in the medium term. However, pools of still water following a flood would increase the risk of malaria in the short term as new breeding grounds are generated.

Human lives may be lost as people get caught out by flood waters, get swept away, trapped and/or injured by hidden obstacles (e.g. open man-holes) or floating debris in an attempt to escape. Whilst disaster management and emergency services are able to cope with certain levels of flooding at present, an increase in the severity and/or frequency could put increasing pressure on these services and reduce their ability to respond in a reasonable timeframe.

Agricultural production and forestry could be disrupted during and post flood events, waterlogged root systems and land compaction could prevent harvesting once the soil has dried. Poor soil management will be exposed during extreme weather events with leaching of nutrients (nitrates and phosphates), erosion and an increased risk of landslides etc.

Estuarine habitats, coral reefs and fish stocks could be thrown out of balance with an increase in the flood cycle potentially reducing the ecosystems ability to be restored rapidly.

2.5 *STORM DAMAGE*

2.5.1 *Projected change due to climate change*

Under projected climate change scenarios, cyclones are expected to track further south down the Mozambique Channel increasing the likelihood that severe storms will occur in the Durban region. Even without an increase in the frequency of storms, their severity is projected to increase given the increase in precipitation and sea level rise (Webster, 2005; Swiss Re, 2009).

2.5.2 *Consequence and vulnerability*

The discussion below is restricted to the impact of waves, wind, hail and lightning. Wave action is amplified due to sea level rise and the impact of flooding is discussed in *Chapter 2.4*.

Wave action will result in increased coastal erosion, damage to coastal habitats and infrastructure and inundation of low lying areas. Roads, bridges, railway lines, storm water and sewerage pipes as well as beachfront property could be washed away (as was the case at Ballito in March 2007). Depending on the severity of this disruption, transport links may be disrupted for considerable periods of time which could have an impact on food security and health services in the region.

Disruptions also undermine the coastal tourism industry through damage or removal of beaches and tourist attractions and damage to access routes.

Disruption to services at the Port of Durban (e.g. damaged cranes and ships) and the existing airport (e.g. flooded runways) could have short to medium term impact on a wide range of businesses, organisations and activities.

High winds disrupt the entry of ships to the Durban harbour and prevent the operation of port-side cranes. High winds in conjunction with coastal erosion, will damage electricity infrastructure, and place new demands on Eskom and the municipality's ability to repair damaged infrastructure quickly and effectively. High winds expose poorly constructed buildings. Falling trees damage property and block transport routes. Hail damages crops, livestock and property (e.g. denting vehicles and causing roofs to collapse in informal settlements) and can block storm water drains preventing drainage and thereby increasing the risk of flooding. Lightning can cause injury, damage infrastructure and fires.

Devices installed on roofs such as solar water heaters, mini wind turbines, water harvesting tanks and satellite dishes could be damaged by wind, hail and potentially lightning if they are not properly secured.

Storms have a negative impact on tourism and the local economy as beaches, attractions and other amenities are damaged/destroyed and tourists may head for less hazardous holiday locations.

Powerful waves, strong winds and inundation of low lying areas are associated with traffic, building and shipping accidents, isolated communities and loss of human life. This would increase the load on emergency services and health care facilities. Potentially large populations may be displaced from their homes and clean up operations could take days/weeks/months depending on the severity of the storm, placing significant pressure on disaster management resources within the municipality.

Extreme stress and trauma experienced during and immediately after a severe storm could induce Post Traumatic Stress Disorder and depression, and trigger other mental disorders. This would have a knock on effect on the immediate family potentially leading to a change in dependency ratios and disruption to social circles.

Whilst eThekweni Municipality has dealt with all of these contingencies at some stage in the past, the heightened frequency and intensity of projected storms will require novel coping capacity.

2.6 *RISING TEMPERATURES*

2.6.1 *Projected change due to climate change*

In line with the global trend, temperatures are expected to rise in the Durban area. Golder Associates are currently analysing the spatial distribution of potential temperature increases based on work by the University of KwaZulu Natal. The key findings are as follows:

- an average annual temperature increase by approximately 2-2.5°C in the intermediate future (by 2045-2065) and by approximately 4-5°C in the distant future (2081-2100) (Knoesen et al, 2009);
- highest increase in spring and summer (September – February); and
- an increase in the number of days with temperatures over 30°C (Golder Associates, 2008).

2.6.2 *Consequence and vulnerability*

Higher temperatures will reduce the need for heating in winter but increase the need for cooling in summer. High temperatures will have a marked impact on crop productivity, the welfare of farmed livestock and the viability of poultry farms.

Similarly, higher temperatures can eliminate frost pockets in Durban's high-lying areas and increase the scope for crop production. The more likely result of higher minimum (nocturnal) temperatures in particular is the increased rate of nocturnal respiration in horticultural and sugarcane crops and in forestry plantations. Increased nocturnal respiration massively reduces the yields and viability of affected crops.

Any reduction in the productivity of agriculture will result in rising unemployment in rural economies. Agricultural employees tend to be among the least skilled members of the labour force and when unemployed they typically become a burden on the social security system. The ability of this system to absorb new entrants may be particularly constrained by the local, provincial and national government's need to respond to related climate change impacts.

Where poverty or age prevents access to cooler conditions or a reduced ability to cope, heat stress related health impacts will occur. These impacts include dehydration (particularly for AIDS sufferers), heat stroke, premature babies, heat-related cardio/respiratory failure; and death etc.

Very hot weather tends to result in a general lethargy in the population where a lack of energy reduces productivity and efficiency.

Higher temperatures increase demand for potable water and clean water for the cooling of heavy machinery and air conditioners. Simultaneously, warmer temperatures accelerate the rate at which stored water and stagnant water putrefies, placing a strain on the water supply system which in turn increases the incidence of waterborne diseases such as cholera. Where contaminated water leads people to consume more bottled water, the long term burden on the environment is increased due to the resources and energy required to bottle water, and the need to manage the plastic load associated with bottles.

Hot and dry conditions will increase fire risk.

High temperatures place increased pressure on food supply chains and stored foods will deteriorate more quickly, increasing the incidence of food-borne diseases.

3.1 INTRODUCTION

Higher temperatures, increased precipitation and changing humidity levels will have an indirect impact on the way of life in Durban through changes in the distribution and intensity of diseases and changes in the geographic range within which certain crops can grow.

The knock-on implications of these changes are discussed below. They predominantly affect the services of the Health Department of eThekweni Municipality, but can feedback onto the physical impacts, thereby compounding their threat. For example, crop failure due to higher temperatures and drought, can cause an increase in migration to urban areas and the development of informal settlements which in turn place localised demand for water and possible contamination of available water resources, thereby aggravating the initial drought.

Similarly where altered flooding risks result in higher insurance premiums, some households may choose to remain uninsured thereby exposing them to greater liability in the event of a flood.

Adaptation strategies that ignore the indirect (or induced) impacts of climate change tend to underestimate the challenge and remain naive to crucial causal relationships between climate change and observed social and institutional impacts.

3.2 AIR POLLUTION**3.2.1 *Projected change due to climate change***

An increase in daily maximum temperatures has knock-on effects to factors which control ozone generation, such as the emissions of volatile organic compounds (which react to form ozone and are emitted at higher rates as temperatures increase), and increases in ozone precursor production rates (which also increase with ambient temperature). It is projected that climate change could result in a possible four fold increase in surface concentrations of ozone in Durban (Golder Associates, 2008).

3.2.2 *Consequence and vulnerability*

As the population and number of vehicles on the roads in Durban increases, urban smog will increase. This is coupled with an increase in the generation of ozone due to warmer temperatures. Ozone is toxic at low concentrations and deadly at high concentrations and an increase in ground-level ozone would lead to a subsequent increase in ozone-related respiratory diseases by

damaging lung tissue, reducing lung function and sensitising the respiratory tract to other irritants.

Warmer temperatures drive up pollen counts, and higher carbon dioxide levels cause more plant growth further increasing pollen count which will worsen the symptoms of allergy sufferers.

The risk of fire during hot dry periods would exacerbate air pollution levels as smoke settles over the region.

Climate change mitigation activities such as a shift from fossil fuel to renewable energy (in both industries and vehicles) will have the dual benefit of reducing greenhouse gas emissions as well as air pollution.

3.3 *DISEASE*

3.3.1 *Projected change due to climate change*

Higher temperatures, increased precipitation and changing humidity levels will affect the distribution and intensity of both food- and water-borne diseases such as cholera, malaria, *E.coli*, salmonella, foot and mouth, etc.

3.3.2 *Consequence and vulnerability*

Environmental conditions in Durban currently support the transmission of malaria (Golder Associates, 2008) and measures to control both the vector and the parasite have, to date, been successful in keeping malaria out of the region. Climate change is likely to enhance environmental conditions which are favourable for malaria transmission. Therefore, malaria control measures and the supporting health infrastructure will also need to be enhanced to prevent an increase in the prevalence of malaria in Durban.

Higher temperatures accelerate the rate at which food decays, placing a strain on supply chains which in turn increases the incidence of diseases.

Warmer temperatures accelerate the rate at which stored and stagnant water putrefies, and storms and floods could damage/overwhelm sewerage systems placing a strain on the water supply/purification system which in turn increases the incidence of waterborne diseases such as cholera.

The range of diseases affecting livestock (e.g. foot and mouth, blue tongue) and crops (e.g. fruit fly) is likely to spread and outbreaks may occur in the region.

Climate change is likely to increase the number of HIV carriers developing AIDS as heat stress, dehydration and malnutrition further reduce resistance to gastro-enteritis, malaria, tuberculosis etc.

High stress levels following traumatic events (e.g. bereavement and/or damaged property during a storm) or trying to cope with dislocated families (e.g. separated by urban migration, AIDS orphans, etc) can trigger mental health problems such as bipolar, insomnia and other disorders.

3.4 FOOD SECURITY

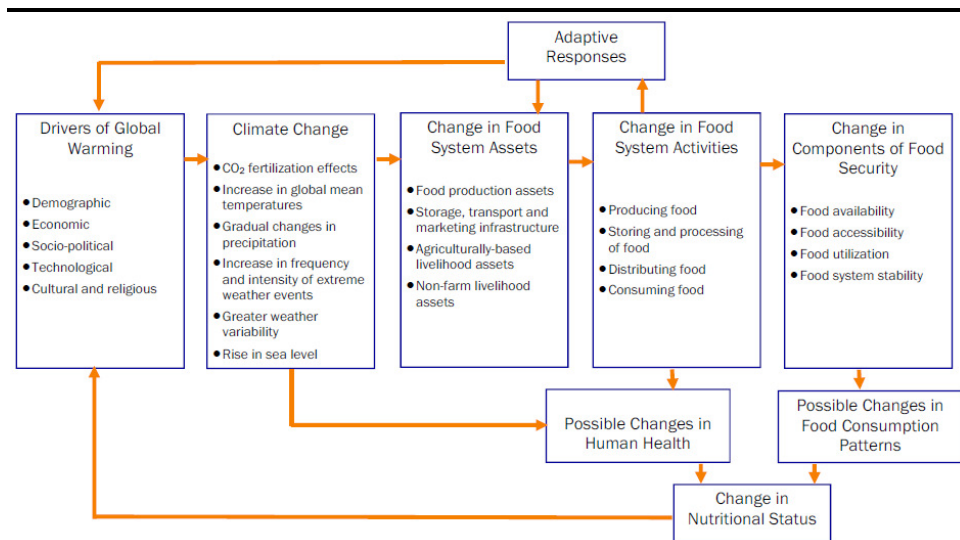
3.4.1 Projected change due to climate change

Food security refers to both the production of food and the ability to access existing food supplies. Both dimensions of food security are expected to be impacted by climate change. Higher temperatures and increased precipitation will alter the geographic range within which certain crops grow, affect food quality and potentially disrupt food distribution systems.

3.4.2 Consequence and vulnerability

Food security is the outcome of food system performance at global, national and local levels. It is often directly or indirectly dependent on agricultural and forest ecosystem services, e.g. soil and water conservation, watershed management, combating land degradation, protection of coastal areas and mangroves, and biodiversity conservation (FAO, 2008). *Figure 3.1* illustrates the interlinkages between adaptive responses to climate change impacts and the associated change in food security.

Figure 3.1 Links between climate change and food security



Source: FAO (2008)

Changes to food production have the potential to be both positive and negative depending on geographic location and the ability to identify changes and re-invest in arising opportunities. Golder Associates (2008) has profiled the changing distribution of a range of crops including maize, sorghum,

avocado, banana, sugar cane etc and this information will help inform sustainable farming strategies.

Market forces and voluntary choices will influence individual decisions both about what food to eat and how to maintain good health in the face of climate change.

Where climate change results in restricted mobility, or the collapse or co-option of social institutions such as food markets, this too will impact negatively on food security. The probability of this is most acute at the local or community level, where the erosion of a single transport route can isolate the community from food supplies, or where the collapse of community social structures under the strain of environmental or health stresses, can disrupt the trading of food.

