Development of a Climate Change Response Strategy for the Ugu District Municipality

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Executive Summary

Concepts and Definitions

Term	Definition
Adaptation	The process of adjustment to actual or expected climate change and its effects, in order to moderate negative impacts or exploit potential opportunities.
Baseline/observation data	The simulated climate model output constrained by known observational satellite and station data.
Capacity	The combination of all strengths, attributes and resources available within a community, society or organisation that can be used to achieve agreed goals.
Climate	Defined in a narrow sense as the average weather experienced over a period of time.
Climate Change	Climate Change refers to the long term shift in weather patterns. It may involve changes in average weather patterns or in the frequency and intensity of events. Climate change can be caused by natural processes or human causes.
Climate Variability	Climate variability refers to short term variations in the average state of climate variables, without influencing the long term averages.
Dry spell duration	The number of consecutive days not classified a rainfall day.
Extreme rainfall day	Twenty four hours during which 15mm or more of precipitation fell.
Extreme temperature day	A day where the mean day time temperature exceeded/will exceed 35°C
GCM	Global Circulation Model: simulates the global climate under particular climate scenarios in order to assess the likely future global climate status.
Hazard	A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydro meteorological and biological) or induced by human processes (environmental degradation and technological hazards). Hazards can be single, sequential or combined in their origin and effects. Each hazard is characterised by its location, intensity, frequency and probability.
Heat wave event	Five consecutive days with daytime temperatures higher than the observed monthly climatological mean.
Impact	Impacts refer to the effects on human and natural systems. In this document it refers primarily to the effects of extreme weather and climate events and climate change on human and natural systems.
Mitigation (Climate Change)	A human intervention to reduce the sources of greenhouse gases.
Rainfall/precipitation day	Twenty four hours during which 0.2mm (cumulative) of precipitation fell.
RCM	Regional Climate Model: simulates a particular regional climate in higher resolution than a GCM and is able to give more localised projected climate information.
Resilience	The capacity of a system, community or society potentially exposed to hazards to adapt by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organising itself to increase this capacity for learning from past negative impacts for better future protection and to improve risk reduction measures.
Response	Climate Change Response encompasses a two-pronged approach addressing both climate change mitigation and adaptation.
Risk	The combination of the probability of an event occurring and its negative consequences.
Vulnerability	The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. Conditions of vulnerability and susceptibility to the impact of climate change impacts are determined by physical, social, economic and environmental factors or processes.

1 Problem Statement

There is consensus that climate change in anthropogenic in cause and that it has already, and will, result in increased day and nighttime temperatures and more variable and uncharacteristic rainfall patterns globally.

In the context of South Africa, the varied environments will result in areas experiencing differing impacts as a result of this climate change. There are likely to be both “winners” and “losers” from climatic changes[1] with some areas potentially benefiting from more favourable rainfall regimes and more temperate climates, while others might be rainfall deprived and experience enhanced heatwave activity. In South Africa the Long Term Adaptation Scenarios (LTAS) flagship program confirmed these trends and outlined four possible climate change scenarios for different areas within South Africa.

1. Warmer (<4°C above 1961-2000) and wetter with greater frequency of extreme rainfall events.

2. Warmer (<4°C above 1961-2000) and drier, with an increase in the frequency of drought events and somewhat greater frequency of extreme rainfall events.

3. Hotter (>4°C above 1961-2000) and wetter with substantially greater frequency of extreme rainfall events.

4. Hotter (>4°C above 1961-2000) and drier, with a substantial increase in the frequency of drought events and greater frequency of extreme rainfall events.