Reduced access to affordable food and potable water will undermine rural livelihoods. It will also impinge on individual health and worker productivity and increase the burden on social grants and municipal support services.

In the context of HIV, malnutrition can have particularly catastrophic consequences.

Where a breakdown of food production requires the importing of food, and higher food prices, households in Durban will be required to spend more of their income on food, leaving fewer financial resources to address other threats imposed by climate change.

Bioenergy is likely to play an increasingly important role in meeting the growing demand for energy with low carbon and renewable energy sources. It is, however, important that this does not undermine food security (i.e. biofuel crops grown at the expense of food crops).

4.1 INTRODUCTION TO ADAPTATION PLANNING

The discussion above outlines a very wide range of impacts climate change might have on the people and environment in Durban. There is an equally wide range of activities which could be undertaken to reduce the impacts. Whilst most of these activities are sound in their own right, there is a risk that each carried out in isolation may result in impacts that either duplicate or negate other efforts – a form of maladaptation.

Potential maladaptive approaches could include:

- an increase in the number of dams with the associated negative environmental and social impacts and increased methane emissions;
- allowing communities to address food security shortages by farming in areas at high risk of flooding or with high biodiversity value;
- increasing use of DDT for malaria prevention without assessing the impact on local communities, water sources and ecology;
- concentrating food production in the hands of a few giant agribusinesses that can afford to monitor and manage climate change impacts, with the associated impacts on rural development, food prices and equality; and
- relying on desalination to address water shortages without consideration of the electricity demands or the impacts of brine discharge that is generated from these plants.

It is essential that any approach to developing an adaptation plan considers the suite of potential impacts facing a region and implements activities which will reduce as many of these impacts as possible.

Climate change will impose costs on eThekweni Municipality, but so too will most of the adaptation options pursued by the municipality. Given that eThekweni Municipality cannot assume responsibility for – or even “enable” - all adaptation responses and that so many impacts are related or connected via ecosystems, markets or social knock-on effects, the challenge is for the Municipality to identify the few plausible interactions that will result in the greatest reduction of climate change risk. It is possible that a large number of the potential impacts can be prevented or reduced by implementing a few key activities.

4.2.1 *Identification of interventions*

Adaptation interventions were identified through reference to international best practice, the *Headline Adaptation Strategy* (CSIR, 2006) and discussion with officials in the Health and Water sectors within eThekwini Municipality.

ERM facilitated the development of the specific adaptation interventions set out in this Municipal Adaptation Plan (available at *Annex A*) through a series of workshops. The focussed stakeholder engagement process has resulted in an increased awareness of climate change risks and vulnerabilities (particularly in the Health Sector) and this is critical to the successful implementation of these interventions.

The interventions described in *Annex A* focus on specific actions which aim to achieve social and institutional resilience and to facilitate effective decision making and actions in the context of adaptation. In many cases, interventions which would appear to be the most obvious adaptation response are already taking place and therefore have not been included in this plan which aims to identify interventions which are 'additional' to what is taking place in the normal course of business. For example, a comprehensive disease surveillance programme is in place which will be scaled up in the event of an increase in disease prevalence and hence deals with the likely increase in malaria in the future.

The interventions have been divided into Water, Health, Disaster Management and 'Other' sectors and categorised according to type of response to different impacts. 'Other sectors' cover interventions which have been identified as important to mitigate and adapt to risks in the Health and Water sectors but over which these sectors or the Municipality do not have control. For example adaptive farming to improve food security falls under provincial and national agriculture departments.

The tables detail the intervention, implementation plan, expected outcome, priority, responsible parties, resource availability (i.e. whether resources are available 'in house' and the activity can be implemented in the normal course of business or whether additional funding or resources are required), timing and where the activity links into eThekwini Municipality's Integrated Development Plan.

Fundamental to the successful implementation of the interventions in this plan is the identification of human resources requirements and recruitment of critical vacancies required to implement the interventions. This is particularly relevant to the Disaster Management Department. However throughout the development of this plan lack of resources has been raised as a concern which requires urgent attention.

The remainder of this section discusses the broad focus of the adaptation interventions for each category. *Table 4.1* summarises the impacts discussed in the preceding chapters and indicates which adaptation interventions will reduce the effect of that impact.

4.2.2 *Water Management*

Water is an increasingly valuable economic resource in addition to being a public and social necessity. Whilst economic growth and wealth does not insulate people from climate change impacts, it can reduce exposure to impacts and enhance the set of options available for adaptation. Crucially, economic growth also swells the fiscal resources with which local governments can tackle climate change challenges. Ensuring a more abundant water supply and marshalling this water so as to enhance economic growth represents a national priority and a legitimate climate change adaptation objective. The implications of climate change should be placed at the forefront of all spatial land use planning considerations to ensure that any planning proposals or development approvals compliment the adaptation measures listed in *Annex A*.

Water Availability

Planning of bulk water resources and infrastructure fall within the remit of the Department of Water Affairs (DWA). Umgeni Water is responsible for supplying water to Durban. Strategic planning is based on the DWA *Water Reconciliation Study* which, it is understood, does not currently include the impact of climate change on water availability in the region. At present, water supply is designed to withstand a 1:100 year drought. Climate change might increase the severity of a 1:100 year drought requiring the system to be redesigned to manage the change in conditions.

The work that the University of KwaZulu Natal and Golder Associates are currently undertaking will provide important projections which should feed into the second phase of the *Water Reconciliation Study* to ensure that the impact of climate change is factored into bulk water infrastructure planning. This should improve confidence in the future of Durban's water security.

In addition to securing water supply, it is important that Durban residents are encouraged to reduce water consumption, use grey water systems and recycle or capture as much water as possible (e.g. through rainwater harvesting). Given that water availability is already an issue in the region, eThekweni Municipality already has a raft of measures in place to help conserve water including public awareness campaigns and water loss prevention (e.g. replacement of pipes, leak detection etc). The interventions discussed in *Annex A* focus on additional activities that can conserve or reduce demand for water in Durban. Improved accessibility to water resources will be a key to future sustainability of many existing livelihood systems, especially those of small-scale farming households.

Infrastructure protection

Existing catchment and storm water management plans aim to manage river and surface water run-off. It is important that these plans take into account the likely increase in water during precipitation events and the impact of surface sealing. This will help mitigate the risk of flooding and take advantage of the increased run-off when it occurs by way of improved water catchment and storage.

Careful management of run-off and water quality e.g. through run off/nitrate control, maintenance of drainage infrastructure, and supply to informal settlements has many advantages. It will increase the water available to Durban as new settlements need to be supplied with water, will satisfy agricultural and industry demand for water, as well as the need to protect the ecological reserve. It will also reduce the risk of waterborne diseases spreading during times of flood and drought.

Planning applications go through the Coastal, Storm Water and Catchment Management (CSCM) Department to ensure that developments do not have a negative impact on surrounding lands through an increase in run-off. All new developments or extensions to existing properties in the Durban area are required to provide information relating to 1:50 and 1:100 year flood risk. The CSCM Department has developed a 'Flooding Annexure' which outlines design specifications and the requirement for hydrological surveys for developments falling within the 1:100 flood line and the design of storm water catchment and attenuation infrastructure. These designs are based on rainfall data which is published on eThekweni Municipality's website.

Revision of this rainfall data on the eThekweni Municipality website to include the impact of climate change will result in attenuation infrastructure and developments that are designed to manage increased run-off and rainfall.

Defining the 1:50 and 1:100 flood lines using the revised rainfall data will increase the area at risk of flooding. By revising the flood lines, developments potentially at risk through a climate change induced increase in flood levels will be required to adhere to the requirements of the 'Flooding Annexure'.

Routine inspection, clearance and maintenance of all storm water channels, attenuation infrastructure and water courses would provide more space for water during extreme precipitation events, reduce the number of illegal drainage connections and reduce conditions conducive to the spread of water borne diseases.

Coastal Zone Management

The key impact of climate change in coastal areas is the amplification of wave run-up and storm damage due to sea level rise. The damage associated with storms can be mitigated through pre-emptive measures and disaster management.

Of particular importance in coastal zones is the enforcement of coastal buffer zones in order to limit damage to property in the event of a storm surge and to allow dunes and coastal vegetation to be re-established following a storm.

The Integrated Coastal Management Act (2009) requires the development of Coastal Management Plans. The Act requires the development of Shoreline and Estuary Management Plans which protect the built and natural environments. Development of these plans requires detailed investigation of the impact of coastal flooding and wave damage on the infrastructure and environment in the area.

Coastal run-up and modelling of set-back lines should be based on the latest sea level rise models which incorporate the impact of climate change.

Through development of Coastal Management Plans for the entire Durban coastline, a detailed assessment will be made of the risk in the area. Activities required to mitigate this risk or adapt to changing conditions will be identified. This includes consideration of the following:

- shore stabilisation: dune building, wetland creation, artificial beach replenishment;
- protection of biological defences such as estuaries, mangroves, coastal forests, sand dunes, sandbars and reefs from settlement or destruction;
- increasing the height of natural shoreline stabilisation measures if appropriate to avoid flooding;
- prohibition of land reclamation in estuaries and coastal areas;
- prevention/restriction of development within coastal set-back lines;
- response and rehabilitation plans following storm events – i.e. should the coastline be protected, defended, advanced or left as is?

Development of a Coastal policy similar to the Flooding Annexure discussed above will ensure that planning applications go through similar scrutiny to help to reduce the risk to infrastructure and developments.

A co-ordinated, effective disaster management response is essential during and after events in order to:

- minimise disruption to infrastructure and business,
- manage social disruption such as evacuations, injuries, housing displaced populations;
- manage infrastructural disruption such as flooded/washed away roads and bridges etc, and
- manage the clean up process.

4.2.3

Health

Public health is at risk from increased disease outbreaks, air pollution, and extreme weather events (heat waves/storms). Managing food security will reduce disease risk and help increase the public's resilience in the face of

health stresses (through better nutrition). Effective monitoring and management of water courses will reduce water contamination and disease vector breeding grounds and hence the risk of spreading diseases.

Existing surveillance and monitoring systems should detect changes in disease distribution due to climate change and allow assessment of the effectiveness of existing disease control measures and the need to revise plans. Outbreaks could be reduced through an increase in public awareness with regard to the transmission of diseases and appropriate food handling practices.

High temperatures and humidity can be managed through provision of 'cool areas' where people can go to keep out of the heat. In addition, the public can be made aware of how to keep their houses cool.

The impact of higher air pollution levels is already being managed through campaigns to alert the public to the risk and by taking action and reducing general air pollution levels in the city.

Effective contingency planning and disaster management is key to ensuring that health and emergency services are able to withstand high pressure during emergencies

4.2.4 Disaster Management

Whilst the adaptation interventions discussed above will help to reduce the impact climate change will have on Durban, it is not possible to climate proof an entire municipality in light of the potential scale of some of the impacts (particularly storms). Neither is it possible to reduce emissions sufficiently or sufficiently quickly, to avoid all climate change impacts. The inevitability of a significant 'residual risk' (Parry, 2009) – that is climate change impacts and costs that must simply be carried by affected parties – is now accepted. Much of the responsibility for dealing with these impacts will fall on Disaster Management Units and planning within these units for the altered nature, frequency and combination of disasters is important. The type of emergencies likely to challenge eThekweni Municipality are discussed throughout this Plan and could include (but are not limited to) the following:

- Roads, bridges, railway lines, storm water and sewerage pipes as well as beachfront property could be washed away;
- Large numbers of displaced individuals or communities needing care and relocation;
- Areas cut off from external access with communities requiring medical attention, food, clean water etc;
- Emergency services (police and fire stations and hospitals etc) may be compromised e.g. through flooding or power outages;
- Increased human injuries and emergency medical cases resulting from collapsed buildings, fallen trees/pylons, people trapped in flood water, traffic accidents etc;

- Multiple different emergencies over wide geographical area (e.g. infrastructure washed away at coast, traffic accidents, fires, flooding, disrupted communities (informal settlements washed away);
- During heat waves there could be an increase in people suffering from dehydration (particularly for AIDS sufferers), heat stroke, premature babies, heat-related cardio/respiratory failure; and death etc;
- Disease outbreaks in informal communities or refugee camps would put pressure on health systems;
- Drought may cause food shortage and storms/floods may damage crops leading to a food shortage and the Municipality will be called upon to help those who cannot access or afford food.

EThekweni Municipality already has a disaster management capacity and the Municipal Adaptation Plan for the Health and Water Sectors looks to inform and equip this unit with the ability to cope with the greater frequency of disasters, and the specific types of disasters, that can be expected by climate change. This capacity should be linked to hospitals and other health services, and as a matter of priority should both enhance its ability to predict climate change related disasters and its means of communicating early warnings to the public in a responsible and effective manner.

The Disaster Management Department should enhance its capacity to actively manage and cope with disasters by developing a comprehensive Disaster Management Plan incorporating emergency planning, response and recovery.

Key to initiating this process is approval of the disaster management framework in the Municipality and raising awareness and understanding of the need for an effective disaster management within the responding agents. A comprehensive understanding of the full suite of risks facing Durban is essential and can be achieved through development of a comprehensive risk assessment which includes climate change impacts. Disaster management policies can be developed and contingency plans revised and rehearsed in order to better equip the municipality to respond to the frequency and scale of natural disasters projected to be inflicted by climate change.

Research and technological advances have massively improved the prediction capacity of sea level rise, cyclones and extreme storm events. Early warning systems coordinated with disaster management plans will help ensure capacity is in place to respond to the predicted scale of event.

Public awareness of the activities individuals can undertake to reduce the impact of extreme weather on their lives should be a key part of disaster management. If individuals are prepared and can prevent or minimise damage and/or can help themselves during a crisis, pressure on the emergency services will be reduced as will the loss of life and property.

Disaster Management policies and contingency plans should be reviewed regularly in light of lessons learned from emergency events.

This group of interventions have been identified as important to mitigate and adapt to risks in the Health and Water sectors but responsibility for the development and implementation of the intervention lies with other sectors.

Development of socio-institutional learning capacity within the Municipality is key to developing a shared understanding of problems and potential for joint solutions, improving decision making and avoiding maladaptative practices, contradictory policies, actions and unforeseen outcomes. This intervention involves all climate impacts and sectors within the Municipality co-ordinated by the Environmental Management Department.

Modifying the design requirements for low cost housing to incorporate water conservation and temperature regulation measures will reduce costs to low income families through reduced energy demand as well as reducing the total carbon and water footprints of the Municipality. This intervention can be co-ordinated by the eThekweni Housing Department but will require discussion with the provincial and national housing departments in order to promote changes to the housing subsidy schemes.

Given the inevitable 'residual risk' (Parry, 2009), the municipality needs to plan to cope with increasing insurance losses. In order to better understand potential cost to the Municipality, an assessment of the infrastructure inventory against age, location, climate change risk, insurance value and maintenance budget will enable insurance policies and capital reserves to better withstand future demands in the face of climate change related infrastructure damage. This intervention can be co-ordinated by the Environmental Management Department and implemented by the Procurement and Infrastructure sector and Finance Department.

Flooding, stormy seas and higher temperatures could have a significant impact on the transport infrastructure in Durban. An assessment of the potential impacts and vulnerabilities will allow a response to the impacts of climate change to be incorporated in Integrated Transport Plans from 2010. This intervention can be implemented by the Strategic Planning Unit of the eThekweni Transport Authority.

Climate change is likely to have a significant impact on agriculture which has a knock-on impact on food security. Local, provincial and national agriculture departments need to work together to develop and implement the interventions identified in this plan. The indirect impact of food availability and subsistence farming on local communities is complex and significant and manifests via pressure on the Health Services (e.g. malnutrition, an increase in AIDS cases, diseases), increased dependence on employed family members and remittances, the relocation of people into urban centres, the concentration of food producing responsibility in the hands of agribusiness, increased dependence on social grants and fiscal resources.

Social and institutional interventions will provide individuals with the necessary knowledge to adapt to changing environments. They will be better able to maintain sustainable farming practices and high levels of production. This in turn will ensure security of food supply to low income households and others in the region. It will also increase resilience and reduce the need for external assistance in the event of natural disasters such a floods or droughts.

Adaptive farm management is key to maintaining sustainable food production in the region. While some potential is contained in the introduction of new or modified crops, a more robust response is likely to occur where farmers are encouraged to monitor and consider local impacts of climate change - an approach called adaptive farm management. Growers of annual or short-rotation crops will be better able to adapt than those involved in fruit cultivation where rotation cycles are in excess of 20 years, and risk-averse farmers should be made aware of this distinction.

Effective surveillance programmes are needed to provide early warning of disease outbreaks and to facilitate tracing and containment of vectors. This will help limit the damage disease outbreaks can have on crops and livestock and help health care providers prepare for and manage emergencies.

Table 4.1 summarises the impacts discussed in the preceding chapters and indicates which adaptation interventions will reduce the effect of that impact.

Table 4.1 *Summary of impacts reduced/prevented by adaptation interventions*

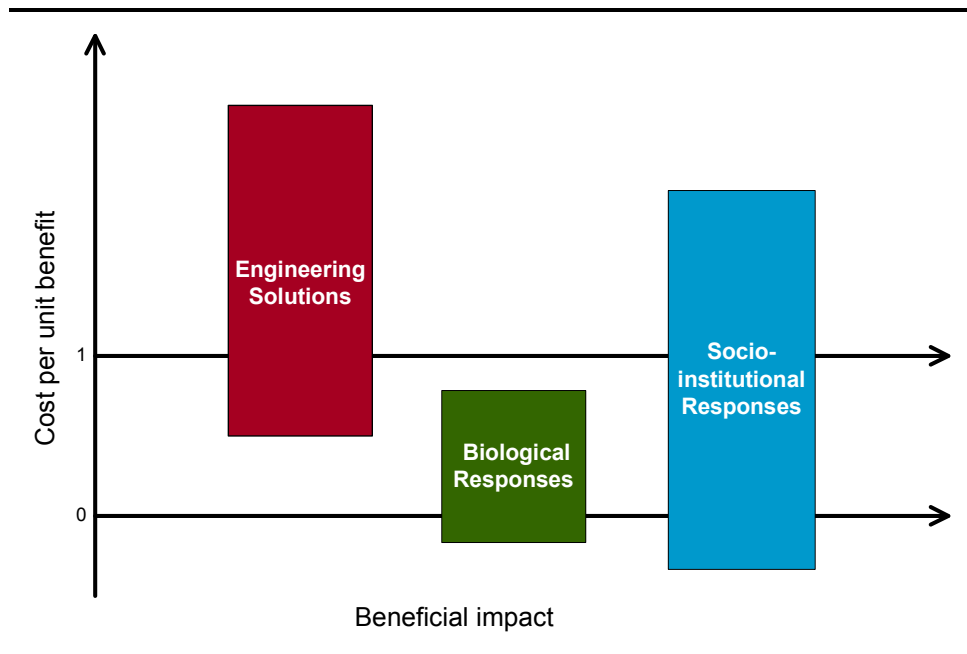
Impact on Durban	Adaptation Interventions			
	Water Management	Health	Disaster Management	Other
Water related impacts - infrastructure and society				
Demand for water purification	Yes	Yes	Yes	
Displaced populations	Yes		Yes	Yes
Drainage system failure	Yes		Yes	
Sewerage system failure	Yes		Yes	
Basement flooding of properties	Yes		Yes	
Damage to houses	Yes		Yes	
Increased urbanisation	Yes	Yes		
Shipping and port disruption			Yes	Yes
Airport disruption			Yes	Yes
Transport disruption			Yes	Yes
Cut off rural communities			Yes	Yes
Business disruption	Yes		Yes	
Loss of Tourism Heritage	Yes		Yes	
Electricity disruption			Yes	
Pressure on dams	Yes			
Drought – water shortage	Yes			
Loss of human life			Yes	

Impact on Durban	Adaptation Interventions			
	Water Management	Health	Disaster Management	Other
Water related impacts - environment and agriculture				
Land access			Yes	Yes
Coastal erosion	Yes		Yes	
Landslides	Yes		Yes	
Clear water channels	Yes	Yes		
Coral damage	Yes			Yes
Mangrove damage	Yes			Yes
Fish stocks	Yes			Yes
Livestock loss				Yes
Crop loss/failure				Yes
Land compaction				Yes
Strained subsistence agriculture				Yes
Soil fertility (nitrate leaching)				Yes
Reduced crop productivity				Yes
Crop & livestock pests				Yes
Poor soil management exposed				Yes
longer growing season				Yes
Estuarine balance	Yes			
Inundation of low lying areas	Yes			
Borehole reliability	Yes			
Salinisation of aquifers	Yes			
Siltation	Yes			
Health and communities				
social collapse	Yes	Yes	Yes	Yes
dependency ratios	Yes	Yes	Yes	Yes
mental health	Yes	Yes	Yes	Yes
Loss of human life	Yes	Yes	Yes	Yes
Stress increasing AIDS cases	Yes	Yes		Yes
cholera	Yes	Yes	Yes	
dehydration	Yes	Yes	Yes	
Reduced human productivity		Yes	Yes	Yes
Increased prevalence of Malaria	Yes	Yes		
heat stress		Yes	Yes	
Air pollution		Yes	Yes	
Food storage and distribution		Yes		Yes
Asthma & pulmonary disease		Yes		
Other impacts				
Strain on health care providers	Yes	Yes	Yes	
Strain on emergency services	Yes		Yes	
Wind damage			Yes	
Fire damage			Yes	
Lightning damage			Yes	

4.3.1 Introduction

The aim of the Municipal Adaptation Plan project is to identify and select those activities that will deliver the greatest benefit for the least cost. Conventionally cost-benefit analysis is applied to select the best options in these cases, but there are limitations to the application of standard cost-benefit approaches to climate change adaptation. *Figure 4.1* is a stylised depiction of the potential cost and impact of engineering (infrastructure), biological and socio-institutional responses to sea level rise. It should be noted that the categories are not necessarily distinct from each other.

Figure 4.1 The potential cost and impact of adaptation responses to sea level rise



Limitations of cost: benefit approaches

As mentioned above, there are limitations to the application of standard cost-benefit approaches to climate change adaptation including:

- It can be very difficult to capture the full extent of costs and benefits that manifest over wide and very different temporal and spatial scales. Conventional cost-benefit analysis relies on discount rates for comparison of costs and benefits that occur at different times since the cash flow in the early years of a project has a greater value than the same amount in the later years of a project. Discounting environmental impacts or benefits remains controversial and not necessarily accurate.
- Differences exist between the financial costs and benefits that are typically applied in cost-benefit analyses, and the economic values (or shadow costs)

that more accurately reflect the net economic impact of environmental impacts. It is not necessarily true that damage to a property requiring R1 million to replace, has an equivalent negative impact on the economy of that region. On the contrary replacing infrastructure and houses damaged by environmental disasters can, counter-intuitively, be good for economic growth. Unfortunately different economic analyses apply replacement costs, insured losses, financial losses and economic impact variably and inconsistently, making comparisons problematic.

- Some adaptation interventions such as sea-walls remove the potential for other options such as coastal buffer zones, while coastal buffer zones do not remove the option of building a sea-wall should the level of protection provided by the buffer prove inadequate. Retaining options in the face of uncertainty is clearly valuable, but valuing this benefit is difficult within the confines of cost-benefit analysis.
- It is widely acknowledged that functional ecosystems offer a great deal of protection against climate change impacts, but valuations of ecosystem goods and services remain assumption dependent and subjective. The difficulty in valuing natural capital can lead to a bias towards infrastructural approaches in cost benefit analysis, in spite of the proven efficacy of biological buffers.
- Cost benefit analyses tend to focus on discrete options whereas in reality the most effective adaptation intervention often involves a combination of responses.
- The data required to conduct robust cost benefit analyses are often lacking requiring decisions based on other criteria. It is not always the case that climate adaptation responses can wait for sufficient data with which to make a decision.

This is not to suggest that an assessment of costs and benefits is not important, but rather that cost-benefit analysis should constitute one of a number of approaches used to inform robust decision making.

4.3.2 *Methodology for undertaking this multi-criteria assessment*

In an attempt to prioritise interventions while considering both the importance and limitations of cost: benefit analysis, the approach applied in the development of the Municipal Adaptation Plan for the Health and Water sectors assesses options in terms of multiple criteria.

The assessment involved the ranking of a series of criteria according to the relative positive (3), neutral (2) or negative (1) impact of the intervention. Precise answers or numerical values cannot be given to each of these criteria, but decisions that have considered these issues are more likely to produce effective adaptation rather than knee-jerk or piece-meal responses.

The relative merit of individual interventions has been determined by adding the scores for each criterion but does not directly inform the sequencing or scheduling of adaptation efforts. It is not the case that every merit-worthy option available to the Municipality should be implemented as soon as budget is available. On the contrary, for some options it is better to wait and see if they are required, while other options are best delivered only once earlier efforts have been tried or in combination with other options.

The multi-criteria assessment has been augmented by a measure of “urgency”. All of the interventions presented in this plan are considered to be desirable and important, but they have been ranked relative to each other in terms of 1 = medium urgency, 2 = high urgency and 3 = very high urgency. Those options (often called “no regrets options”) that are either so beneficial, have such low cost or are so critical to sustainable development that their implementation cannot be delayed, are accorded an urgency ranking of 3.

By multiplying the merit ranking by the urgency ranking, the basis of a priority ranking and implementation schedule is obtained. Once again the real benefit arises from taking decision makers through this process through collaborative debate of issues and assignment of urgency rankings, rather than focusing on the precise numbers that are produced at the end of the exercise.