Each of the six hydrological zones in South Africa will, to some degree, adhere to these scenarios and the day to day meteorology will be manifest through these climate changes. The changes already experienced in South Africa pose a significant challenge to the long term socio-economic well-being of South Africa in general and Ugu District Municipality and its residents in particular. Climate change threatens the resources and systems which support human life including water resources, human health, food security and ecosystem services. Climate change has the potential to impact every aspect of our day-to-day lives:

- Ecosystems may suffer biodiversity and habitat loss from to retreat of natural vegetation forced by temperature threshold sensitivity. The enhanced variability of the rainfall will disadvantage present sensitive rain fed vegetation and ecosystems and advantage insensitive vegetation;

- In the presence of higher temperatures and less reliable rainfall, the agricultural sector will be forced to adapt practices, rely heavily on seasonal forecasts or consider crops alternative;

- Warmer nighttime temperatures may allow for increased mosquito activity further south and over more of the year then currently observed. This will impact human health through the spread of potential disease vectors;

- Both the increased temperature and the variability of rainfall intensity will impact the durability and maintenance schedule of current urban systems and infrastructure through the enhanced thermal expansion of infrastructure, and heightened overland flow and erosion rates. Approaches to development must consider these influences;

[1] Schulze. R.E., Approaches towards practical adaptive management options for selected water-related sectors in South Africa in a context of climate change, ISSN 1816-7950, Water Research Commission, Vol. 37 No. 5, Kempton Park, September 2011.

- The greening of the economy, focusing on the fair and sustained usage of resources, will begin to override, and over time supersede traditional business models unaligned with sustainable development goals, particularly in the context of further climate changes; and

- Climate change, if adaption measures are not undertaken, can render areas unsuitable for sustained habitation or agriculture. In such cases migration or adaptation of livelihoods is forced. The populous may favour industry less sensitive to climate changes and voluntarily migrate to economic centers and thereby exacerbating existing urbanization complications.

Ugu District is mandated under the Constitution of the Republic of South Africa (1996) Section 24 (a) to guarantee everyone an environment that is not harmful to his or her health or well-being. The subsequent clause advocates for sustainable development in which social and economic development is pursued for the present generation without compromising opportunities for future generation. Further the National Development Plan states that a climate change response is imperative to strengthening the nations' resilience and requires the identifying and putting into effect appropriate policies and measures to be climate adaptive.

The Ugu District has recognized the crucial role it plays in responding to climate changes by building resilience and adaptive capacity, particularly with regard to human settlement and urban development planning in the short, mid and long term. In order to suitably address the challenges posed by climate change in Ugu District, the study of the likely changes to the climate to be experienced, the assessment of the risks and vulnerabilities in each sectors and the development of a robust, no-regrets strategy must be undertaken. In doing so Ugu District seeks to fulfil its objectives of sustainable and equitable service provision, enabling socio-economic development and providing a safe and healthy environment for all.

1.1 Climate change

Studying the likely climate changes refers to assessing the long term climatic condition variation from the normal (observed) climate patterns and establishing an altered baseline from which natural (seasonal, annual and decadal) variability acts.

Climate change is driven by the introduction of long residence greenhouse gases into the atmosphere at heightened volumes through unchecked industrial development. While greenhouse gases are naturally present and required in the atmosphere, the excessive utilization of fossil fuels through industry, vehicle emissions, landfill sites and farming, escalates the atmospheric levels of carbon dioxide and methane, in particular.

Global temperatures are increasing and will continue to do so, and that these can largely be attributed to human impacts[2]. There is still uncertainty regarding the potential for future impacts on spatial precipitation changes. Some areas of the global likely to experience increased precipitation with changes in the likely onset, duration and intensity of monsoons and large rain events as well as frequency of rainfall events leads to heightened flood risk. While other areas are projected to receive reduced average annual precipitation and may experience increased dry spell duration with droughts becoming more prevalent. It is however agreed that the in general, precipitation is likely to become more variable with an increase in the occurrence of extreme events contributing to a heightened potential risk of both floods as well as droughts. Other impacts include the decline of global ice and snow cover and the subsequently reduced surface albedo enhancing temperature increase further. The increase in fresh water moving into the oceans compounded with rising ocean temperatures is weakening the thermohaline circulation which drives ocean climatology. The thermal expansion of the ocean also results in sea level rise and risk of coastal inundation. The combined effects of these impacts will serve to impact the climatic risk and vulnerability profiles between different regions over time.

[2] Intergovernmental Panel on Climate Change, 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report, Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

1.2 Risk and Vulnerability

The climatic vulnerability of an area or sector is the degree to which day to day systems and functionality are susceptible to the impacts associated with changes in the persistent weather regime and the inability to adapt/cope with these changes over time. Assessing the risks and vulnerabilities of sectors and areas within the Ugu District will allow for improved processes for responding, adapting to and mitigating against (where possible), the effects of climate change will be necessary not only to protect against adverse consequences, but also to enable societies to take advantage of any potential benefits that may result.