The criteria considered include:

- The extent to which the option would be expected to reduce **climate change risk**. Although it is acknowledged that it can be difficult to know this precisely in advance, options that are perceived to reduce the greatest amount of risk are obviously more desirable;
- **Ancillary benefits** realised by undertaking the activities. Many of the interventions pursued under the remit of adaptation would be worth doing even if climate change were not taking place because they incorporate sustainable development benefits;
- The extent to which the option is **reversible or flexible**, should the nature of climate change transpire to be different from that projected. Reversibility and flexibility come at a premium given the uncertainty over future climate impacts;
- The extent to which the option either **mitigates** or exacerbates the release of further **greenhouse gases**;
- The extent to which the option permits **complementary options** and reduces or retains the set of options available for responding to climate impacts. The understanding is that those interventions that retain options are more desirable;

- The **ease** with which an option can be **implemented** and the related likelihood of it being successfully implemented;
- The **institutional complexity** with regard to implementation of the intervention in relation to municipal processes and procedures and the number of departments requiring input;
- The **cost: benefit** of the intervention. For this project, no detailed analysis was undertaken, rather a broad judgement was made with regards to 'high cost: low benefit'; 'high benefit: low cost' of options;
- The risk of an intervention inadvertently constituting '**maladaptation**' through ill-considered implementation. This criterion is based on the understanding that some options are safer in terms of unintended adverse impacts, than others.

It should be noted that multi-criteria assessments do not provide a perfect assessment screen. Questions around "Who gets to select the criteria?" and "Who gets to perform the assessment?" are legitimate. One of the central benefits in applying this approach, however, involves not the results that are produced but the institutional capacity for better decisions that is created during the process of selecting criteria and assessing options (van Ierland et al., 2007; Hallegatte, 2008).

4.3.3 *Results of the multi-criteria assessment*

Representatives from the Health and Water sector were involved in the assignment of scores associated with the merit and urgency ranking. The results of this analysis are presented in order of priority in *Table 4.2*. The values assigned to the interventions in this plan should be reviewed periodically and any new interventions identified should be subjected to the same analysis. It is important that the potential for complementary interventions is considered when interpreting the interventions.

In general the multi-criteria assessment tends to reveal that infrastructural responses are expensive, difficult to implement well and have a high propensity to yield unforeseen adverse consequences. Where well constructed, however, they can provide high levels of protection. Biological and socio-institutional responses can be cost-effective but can be complicated to mobilise. These approaches do tend to be safer and can also yield a high degree of protection.

Interventions that target water and health are shown to have many merits. This is unsurprising. Both health and water availability and quality impact on almost every aspect of Durban's society and economy, and improvements in these areas will have multiple positive knock-on effects. What is less intuitive, but equally clear from the multi-criteria analysis is that institutional responses and responses that involve updating and improving the collection and

application of information are highly effective. Better run-off data, revised precipitation projections, the retention of riparian vegetation and public awareness of the benefits of water harvesting, water infiltration projects and efforts to reduce run-off are not only implementable, have many ancillary benefits and very little propensity to contribute to maladaptation, but can also significantly reduce climate change risk for the Municipality. This is in contrast to the current focus of many climate change responses both internationally and in South Africa which tend to favour infrastructure solutions. Not only does infrastructure present greater risks of maladaptation and increased GHG emissions, but it also forecloses options that may prove valuable under future climates and are probably worth retaining.

Table 4.2 eThekweni Municipality Adaptation Plan Multi-criteria assessment

Ref	Adaptation Category	Sub-category	Impact	Intervention	Impact on risk 3 = Risk reduced 2 = none 1 = Risk increased	Ancillary benefits 3 = Yes 2 = No	Reversible/ Flexible? 3 = Yes 2 = Neutral 1 = No	Impact on emissions 3 = reduced 2 = none 1 = increased knows	complementary interventions 3 = Yes 2 = Neutral 1 = No	implementation 3 = Easy 2 = Neutral 1 = Difficult	complexity 3 = Simple 2 = Neutral 1 = Complex	cost-benefit 3 = low cost/high benefit 2 = neutral 1 = high cost/low	Risk of maladaptation 3 = low 2 = medium 1 = high	Merit (sum of criteria)	Urgency 1 = Medium 2 = High 3 = Very High	Priority (Merit x Urgency) H = >45 M = 22 - 45 L = <22	
W1	Water	Infrastructure Protection (New)	Flooding	Detailed analysis of latest rainfall/run-off projections and modelling of systems to be finalised.	2	3	3	2	3	3	3	3	3	25	3	75	H
W2	Water	Infrastructure Protection (New)	Flooding	Revise rainfall data in line with latest projections (as of 30 September 2009) and review every 5 years.	2	3	3	2	3	3	3	3	3	25	3	75	H
W9	Water	Infrastructure Protection (existing)	Flooding	Protect and restore riparian vegetation so as to protect integrity of river banks and retain biological buffers against flooding.	3	3	3	3	3	2	2	3	3	25	3	75	H
W5	Water	Infrastructure Protection (New)	Flooding	Develop Master Drainage Plans for all river catchments within eThekweni municipal boundaries	3	2	3	2	3	3	2	3	3	24	3	72	H
W6	Water	Infrastructure Protection (New)	Sea Level Rise	Revise coastal set back lines	3	3	3	2	3	3	1	3	3	24	3	72	H
H1	Health	Disaster Management	All	Improve the ability of Health Care Systems to respond effectively during emergencies.	3	3	3	2	3	1	2	3	3	23	3	69	H
DM2	Disaster	Disaster Management	All	Implement Disaster Risk Management Framework	2	3	2	2	3	3	1	3	3	22	3	66	H
DM3	Disaster	Disaster Management	All	Undertake a detailed assessment of all risks in Durban.	2	3	3	2	3	2	1	3	3	22	3	66	H
W8	Water	Infrastructure Protection (New)	Sea Level Rise	Prepare Coastal Management Plans for entire Durban coastline	3	3	3	2	3	1	1	3	2	21	3	63	H
W17	Water	Water security	Water Availability	Incorporate requirement that Umgeni Water consider the impact of climate change on rainfall and run-off into eThekweni Municipality's water purchase agreement.	2	3	3	2	3	1	1	3	3	21	3	63	H
W18	Water	Water Demand Management	Water Availability	Develop an overarching Water use strategy which captures existing interventions being undertaken within the Municipality, identifies additional interventions and creates clear priorities and an implementation plan for responding to the challenges of a current water shortage impacted on by climate change and it's further impact on water security.	3	3	2	2	3	2	1	3	2	21	3	63	H
DM1	Disaster	Disaster Management	All	Secure additional resources for Disaster Management Branch	3	3	2	2	2	1	2	1	3	19	3	57	H
DM4	Disaster	Disaster Management	All	Revise Contingency Plans for key risk areas.	3	3	2	2	2	1	1	3	2	19	3	57	H

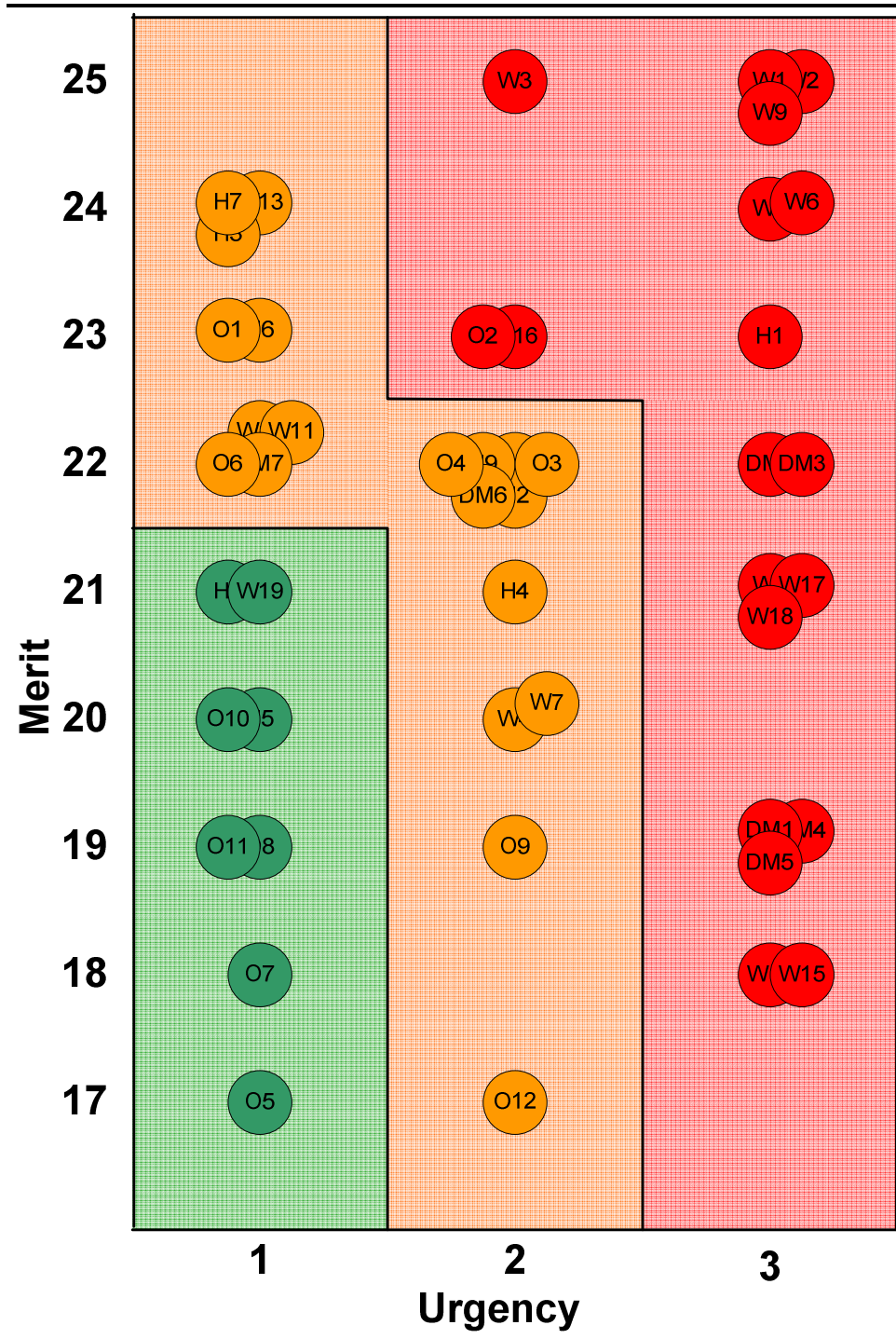
Ref	Adaptation Category	Sub-category	Impact	Intervention	Impact on risk 3 = Risk reduced 2 = none 1 = Risk increased	Ancillary benefits 3 = Yes 2 = No	Reversible/ Flexible? 3 = Yes 2 = Neutral 1 = No	Impact on emissions 3 = reduced 2 = none 1 = increased	complementary interventions 3 = Yes 2 = Neutral 1 = No	Ease of implementation 3 = Easy 2 = Neutral 1 = Difficult	Administrational complexity 3 = Simple 2 = Neutral 1 = Complex	Cost-benefit 3 = low cost/high benefit 2 = neutral 1 = high cost/low	Risk of maladaptation 3 = low 2 = medium 1 = high	Merit (sum of criteria)	Urgency 1 = Medium 2 = High 3 = Very High	Priority (Merit x Urgency) H = >45 M = 22 - 45 L = <22	
DM5	Disaster	Disaster Management	All	Disaster Management Summit - to raise awareness of Disaster Management function and departmental responsibilities - refer to hosting a successful FIFA 2010 World Cup and managing climate change risk	3	3	3	1	3	1	1	3	1	19	3	57	H
W14	Water	Infrastructure Protection (Existing)	Flooding, Sea Level Rise	Relocate informal settlements which are highly vulnerable to flooding and sea level rise.	3	3	1	3	3	1	1	2	1	18	3	54	H
W15	Water	Infrastructure Protection (Existing)	Flooding, Sea Level Rise	Protection of municipal infrastructure (e.g. transport, storm water, sewerage, electric etc)	3	3	1	1	2	3	3	1	1	18	3	54	H
W3	Water	Infrastructure Protection (New)	Flooding	Elevate Flood Annexure to Council Policy	3	3	3	2	3	3	2	3	3	25	2	50	H
W16	Water	Infrastructure Protection	Flooding	Develop co-ordinated procedure for inspection, clearance and maintenance of all storm water channels, attenuation infrastructure and water courses	3	3	2	2	3	2	2	3	3	23	2	46	H
O2	All	All	All	Raise public awareness of issues associated with climate change to build capacity, encourage early action and facilitate national policy development	3	3	3	3	3	1	1	3	3	23	2	46	H
W12	Water	Infrastructure Protection (New)	Flooding	Amend Town Planning 'Scheme Controls' to incorporate fixed parameters for run-off in order to reduce storm water run-off from new developments	3	3	3	2	3	1	1	3	3	22	2	44	H
H2	Health	Disease control	Disease	Enhance analysis of data on of existing "notifiable medical conditions" surveillance and prevention programmes.	2	3	3	2	3	2	1	3	3	22	2	44	M
H9	Food	Disease control	Disease	Investigate research on the impact of climate change on food e.g. red tide poisoning and impact of increased survival of microbes in the warmer temperatures on food poisoning	2	3	3	2	3	3	1	3	2	22	2	44	M
DM6	Disaster	Disaster Management	All	Develop a reliable early warning system alerting residents and disaster management to the likely occurrence of emergencies	3	2	3	2	3	2	3	3	1	22	2	44	M
O3	Agriculture	Adaptive farming	Food	Develop a system to provide financial support to rural communities in order to encourage an approach of adaptive farming including access to credit, investment in the rural economy and support to institutions.	3	3	3	3	2	1	1	3	3	22	2	44	M
O4	Agriculture	Adaptive farming	Food	Develop training programme to encourage farming approaches that include greater awareness of climate change	3	3	3	3	2	1	1	3	3	22	2	44	M
H4	Health, Water	Disease control	Disease	Develop a framework within which all responsible parties work together to identify and manage problem sources of contaminated water	3	3	3	2	3	1	1	3	2	21	2	42	M