Vulnerability and the inability to cope can be increased due to anomalous seasonality, frequency, intensity, spatial extent and duration of weather and climate related extremes. These variations have been noted in the observed record of the Ugu District, examples would be the recent heat waves present in the area during October to November 2015. The observed and projected increase in the magnitude and probability of more severe weather events is measured against the vulnerability of an area to determine the potential risk associated climate impacts. A lack of resilience and capacity (both institutional and personal) to adapt will intensify the pressure being placed on human and natural systems increasing their susceptibility to the adverse effects of climate change.

1.3 Strategy development

The aim of developing a climate change response strategy is to provide high level recommendations for how the Ugu District can address the risk of climate change and enable the Ugu District to initiate administrative functions, instruments and processes required to influence mitigating and adaptive behavior, progressing towards more sustainable livelihoods and improved community resilience improving overall well-being irrespective of the actual pace and severity of climate change within the expected climate change envelope.

The specific objectives of the Strategy are:

- Water security and efficiency;
- Climate resilient and low carbon development:
    - Infrastructure
    - Transport
    - Settlements
- Energy efficiency and demand side management;
- Biodiversity and ecosystem management;
- Food security (Agriculture);
- Public health;
- Disaster management; and
- Build response capacity through improved coordination and awareness.

Addressing climate change will require a shift away from business as usual, with specific reference to production and consumption patterns in priority sectors such as water, energy and agriculture. Ugu District will be required to play an active role in shifting perceptions and facilitating the implementation of both mitigation and adaptation strategies if they are to properly fulfill service delivery needs and to

provide long term peace, stability and economic development. Taking action now to safeguard against inevitable climate changes will limit future losses and contribute to building a resilient Ugu District and support sustainable development goals.

Climate changes are not constrained by the timeframe of political tenure and as such, an effective climate change response requires visionary long term planning and decision-making for reaping benefits in time horizons beyond normal administrative timeframes. If managed correctly, climate change can be transformed into an opportunity for governance innovation within the Ugu District. Acting in the sphere of an uncertain climate future, an appropriate climate change response will likely become a normal component of what is considered as "good governance"[3].

[3] Du Plessis and Kotze. 2013. The role of local government in South Africa's climate change effort. Unpublished Conference paper delivered at the UNITAR Second Global Conference on Environmental Governance and Democracy strengthening institutions to address climate change and advance Green economy.

2 Strategic Context

2.1 Municipal Overview

The Ugu District Municipality comprises of six local municipalities:

- Hibiscus Coast Local Municipality
- Ezinqoleni Local Municipality
- Umuziwabantu Local Municipality
- Vulamehlo Local Municipality
- Umzumbe Local Municipality
- Umdoni Local Municipality

The municipality is situated in southern KwaZulu Natal and is bordered by Ethekwini Municipality (north), Umgungundlovu District Municipality (west), Sisonke District Municipality (west) and the Eastern Cape Province (south) (Figure 1).