Ref	Adaptation Category	Sub-category	Impact	Intervention	Impact on risk 3 = Risk reduced 2 = none 1 = Risk increased	Ancillary benefits 3 = Yes 2 = No	Reversible/ Flexible? 3 = Yes 2 = Neutral 1 = No	Impact on emissions 3 = reduced 2 = none 1 = increased	complementary interventions 3 = Yes 2 = Neutral 1 = No	Implementation 3 = Easy 2 = Neutral 1 = Difficult	complexity 3 = Simple 2 = Neutral 1 = Complex	cost: benefit 3 = low cost/high benefit 2 = neutral 1 = high cost/low	Risk of maladaptation 3 = low 2 = medium 1 = high	Merit (sum of criteria)	Urgency 1 = Medium 2 = High 3 = Very High	Priority (Merit x Urgency) H = >45 M = 22 - 45 L = <22	
W4	Water	Infrastructure Protection (New)	Flooding	Reduce risk to developments in flood plains through amendment of Bylaw 5.2 (2) (iii) to require developments within the 1:100 yr flood line within eThekweni boundaries to comply with the Flood Annexure	3	2	3	2	3	1	1	2	3	20	2	40	M
W7	Water	Infrastructure Protection (New)	Sea Level Rise	Develop Council Policy and By-laws or scheme controls covering development within coastal set back lines	3	2	3	2	3	1	1	2	3	20	2	40	M
O9	Housing	Water Conservation, Health	Water Availability, Temp	Design requirements for low cost housing to incorporate water conservation and temperature regulation measures such as rain water harvesting tanks, solar water heaters, ceilings, size of windows and orientation etc. Developments to include communal renewable energy, grey water and/or sanitation systems.	3	3	2	3	3	1	1	2	1	19	2	38	M
O12	Water	Infrastructure Protection	Flooding	Incorporate response to the impacts of climate change in Integrated Transport Plans from 2010	3	2	1	3	2	2	1	2	1	17	2	34	M
W13	Water	Infrastructure Protection (Existing)	Flooding	Public awareness campaign to raise awareness of the benefits of retrofitting storm water run-off reduction techniques e.g. green roofs, retention/wet basin, detention/dry basin, infiltration basins, rain water harvesters etc to reduce runoff from existing developments .	3	3	3	2	3	3	2	2	3	24	1	24	M
H3	Health	Disease control	Disease	Public awareness campaign on: - conditions favourable to rodent/mosquito breeding - preventative measures (e.g. use of mosquito nets) - identification of related illnesses	3	3	3	2	3	3	3	3	1	24	1	24	M
H7	Food	Disease control	Disease	Expand public awareness programme to increase awareness of: - food hygiene and good food handling practices - food borne illnesses and reporting process - infection prevention and control from contaminated water	3	3	3	2	3	3	2	3	2	24	1	24	M
H6	Health	Health	Temp	Increase public awareness of how to keep cool in a heat wave without increasing electricity consumption through use of fans and air conditioners.	3	3	2	3	3	2	2	2	3	23	1	23	M
O1	All	All	All	Develop socio-institutional learning capacity within the Municipality to facilitate better decision making and avoid mal-adaptive approaches	3	3	2	2	3	3	1	3	3	23	1	23	M
W10	Water	Infrastructure Protection (existing)	Flooding	Ensure that Asset Management Plans consider revised rainfall/runoff data in assessment of the condition of storm water and catchment management assets.	3	2	3	2	3	2	3	3	1	22	1	22	M

Ref	Adaptation Category	Sub-category	Impact	Intervention	Impact on risk 3 = Risk reduced 2 = none 1 = Risk increased	Ancillary benefits 3 = Yes 2 = No	Reversible/ Flexible? 3 = Yes 2 = Neutral 1 = No	Impact on emissions 3 = reduced 2 = none 1 = increased	complementary interventions 3 = Yes 2 = Neutral	Ease of Implementation 3 = Easy 2 = Neutral 1 = Difficult	institutional complexity 3 = Simple 2 = Neutral 1 = Complex	Cost-benefit 3 = low cost/high benefit 2 = neutral 1 = high cost/low	Risk of maladaptation 3 = low 2 = medium 1 = high	Merit (sum of criteria)	Urgency 1 = Medium 2 = High 3 = Very High	Priority (Merit x Urgency) H = >45 M = 22 - 45 L = <22	
W11	Water	Infrastructure Protection (existing)	Sea Level Rise	Ensure that Asset Management Plans consider revised sea level rise scenarios in assessment of the condition of coastal assets.	3	2	3	2	3	2	3	3	1	22	1	22	M
DM7	Disaster	Disaster Management	All	Public awareness campaign alert population to: - Reducing the potential impact of an emergency and what to do when one occurs - Maintaining health during hot periods (reduce exercise, drink more liquids, stay indoors etc) - Linking risk reduction with development	3	3	3	2	3	1	1	3	3	22	1	22	M
O6	Agriculture	Disease control	Disease	Develop disease reporting protocol to provide early warning of crop and livestock disease outbreaks and to facilitate tracing and containment/isolation of vectors and dangerous food.	3	3	3	2	3	1	1	3	3	22	1	22	M
W19	Water	Water Demand Management	Water Availability	Revision of the water level regulation licences to promote water demand reduction	3	3	2	2	3	1	1	3	3	21	1	21	L
H8	Food	Disease control	Disease	Environmental Health Practitioners (EHPs) to: - raise awareness of increased risk of disease through higher temperatures and changing conditions during routine audits of formal and informal food trades. - encourage food industries to develop contingency plans to manage food supply chains to reduce the impact of hot weather.	3	3	3	1	3	1	3	2	2	21	1	21	L
H5	Health	Health	Temp	Research to create a better understanding of heat related morbidity and mortality which could help with disaster management	2	3	3	2	3	3	1	2	1	20	1	20	L
O10	All	All	All	Encourage insurance industry to reassess risks taking climate change impacts into account	2	2	3	2	3	3	1	3	1	20	1	20	L
O8	Energy Office	Health	Temp	Promote cooling technologies that do not increase the consumption of fossil fuels and exacerbate greenhouse gas emissions.	2	3	1	3	2	1	2	2	3	19	1	19	L
O11	All	All	All	Assess infrastructure inventory against age, location, climate change risk, insurance value and maintenance budget to better understand potential cost to Municipality	3	2	2	1	3	1	1	3	3	19	1	19	L
O7	Agriculture	Other	Food	Improved market access so as to increase the geographical spread from which food in Durban is sourced. Improved rail freight for farmers food so as to allow wider access to food markets	3	3	3	1	2	1	1	2	2	18	1	18	L
O5	Agriculture	Adaptive farming	Food	Link crop development programmes to climate change projections	3	2	1	3	3	1	1	2	1	17	1	17	L

Figure 4.2 illustrates the relative priority of individual interventions by plotting merit versus urgency. Those interventions that fall into the red sector can be viewed as high priority, orange as medium and green as being low priority. Each point relates to an intervention in Table 4.1 and Annex A as indicated by the letter/number reference. These results support the methodology described above.

Figure 4.2 Graph showing relative priority of chosen interventions



Climate change will have a significant impact on the city of Durban and the functioning of eThekweni Municipality. Physical climate risks relating to water availability, sea level rise, flooding, storm damage and rising temperatures have multiple, interlinked, secondary and tertiary impacts, including affects on social and institutional arrangements. Higher temperatures, increased precipitation and changing humidity levels will have an indirect impact on the way of life in Durban through changes in the distribution and intensity of diseases and changes in the geographic range within which certain crops grow.

Water availability and quality and health have been identified as being critically affected by climate change in Durban with disaster management playing an important role in reducing the risk to society.

Given the complexity and pace of climate change impacts, however, local authorities such as eThekweni Municipality will be called upon to provide unprecedented support to existing adaptation efforts and to formulate responses to existing and new threats. There is a need for planned and, in some cases pre-emptive, adaptation responses for which the Municipality has a particular responsibility.

eThekweni Municipality has recognised the need to develop climate change adaptation plans to allow Durban to continue to function and develop effectively and sustainably. Given that the Municipality cannot assume responsibility for – or even “enable” - all adaptation responses and that so many impacts are related or connected via ecosystems, markets or social knock-on effects, the challenge for eThekweni Municipality is to identify the few plausible interactions that will result in the greatest reduction of climate change risk. It is possible that a large number of the potential impacts can be prevented or reduced by implementing a few key activities.

The approach taken in this plan is to reduce vulnerability to a wide range of climate uncertainties and associated impacts by providing information and preparing institutions and communities. This involves a process – it is not a once off deliverable. It is not possible to perfectly predict how, where and when climate change impacts will manifest in Durban and it is not possible to ‘climate proof’ the city. The outcome of this adaptation planning process will be a Municipality that is prepared and has the ability to adapt well to the changes that it encounters i.e. that is ‘climate smart’.

Key to ensuring this occurs is the assessment of adaptation interventions against a consistent set of principles and criteria in the form of a ‘multi-criteria assessment’. In general the multi-criteria assessment revealed that

infrastructural responses are expensive, difficult to implement well and have a high propensity to yield unforeseen adverse consequences. Where well constructed, however, they can provide high levels of protection. Biological and socio-institutional responses can be cost-effective but can be complicated to mobilise. These approaches do tend to be safer and can also yield a high degree of protection.

The adaptation interventions listed in this Municipal Adaptation Plan have been developed and agreed by officials in the health and water sectors within the Municipality. ERM co-ordinated a focussed stakeholder engagement process in order to increase awareness of climate change risks and vulnerabilities and ensure that collaborative decision making resulted in realistic and feasible interventions. This along with adequate resourcing (particularly with regard to staffing) is critical to the successful implementation of these activities.

The adaptation interventions identified should be implemented in a manner which embeds the activities and processes in the day to day operations of the Municipality. This will ensure that the full benefit of the intervention is achieved and that the resilience of Durban to the impacts of climate change is increased.

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Annex A

Detailed sector specific
adaptation interventions for
eThekweni Municipality

Table A.1 Water Sector Adaptation Interventions

Ref	Adaptation Category	Sub-category	Impact	Intervention	Implementation plan (including policy framework for addressing issue)	Outcome	Priority	Responsible Parties (1st listed = lead)	Resource Availability (within lead party)	Timing	Aligned with IDP?
W1	Water	Infrastructure Protection (New)	Flooding	Detailed analysis of latest rainfall/run-off projections and modelling of systems to be finalised.	University of KwaZulu Natal to finalise detailed analysis of quinary level projections. Water sector officials to work with researchers to understand the nature of and how to interpret results. Expand municipality's rain gauge network by 30 gauges.	Improved understanding of the impact of climate change on rainfall and run off and identification of particularly vulnerable areas.	H	<u>Environmental Management Department</u> , University of KwaZulu Natal, Coastal and Storm water Catchment Management	Available - work in progress	Ongoing	Plan 1: Sustaining our Natural and Built Environment Plan 3: Quality Living Environments
W2	Water	Infrastructure Protection (New)	Flooding	Revise rainfall data in line with latest projections (as of 30 September 2009) and review every 5 years.	Coastal and Storm water Catchment Management officials to commission revision of rainfall data for Durban based on projections as of 30 September 2009. Revised report to be published on eThekweni website	- Impact of climate change on rainfall patterns, flooding and run-off embedded into surveys, planning and design - New infrastructure to be designed to manage increased runoff/reduced water availability (e.g. pipe size fits amended run off projections) - Increased resilience of Durban's infrastructure and development to extreme weather events - Any changes in projected rainfall patterns incorporated into planning through regular review of latest research.	H	<u>Coastal and Storm water Catchment Management</u> , Coastal Policy	In house, in the normal course of business.	Revised data to be published by Dec 09, 5 yearly review	Plan 1: Sustaining our Natural and Built Environment Plan 3: Quality Living Environments
W9	Water	Infrastructure Protection (existing)	Flooding	Protect and restore riparian vegetation so as to protect integrity of river banks and retain biological buffers against flooding.	Initiate a 'Working for Rivers' programme on a catchment by catchment basis	- Reed beds and wetlands retained. - Ecosystem services secured - Reduced risk of flooding to residential and public property.	H	<u>Coastal and Storm water Catchment Management</u> , Environmental Management Department	None at present, resource requirements to be determined	Identify budget/resource requirements by end FY 2009/10. Develop work plan by end FY 2010/11. Implement in FY 2011/12	Plan 1: Sustaining our Natural and Built Environment
W5	Water	Infrastructure Protection (New)	Flooding	Develop Master Drainage Plans for all river catchments within eThekweni municipal boundaries	- Based on rainfall projections at 30 September 2009, revise 1:50 and 1:100yr flood lines to take revised rainfall and run-off data into account - Identify priority areas for interventions to reduce risk	- Impact of development on flow better understood and reduced. - Floodlines reflect flood risks modified for climate change influence on run-off. - Newly identified developments potentially at risk required to comply with the Flooding Annexure and become resilient to climate change. - Better alignment of planning and risk.	H	<u>Coastal and Storm Water Catchment Management</u>	In house, in the normal course of business.	From October 2009 - ongoing	Plan 3: Quality Living Environments
W6	Water	Infrastructure Protection (New)	Sea Level Rise	Revise coastal set back lines	Determine and demarcate the High Water Mark based on sea-level rise modelling and revise coastal set back lines accordingly	Coastal set back lines modified for climate change influence on sea level and storm surges	H	<u>Coastal Policy</u> , Coastal and Storm water Catchment Management	In house, in the normal course of business.	By 30 September 2009 for a new set-back line.	Plan 1: Sustaining our Natural and Built Environment
W8	Water	Infrastructure Protection (New and existing)	Sea Level Rise	Prepare Coastal Management Plans for entire Durban coastline	Identify and prioritise coastal areas at highest risk from storm damage and flooding using sea level rise model. Prepare Shoreline and Estuary Management Plans for whole Durban Coastline (focussing initially on Central Beach Front, Amanzimtoti, Bluff Dunes and Umhloti)	- Detailed understanding of the impact of coastal storms and flooding on coastline - Mitigation of risk through prevention, reduction or adaptation - Rehabilitation plans following storm events - Better management of estuaries	H	<u>Coastal Policy</u>	In house, in the normal course of business.	Ongoing for 3-5 years	Plan 1: Sustaining our Natural and Built Environment

Ref	Adaptation Category	Sub-category	Impact	Intervention	Implementation plan (including policy framework for addressing issue)	Outcome	Priority	Responsible Parties (1st listed = lead)	Resource Availability (within lead party)	Timing	Aligned with IDP?
W17	Water	Water security	Water Availability	Incorporate requirement that Umgeni Water consider the impact of climate change on rainfall and run-off into eThekweni Municipality's water purchase agreement.	Head of Water Department to negotiate with Umgeni Water Umgeni Water to work with Department of Water Affairs to ensure detailed analysis of future water availability takes into account the impact of climate change on rainfall and run-off by adopting the modelling carried out by University of KwaZulu Natal and other recognised research	- Climate Change incorporated in Department of Water Affairs and Umgeni Water's strategic planning. - Umgeni Water meets its contractual "assurance of supply" commitment to eThekweni municipality.	H	<u>Water and Sanitation</u>	In house, in the normal course of business.	March 2010	Plan 1: Sustaining our Natural and Built Environment Plan 3: Quality Living Environments
W18	Water	Water Demand Management	Water Availability	Develop an overarching Water use strategy which captures existing interventions being undertaken within the Municipality, identifies additional interventions and creates clear priorities and an implementation plan for responding to the challenges of a current water shortage impacted on by climate change and it's further impact on water security.	Draft note seeking budget and recruit staff Develop strategy which is aligned with Strategic Environmental Assessments and ensures that the implications of climate change are placed at the forefront of all spatial land use planning considerations to ensure that any planning proposals or development approvals complement these adaptation measures. Interventions to include: - domestic, commercial and industrial water use efficiency measures, (demand side management) including possible incentives - measures to reduce non revenue water including billing efficiency and reducing water loss - water being placed at the forefront of all planning decisions to ensure that decisions that rely on a steady water supply, both in qualitative and quantitative terms, adequately factors in water availability. - Review of existing practices for the use of water by the Municipality with the aim of changing these to reduce water demand (e.g. water green spaces at night/less often, use of recycled water) - an ongoing public awareness programme - alternative water resources such as re-use of effluent and de-salination.	- A reduction in the growth of future water demands - Development approvals being subject to adoption of water use efficiency measures - Gradual shift to a more water rational society through behaviour change - Gradual shift to a more "water rational" economy in which existing water resources are allocated to create jobs and revenue.	H	<u>Water and Sanitation</u>	None at present, resource requirements to be determined	Identify budget and recruit resource by end FY2010 Begin work FY2011	Plan 1: Sustaining our Natural and Built Environment Plan 3: Quality Living Environments
W14	Water	Infrastructure Protection (Existing)	Flooding, Sea Level Rise	Relocate informal settlements which are highly vulnerable to flooding and sea level rise.	- Housing Department to be provided with revised floodline and coastal setback data - Housing Department to review priority informal settlements and low cost housing for relocation in light of revised flood and coastal set back lines. - Review to be carried out every 5 years based on population growth and subsequent revisions to flood lines and coastal set back lines.	- Priority relocation list more accurately reflects populations at risk. - Reduced number of people living in flood risk area.	H	<u>Housing, Coastal and Storm Water Catchment Management, Coastal Policy</u>	In house, in the normal course of business.	Every 5 years from 2010	Plan 1: Sustaining our Natural and Built Environment Plan 3: Quality Living Environments Plan 4: Safe, Health and Secure Environment
W15	Water	Infrastructure Protection (Existing)	Flooding, Sea Level Rise	Protection of municipal infrastructure (e.g. transport, storm water, sewerage, electric etc)	Identify key assets at risk following development of: - Master Drainage Plans (W5) - Shoreline Management Plans (W8) - Asset Management Plans (W10&11) Protect infrastructure through relocation or reinforcement/protection	- Better understanding of highly vulnerable assets/infrastructure - Reduced risk to Infrastructure - Opportunity to implement new, efficient, low emissions technology - Simultaneous protection of adjacent private property	H	<u>Coastal and Storm water Catchment Management, Coastal Policy</u>	In house review of plans in the normal course of business	Initial review by end June 2010, subsequent reviews every year as plans are developed	Plan 1: Sustaining our Natural and Built Environment Plan 3: Quality Living Environments

Ref	Adaptation Category	Sub-category	Impact	Intervention	Implementation plan (including policy framework for addressing issue)	Outcome	Priority	Responsible Parties (1st listed = lead)	Resource Availability (within lead party)	Timing	Aligned with IDP?
W3	Water	Infrastructure Protection (New)	Flooding	Elevate Flood Annexure to Council Policy	Write covering report and submit to council for approval	<ul style="list-style-type: none"> - Enables more sustainable development in Durban. - Reduces risk of flooding to property. - Will ensure that the implications of climate change are placed at the forefront of spatial land use planning considerations and will help ensure that any planning proposals or development approvals complement the adaptation interventions listed in this plan. 	H	Coastal and Storm water Catchment Management, Coastal Policy	In house, in the normal course of business.	December 2009	Plan 3: Quality Living Environments
W16	Water	Infrastructure Protection	Flooding	Develop co-ordinated procedure for inspection, clearance and maintenance of all storm water channels, attenuation infrastructure and water courses in order to: <ul style="list-style-type: none"> - maximise use of resources and community support - remove blockages - remove obstructions to free flow of water at bridges and culverts - remove conditions conducive to the spread of water borne diseases - remove alien invasive species and improve biodiversity 	<ul style="list-style-type: none"> - Hold workshop with all affected parties to discuss needs and initiate framework development. - Develop plan of action and procedures in consultation with all stakeholders. - Develop a co-ordinated procedure with due consideration of biodiversity and the ecological impact of the activities drawing on community programmes where possible. 	<ul style="list-style-type: none"> - Water and drainage infrastructure is operating to its design specification. - Community takes greater responsibility for water courses. - Prevents back flooding and inundation of drainage systems. - Reduced flood and disease risk. - Clearance of alien invasive species and improved biodiversity 	H	Coastal and Storm Water Catchment Management, Communicable Disease Control, Environmental Management Department, Parks	In house, in the normal course of business.	Meeting by end October 2009, plan in place by June 2010	Plan 1: Sustaining our Natural and Built Environment Plan 3: Quality Living Environments Plan 4: Safe, Health and Secure Environment Plan 7: Good Governance
W12	Water	Infrastructure Protection (New)	Flooding	Amend Town Planning 'Scheme Controls' to incorporate fixed parameters for run-off in order to reduce storm water run-off from new developments	<ul style="list-style-type: none"> - Develop overarching control to ensure compliance with the "storm water management plan", which states developments may not harden more than 40% of their total area and to encourage installation of green roofs, retention/wet basin, detention/dry basin, infiltration basins etc - Identify existing controls in all areas which need to be repealed to remove conflict - Liaise with Lekha Allopi in Town Planning to ensure public acceptance of changes and correct phrasing 	<ul style="list-style-type: none"> - New developments have neutral or positive impact on run-off in urban areas - Reduced intensity of flood peaks - Increase in recharge of ground water resources. 	H	Coastal and Storm water Catchment Management, Town Planning	In house, in the normal course of business.	Propose changes by end Dec 2009; Consultation January/February 2010; Council approval Feb - May 2010 In force end May 2010	Plan 1: Sustaining our Natural and Built Environment
W4	Water	Infrastructure Protection (New)	Flooding	Reduce risk to developments in flood plains through amendment of Bylaw 5.2 (2) (iii) to require developments within the 1:100 yr floodline within eThekweni boundaries to comply with the Flood Annexure	Coastal and Storm water Catchment Management officials and Gabby Hughes in Legal to produce an appropriate bylaw. Report to be drafted and submitted to Infrastructure Committee and ExCo and published for public comment before approval.	Compliance with the Flood Annexure will ensure revised rainfall data and hence climate change are incorporated in planning and designs	M	Coastal and Storm water Catchment Management, Legal Department	In house, in the normal course of business.	Issue instruction by December 2009	Plan 3: Quality Living Environments
W7	Water	Infrastructure Protection (New)	Sea Level Rise	Develop Council Policy and By-laws or scheme controls covering development within coastal set back lines	Coastal Policy officials to: <ul style="list-style-type: none"> - draft policy - discuss potential bylaws or scheme controls with Gabby Hughes in Legal and Lekha Allopi in Town Planning - Report to be drafted and submitted to Infrastructure Committee and ExCo and published for public comment before approval. 	<ul style="list-style-type: none"> - Developments potentially at risk through a climate induced increase in sea levels and storm damage required to adhere to the requirements of the Coastal Council Policy and become resilient to climate change . - Will ensure that the implications of climate change are placed at the forefront of spatial land use planning considerations and will help ensure that any planning proposals or development approvals complement the adaptation interventions listed in this plan. 	M	Coastal Policy, Legal Department	In house, in the normal course of business.	Policy developed and instructions to legal by 31 December 2009	Plan 1: Sustaining our Natural and Built Environment

Ref	Adaptation Category	Sub-category	Impact	Intervention	Implementation plan (including policy framework for addressing issue)	Outcome	Priority	Responsible Parties (1st listed = lead)	Resource Availability (within lead party)	Timing	Aligned with IDP?
W13	Water	Infrastructure Protection (Existing)	Flooding	Public awareness campaign to raise awareness of the benefits of retrofitting storm water run-off reduction techniques e.g. green roofs, retention/wet basin, detention/dry basin, infiltration basins, rain water harvesters etc to reduce runoff from existing developments .	Implement pilot projects within the municipality to demonstrate benefit of interventions. Develop public awareness strategy.	- Reduced run-off from existing infrastructure in urban areas. - Increase in green areas in city.	M	<u>Environmental Management Department</u> , Coastal and Storm Water Catchment Management, Water and Sanitation, Architectural Services	None at present, resource requirements to be determined	Identify budget/resource requirements by end FY2009/10 Develop work plan by end FY 2010/11 Implement in FY2011/12	Plan 3: Quality Living Environments Plan 5: Empowering Citizens
W10	Water	Infrastructure Protection (existing)	Flooding	Ensure that Asset Management Plans consider revised rainfall/runoff data in assessment of the condition of storm water and catchment management assets.	Develop asset management plans and programme for replacement in order of priority	- Drainage infrastructure capable of managing increased run-off (e.g. bigger pipes) - Prioritisation across projects with regards to urgency and impact.	M	<u>Coastal and Storm water Catchment Management</u>	In house, in the normal course of business.	October 2009 - ongoing	Plan 3: Quality Living Environments
W11	Water	Infrastructure Protection (existing)	Sea Level Rise	Ensure that Asset Management Plans consider revised sea level rise scenarios in assessment of the condition of coastal assets.	Develop asset management plans and programme for replacement in order of priority	- Drainage infrastructure capable of managing increased run-up - Prioritisation across projects with regards to urgency and impact.	M	<u>Coastal Policy</u>	In house, in the normal course of business.	October 2009 - ongoing	Plan 3: Quality Living Environments
W19	Water	Water Demand Management	Water Availability	Revision of the water level regulation licences to promote water demand reduction	Water and Sanitation to discuss with provincial and national government	Reduced water demand	L	<u>Water and Sanitation Department of Water</u>	In house resources to initiate discussion. Future requirements to be identified in due course.	Discussion to be initiated and future timing agreed by end December 2009.	Plan 1: Sustaining our Natural and Built Environment

Table A.2 Health Sector Adaptation Interventions

Ref	Adaptation Category	Sub-category	Impact	Intervention	Implementation plan (including policy framework for addressing issue)	Outcome	Priority	Responsible Parties (1st listed = lead)	Resource Availability	Timing	Aligned with IDP?
H1	Health	Disaster Management	All	Improve the ability of Health Care Systems to respond effectively during emergencies.	<p>Presenation to MEC and Provincial Government as first step to getting National Government to incorporate climate change adaptation in National 10 Point Plan. Undertake a structured review of primary health care system to identify interventions required to enhance institutional capacity and develop plan for implementation</p> <p>Implement interventions identified during review</p> <p>Develop umbrella Health Department Emergency Plan to enhance emergency response capability, resourcing, co-ordination and prioritisation of cases between primary, secondary and tertiary response units. Contingency plans should be developed for each response unit including the following aspects:</p> <ul style="list-style-type: none"> - Early warning of disease outbreaks and extreme weather (heat waves/storms) - All hospitals to be equipped with back-up energy (renewable or generators) to cope with the combination of heat related stress and simultaneous power outages. - 'Cool rooms' to be identified in local communities (e.g. air-conditioned church hall) - Particular focus on care for HIV/AIDS patients 	<ul style="list-style-type: none"> - Strengthening of Primary Health Care Services - Heighten the ability of primary health care units to respond to emergencies with fewer referrals to already overburdened hospitals - Health Care Units across the region operate under the same reporting structures and provide consistent services 	H	Health - <u>Clinical</u>	Review to be carried out in house in the normal course of business in order to identify future resource requirements	Presentation by end December 2009, incorporate review in revised IDP in early 2010	Plan 3: Quality Living Environments Plan 4: Safe, Health and Secure Environment
H2	Health	Disease control	Disease	Enhance analysis of data on of existing "notifiable medical conditions" surveillance and prevention programmes.	<p>Recruit an Epidemiologist to work in the Health Unit</p> <p>Joint report to Treasury setting out strategic planning for climate change seeking budget from council for:</p> <ul style="list-style-type: none"> - funding research on causal relationships between climate change impacts and human health, - housing needs, - water requirements, - increased resources within Health Unit 	<ul style="list-style-type: none"> - Better understanding of the factors affecting transmission of disease will facilitate an improved response. - Improved monitoring and analysis of causal factors and spread of "notifiable medical conditions" which includes malaria, cholera, and diarrhoea. 	M	Health - <u>Communicable Disease Control</u>	Development of report within normal course of business. Future resource requirements to be identified	Rerruitment by end December 2009, report by March 2010	Plan 4: Safe, Health and Secure Environment
H9	Food	Disease control	Disease	Investigate research on the impact of climate change on food e.g. red tide poisoning and impact of increased survival of microbes in the warmer temperatures on food poisoning	<p>Desktop review of existing research</p> <p>Link findings with the food programme</p> <p>Ensure that existing disease reporting procedures build on this work to ensure rapid detection of contaminants and source identification, in order to respond quickly to climate-related contamination of food.</p>	<ul style="list-style-type: none"> - Increased understanding of link between climate change and disease risk - Will facilitate awareness raising and associated behaviour change 	M	Health - <u>Environmental</u>	Review to be carried out in house in the normal course of business in order to identify future resource requirements	Incorporate in revised IDP	Plan 4: Safe, Health and Secure Environment
H4	Health, Water	Disease control	Disease	Develop a framework within which all responsible parties work together to identify and manage problem sources of contaminated water including:	<p>Hold workshop with all affected parties to discuss needs and initiate framework development</p> <p>Develop plan of action and procedures in consultation with all stakeholders</p>	<ul style="list-style-type: none"> - Improved quality of recreational water sources in Durban - Reduction in conditions conducive to the spread of and the incidence of water-borne disease. - Fewer illegal connections to sewers. - Drainage and storm water system operates to its specification. Improve ecosystem services. 	M	Health - <u>Environmental, Water and Sanitation, Communicable Disease Control</u> Environmental Management Department	In house, workshop to be held in the normal course of business. Additional resource requirements will be identified through this process	Meeting by December 2010, plan in place by June 2011	Plan 3: Quality Living Environments Plan 4: Safe, Health and Secure Environment Plan 7: Good Governance

Ref	Adaptation Category	Sub-category	Impact	Intervention	Implementation plan (including policy framework for addressing issue)	Outcome	Priority	Responsible Parties (1st listed = lead)	Resource Availability	Timing	Aligned with IDP?
H3	Health	Disease control	Disease	Public awareness campaign on: - conditions favourable to rodent/mosquito breeding - preventative measures (e.g. use of mosquito nets) - identification of related illnesses	Review Clean, Green and Healthy public awareness campaign and if required develop training program for Environmental Health Practitioners targeting climate change and disease awareness. This information to be disseminated to public through Clean Green and Healthy Campaign.	- Reduction in vector breeding areas - Reduction in disease transmission (e.g. malaria, cholera, diarrhoea etc) - Reduced incidence of disease/death	M	Health - Environmental, Clinical, Communicable Disease Control,	In house review, funding may be required for training	Review by end June 2010, training to last 24 months	Plan 4: Safe, Health and Secure Environment
H7	Food	Disease control	Disease	Expand public awareness programme to increase awareness of: - food hygiene and good food handling practices - food borne illnesses and reporting process - infection prevention and control from contaminated water	Social Development facilitators to include this in training package to community health workers Community Health Workers to spread the word within communities	Behaviour change with regard to cultural, social, societal preferences and food handling and processing norms resulting in reduced risk of food poisoning, diarrhoeal diseases, death	M	Health - Environmental, Social Development Communicable Disease Control	In house, develop training package in the normal course of business	by June 2010 and ongoing	Plan 4: Safe, Health and Secure Environment
H6	Health	Health	Temp	Increase public awareness of how to keep cool in a heat wave without increasing electricity consumption through use of fans and air conditioners. Activities could include: - Shade north and west-facing windows - Paint buildings and surrounding walls white to reflect heat - Plant small trees and shrubs around buildings - Replace metal blinds with curtains with white linings to reflect heat outwards where possible	Develop guidance note or public announcements during extreme weather events Incorporate Climate Change in workshop to be held in November 2009	- More comfortable living conditions during hot weather will reduce incidence of heat stress and reduce pressure on health services. - Better communication of climate change risks leads to more appropriate public responses; less panic.	M	Health - Environmental, Social Development	In house, develop guidance note in the normal course of business	By end December 2010	Plan 4: Safe, Health and Secure Environment
H8	Food	Disease control	Disease	Environmental Health Practitioners (EHPs) to: - raise awareness of increased risk of disease through higher temperatures and changing conditions during routine audits of formal and informal food trades. - encourage food industries to develop contingency plans to manage food supply chains to reduce the impact of hot weather.	EHPs Health Education Programme to be reviewed Hazard analysis critical control point (HACCP) systems to be applied to the municipality's food chains. Skills development programme Expand 5 keys to safer food programme beyond 2010	Early warning on food disease outbreaks (including fisheries) via a disease reporting protocol. Increased resilience of food industry to outbreak of disease. Traceability of origin of disease outbreaks.	L	Health - Environmental	In house, curriculum is continually being revised.	Develop initial programme by end December 2009	Plan 4: Safe, Health and Secure Environment
H5	Health	Health	Temp	Research to create a better understanding of heat related morbidity and mortality which could help with disaster management	Encourage tertiary institutions to carry out research Take part in development of graduates Use registrars on their 6 month "attachments".	Better understanding of the factors affecting heat related morbidity and mortality.	L	Health - Clinical	In the normal course of business, Clinical Health officials to identify external resource requirements.	Raise resources by end June 2010 for implementation during FY2010/11.	Plan 4: Safe, Health and Secure Environment

Table A.3 Disaster Management Adaptation Interventions

Ref	Adaptation Category	Sub-category	Impact	Intervention	Implementation plan (including policy framework for addressing issue)	Outcome	Priority	Responsible Parties (1st listed = lead)	Resource Availability (within lead party)	Timing	Aligned with IDP?
DM2	Disaster	Disaster Management	All	Implement Disaster Risk Management Framework	-Determine priorities and ultimate outcomes desired - Establish institutional arrangements required to support the framework including the establishment of an advisory forum and restructure Disaster Management within the City	- Better Disaster Management function within the Municipality - Departments and organisations mandated to undertake certain activities - Framework for escalation of emergencies - Bronze (Operational); Silver (Tactical); Gold (Strategic)	H	Disaster Management	In house, meetings within the normal course of business	Initiate work by March 2010	Plan 4: Safe, Health and Secure Environment
DM3	Disaster	Disaster Management	All	Undertake a detailed assessment of all risks in Durban.	Terms of Reference to be developed and contracting to be arranged through liaison between Disaster Management and Environmental Management Department Contract consultants to: - undertake a Systematic assessment of all risks in Durban building on work done for the FIFA 2010 World Cup and by the military for the province and including the impact of Climate Change. - develop a Disaster Management Policy and Business Plan	- Comprehensive understanding of the scope and nature of risk facing Durban and the vulnerability of the city and its people - Baseline from which to develop contingency plans and enhance Disaster Management Capability in Durban.	H	Disaster Management, Environmental Management Department	External expertise required Some budget available in FY2009/10 Additional budget required	Terms of ref issued 31 December 2009 Contract signed 31 May 2010 Project Complete 30 November 2011	Plan 4: Safe, Health and Secure Environment
DM1	Disaster	Disaster Management	All	Secure additional resources for Disaster Management Branch	Report to Treasury around critical vacancies and motivating for additional staff - keep a log of time spent by existing staff on different tasks (e.g. admin, external meetings etc) - Link staff requirement to FIFA 2010 World Cup to prioritise with politicians Chase HR to proceed with recruitment for vacancies Interview and hire new staff	Disaster Management function within the Municipality will operate more effectively Branch able to do more: Strategic planning Contingency planning Public awareness Social welfare	H	Disaster Management	Recruitment process within the normal course of business	Start logging time end November 2009. Report to Treasury by end March 2010. Have resources in place by November 2010	Plan 4: Safe, Health and Secure Environment
DM4	Disaster	Disaster Management	All	Revise Contingency Plans for key risk areas.	In the short term: - prioritise dealing with South Durban through Major Hazard Installation assessments - revise contact details in existing plans and develop templates and train individual departments to develop their own plans Following completion of the risk assessment project, revise plans to ensure they address all risks and are able to withstand the increased frequency and severity of emergencies likely due to climate change Plans should include provision for: - Well resourced and organised Emergency Operations Centre linked to early warning system - Involve all affected departments and agencies across the Municipality - Must link with Energy and Health Disaster Plans - Include arrangements for facilities to house displaced populations and maintain hygiene standards to prevent outbreaks of disease in refugee camps - Emergency centres (operational control, temporary shelter, mobile clinics etc) should be set up in 'safe areas' where infrastructure and access are unlikely to be severely impacted. - schedule for regular live rehearsal exercises to keep people involved, to identify any shortcomings in plans and to ensure all parties are aware of their responsibilities before, during and after an emergency.	- Disaster Management capability in the region enhanced and co-ordinated emergency response and contingency plans developed for all agencies and departments involved in the response to emergencies. - Better capacitated and resourced Joint Operations Centre - Hazard Management Plans more widely understood and acted upon - More effective and efficient response and recovery from emergencies - Reduced loss of life and property	H	Disaster Management, Fire Department	Following DM1, resources available in house	Revision of contact details by March 2010 Fully revised plans July 2011 - June 2012 Live exercises - biannual from June 2012	Plan 4: Safe, Health and Secure Environment

Ref	Adaptation Category	Sub-category	Impact	Intervention	Implementation plan (including policy framework for addressing issue)	Outcome	Priority	Responsible Parties (1st listed = lead)	Resource Availability (within lead party)	Timing	Aligned with IDP?
DM5	Disaster	Disaster Management	All	Disaster Management Summit - to raise awareness of Disaster Management function and departmental responsibilities - refer to hosting a successful FIFA 2010 World Cup and managing climate change risk	Workshop with all parties involved in Disaster Management activities Invitation from the City Manager to encourage senior management attendance Events covering: 1 - Disaster Management Framework 2 - Concept of Operations (once revised) 3 - Summary of risk assessment project progress 4 - Summary of risk assessment project results 5 - Contingency Plan development 6 - Live exercises to rehearse emergency response (see DM4)	- First step in capacity building process - Begin discussions on the risk to the city and the need for holistic, multilateral response - Departmental Stakeholders ready to participate in risk assessment project (e.g. sharing data sets). - City's Disaster Management Plan in line with the, "National Disaster Management Strategy"	H	Disaster Management	Following DM1, resources available in house	Incorporate in revised IDP in early 2010	Plan 4: Safe, Health and Secure Environment
DM6	Disaster	Disaster Management	All	Develop a reliable early warning system alerting residents and disaster management to the likely occurrence of emergencies - Storms - High river levels (flooding) - Extreme rainfall (flooding) - Extreme high tide - High temperature and humidity levels - Disease outbreaks (e.g. cholera)	Link to implementation of Disaster Management Framework (DM2) Manager of Communications Centre to tighten protocols and develop procedures for: - collection of information from appropriate sources - analysis of data and dissemination of alerts as appropriate - guidance to call centre operators on what to do upon receipt of alert or emergency call	- Communication to emergency services and vulnerable communities will allow contingency plans to kick into action and for preparations to take place in advance of the event (e.g. sandbags to protect houses, cool rooms to be prepared) - Communications centre ready to manage emergencies in advance of the FIFA 2010 World Cup	M	Disaster Management - Communications Centre	In house, in the normal course of business in the Communications Centre	30 April 2010	Plan 4: Safe, Health and Secure Environment
DM7	Disaster	Disaster Management	All	Public awareness campaign alert population to: - How they can reduce the potential impact of an emergency and what to do when one occurs - How to maintain health during hot periods (reduce exercise, consumer liquids, stay indoors etc) - Linking risk reduction with development	Formulation of health network systems and dissemination of information on heat stress Enhance current work with vulnerable communities Link with Air Quality communication strategy	Better informed public more able to take action and reduce risk to themselves and therefore reduce burden on disaster management.	M	Disaster Management Health - Environmental	Following DM1, resources available in house	Incorporate in revised IDP in early 2010	Plan 4: Safe, Health and Secure Environment

Table A.4 Other Sectors Adaptation Interventions

Ref	Adaptation Category	Sub-category	Impact	Intervention	Implementation plan (including policy framework for addressing issue)	Outcome	Priority	Responsible Parties (1st listed = lead)	Resource Availability (within lead party)	Timing	Aligned with IDP?
O2	All	All	All	Raise public awareness of issues associated with climate change to build capacity, encourage early action and facilitate national policy development	Establish a Durban Climate Change Partnership encompassing a wide range of stakeholders within industry, business, government, charity, academic organisations etc Hold seminars and discussion forums on climate change and energy related issues	- Shared understanding of problems and potential for joint solutions between government and private enterprises - Better public support for climate change adaptation measures - Better understanding of the impact of proposed national policies on activities in Durban and the ability to respond to National Government with concrete evidence and proposals	H	Environmental Management Department	Review to be carried out in house in the normal course of business in order to identify future resource requirements	Identify budget/resource requirements and develop work plan by end FY 2009/10 Implement in FY 2010/11	Plan 1: Sustaining our Natural and Built Environment Plan 5: Empowering Citizens Plan 7: Good Governance
O3	Agriculture	Adaptive farming	Food	Develop a system to provide financial support to rural communities in order to encourage an approach of adaptive farming including access to credit, investment in the rural economy and support to institutions.	Agricultural Management Unit to initiate discussion between provincial agriculture departments	Increased resilience of agricultural industry	M	<u>Agricultural Management Unit</u> Environmental Management Department KwaZulu Natal Department for Agriculture and Environmental Affairs Department for Agriculture, Forestry and Fisheries Health - Social Development	In house resources to initiate discussion. Future requirements to be identified in due course.	Discussion to be initiated and future timing agreed by end December 2009.	Plan 1: Sustaining our Natural and Built Environment Plan 2: Economic Development and Job Creation Plan 5: Empowering Citizens Plan 7: Good Governance
O4	Agriculture	Adaptive farming	Food	Develop training programme to encourage farming approaches that include greater awareness of climate change, including: - monocropping and consideration of new crops capable of yielding higher returns under the altered precipitation and temperature regimes - modification of agricultural practices to reduce emissions from land based activities - water-wise irrigation techniques (e.g. mulching, swales, rainwater harvesting) - pest control - distribution of agricultural packs including fertiliser and herbicide (must carefully consider impact on mitigation)	Agricultural Management Unit to initiate discussion between provincial agriculture departments Provide subsistence farmers with a rain gauge and thermometer in order to encourage public monitoring, and analysis, of climate variables relevant to agriculture (temperature, diurnal range, precipitation) over time Develop radio and SMS communication service to better communicate medium term weather forecasts and pending threats to emerging farmers	- Increased resilience of agricultural industry to weather and climate changes and crop disease - Increased security of food supply - Reduced water requirements and greenhouse gas emissions - Increased agricultural yield - Better public understanding of how climate affects agriculture - Subsistence farmers able to monitor weather patterns and improve planning	M	<u>Agricultural Management Unit</u> Environmental Management Department KwaZulu Natal Department for Agriculture and Environmental Affairs Department for Agriculture, Forestry and Fisheries Health - Social Development	Department of In house resources to initiate discussion. Future requirements to be identified in due course. Agriculture user pays systems co-ordinated through farmers associations Donor funding	Discussion to be initiated and future timing agreed by end December 2009.	Plan 1: Sustaining our Natural and Built Environment Plan 2: Economic Development and Job Creation Plan 5: Empowering Citizens
O9	Housing	Water Conservation, Health	Water Availability Temp	Design requirements for low cost housing to incorporate water conservation and temperature regulation measures such as rain water harvesting tanks, solar water heaters, ceilings, size of windows and orientation etc. Developments to include communal renewable energy, grey water and/or sanitation systems.	Determine cost implication of increased specification Clarify potential for changes to existing design of houses (e.g. double rather than single story) Assess potential to generate carbon credits for housing energy efficiency projects Increase public expenditure Amend housing subsidy scheme Incorporate requirements in the terms of tender issued by Housing Department	Proactive planning to prevent risk Low cost houses have better temperature regulation reducing the need for heating/cooling Reduced costs of energy and water Reduced carbon and water footprint or developments Better ventilation (through larger windows)	M	<u>Environmental Management Department</u> (to identify lead department) Housing Water and Sanitation City Engineers	In house resources to initiate discussion and identify future resource requirements - ultimate link to National Housing subsidy and provincial housing programme	Discussion to be initiated and future timing agreed by end December 2009.	Plan 1: Sustaining our Natural and Built Environment Plan 3: Quality Living Environments Plan 4: Safe, Health and Secure Environment

Ref	Adaptation Category	Sub-category	Impact	Intervention	Implementation plan (including policy framework for addressing issue)	Outcome	Priority	Responsible Parties (1st listed = lead)	Resource Availability (within lead party)	Timing	Aligned with IDP?
O12	Water	Infrastructure Protection	Flooding	Incorporate response to the impacts of climate change in Integrated Transport Plans from 2010	Assess the impact of flooding and high temperatures on transport infrastructure; Incorporate adaptation options into future planning e.g. - Define new standards for infrastructure (e.g. for construction of roads); - Relocate or safeguard routes/sites in areas at risk (e.g. from flooding); and - Avoid new transport infrastructure developments in coastal and inland flood sensitive areas. - Reduce the risk to existing infrastructure through modifications (e.g. increase bridge height, culverts etc)	More robust transport infrastructure with reduced risk from flooding	M	Transport Authority (Strategic Planning), Coastal and Storm water Catchment Management, Environmental Management Department	In house	Identify budget/resource requirements by end FY2009/10 Develop work plan in FY 2010/11. Implement in FY2011/12	Plan 3: Quality Living Environments Plan 7: Good Governance
O1	All	All	All	Develop socio-institutional learning capacity within the Municipality to facilitate better decision making and avoid mal-adaptive approaches	Develop training package for all municipal officials - potentially in conjunction with University of KwaZulu Natal Make administration and politicians aware of the multi-criteria assessment process and encourage them to undertake this assessment during policy development	- Shared understanding of problems and potential for joint solutions within government - Better government support for climate change adaptation measures. - Better decision making and avoidance of mal-adaptation practices, contradictory policies and actions and unforeseen outcomes.	M	Environmental Management Department	Review to be carried out in house in the normal course of business in order to identify future resource requirements	Review and resources identified by end FY2009/10. Implementation in FY2010/11.	Plan 1: Sustaining our Natural and Built Environment Plan 7: Good Governance
O6	Agriculture	Disease control	Disease	Develop disease reporting protocol to provide early warning of crop and livestock disease outbreaks and to facilitate tracing and containment/isolation of vectors and dangerous food.	Agricultural Management Unit to initiate discussion between provincial agriculture departments Develop protocol in line with National Health policy for positive incidents Procedure for tracing source of illness and identifying cause of contamination Enhance training of health care providers	Effective monitoring of incidents of disease may help identify trends and ways to improve health care system	M	Agricultural Management Unit Health - Communicable Disease Control Environmental Management Department KwaZulu Natal Department for Agriculture and Environmental Affairs Department for Agriculture, Forestry and Fisheries Agricultural and Veterinary Extension Services	In house resources to initiate discussion. Future requirements to be identified in due course.	Discussion to be initiated and future timing agreed by end December 2009.	Plan 4: Safe, Health and Secure Environment
O10	All	All	All	Encourage insurance industry to reassess risks taking climate change impacts into account	Environmental Management Department to initiate discussion with Treasury. Hold workshop/summit with Insurance Industry to present findings of Integrated Assessment Tool; raise awareness of Climate Change Risk and initiate discussion about changing risk rating	Better alignment of insurance cover and risk	L	Treasury Environmental Management Department KwaZulu Natal Department of Agriculture and Environmental Affairs Department of Finance	In house, meeting within the normal course of business	end June 2011	Plan 4: Safe, Health and Secure Environment Plan 5: Empowering Citizens
O8	Energy Office	Health	Temp	Promote cooling technologies that do not increase the consumption of fossil fuels and exacerbate greenhouse gas emissions.	Environmental Management Department to initiate discussion Include in existing Energy Office initiatives and awareness programmes	Reduced reliance on air conditioning (which emits GHGs) during summer Reduction in GHG emissions	L	Energy Office Environmental Management Department	In house, within the normal course of business	Discussion to be initiated and future timing agreed by end December 2009.	Plan 1: Sustaining our Natural and Built Environment Plan 3: Quality Living Environments

Ref	Adaptation Category	Sub-category	Impact	Intervention	Implementation plan (including policy framework for addressing issue)	Outcome	Priority	Responsible Parties (1st listed = lead)	Resource Availability (within lead party)	Timing	Aligned with IDP?
O11	All	All	All	Assess infrastructure inventory against age, location, climate change risk, insurance value and maintenance budget to better understand potential cost to Municipality	Performance Management Unit to notify all infrastructure departments of need to include impact of climate change in development of Asset Management Plans for all sectors	Municipal capital reserve better able to withstand future demands in the face of climate change related infrastructure damage	L	Performance Management Unit All infrastructure departments	In house, within the normal course of business	Notification by end October 2009, development of plans ongoing	Plan 3: Quality Living Environments Plan 4: Safe, Health and Secure Environment Plan 7: Good Governance
O7	Agriculture	Other	Food	Improved market access so as to increase the geographical spread from which food in Durban is sourced. Improved rail freight for farmers food so as to allow wider access to food markets	Agricultural Management Unit to initiate discussion between provincial agriculture and transport departments	Improved food security	L	Agricultural Management Unit eThekweni Transport KwaZulu Natal Department for Agriculture and Environmental Affairs Department of Transport	In house resources to initiate discussion. Future requirements to be identified in due course.	Discussion to be initiated and future timing agreed by end December 2009.	Plan 4: Safe, Health and Secure Environment Plan 7: Good Governance
O5	Agriculture	Adaptive farming	Food	Link crop development programmes to climate change projections	Agricultural Management Unit to initiate discussion between provincial agriculture departments Review effectiveness of GM crops in coping with climate change	- Increased resilience of agricultural industry to weather and climate changes and crop disease - Increased security of food supply - Increased agricultural yield	L	Agricultural Management Unit Environmental Management Department KwaZulu Natal Department for Agriculture and Environmental Affairs Department for Agriculture, Forestry and Fisheries Health - Social Development	In house resources to initiate discussion. Future requirements to be identified in due course.	Discussion to be initiated and future timing agreed by end December 2009.	Plan 1: Sustaining our Natural and Built Environment Plan 2: Economic Development and Job Creation Plan 5: Empowering Citizens

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