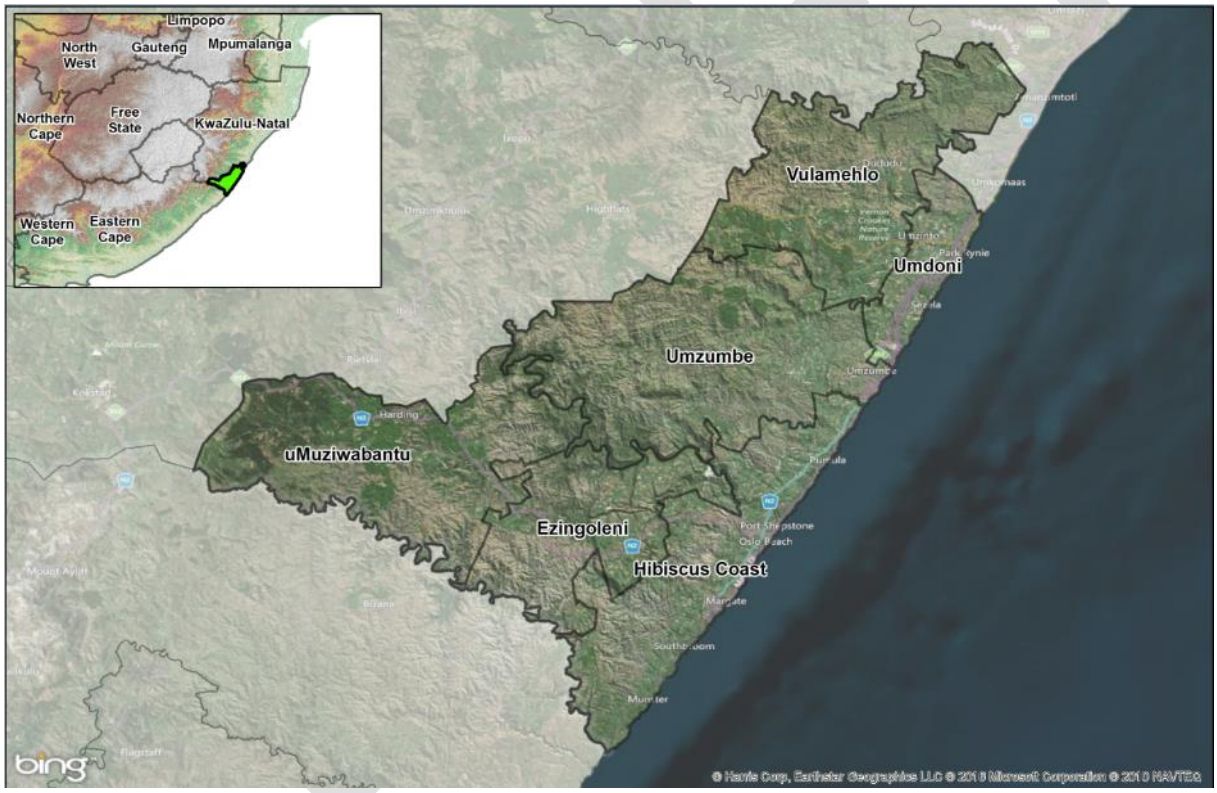


Figure 1 - Locality of Ugu District Municipality and Local Municipalities

The Ugu District Municipality has a well-developed coast with good infrastructure and inland rural areas with limited infrastructure. The inland areas are largely characterised by commercial and subsistence agricultural activities. The District's historical climatic patterns are characterised by summer rainfall and sub-tropical conditions. A more detailed overview is provided as part of the Climate Analysis in Section 3.

A brief overview of the district follows below[4].

[4] For a more detailed situational analysis please refer to the Ugu District IDP

2.1.1 Demographics

The total population for the district is 709 918 with 86% of the Districts' population located in rural areas. The District's population consists of a large number of youth who aspire to move into metro areas due to the limited opportunities for development and entertainment in the District. This could cause implications for the District as the young productive population declines[5]. The total area of the District is 5 866 km^2.

Hibiscus Coast Local Municipality

Hibiscus Coast Local Municipality has its administrative seat in Port Shepstone. The municipality has approximately 90km of coastline comprising 21 beaches, and extends 30km inland, covering a vast, rural area under the leadership of six tribal authorities. It is the most concentrated economic hub within the Ugu District Municipality in the KwaZulu-Natal province.

The Hibiscus Coast Local Municipality is home to the largest population share (35%) of the District. The municipality has an area of approximately 837km2 and comprises of 29 wards. More people live along the coastal belt than the rural hinterland due to economic factors.

The main economic sectors include:

- Finance and business services;
- Wholesale and retail;
- General government services; and
- Agriculture and forestry.

Ezinqoleni Local Municipality

The Ezinqoleni Local Municipality is located in the south western area of Ugu District Municipality adjacent to the west of the Hibiscus Coast Municipality and east of the Umuziwabantu Municipality, and has an area of 649km^2. About 7% of the District's population resides in Ezinqoleni Local Municipality.

The Ezinqoleni municipal offices are situated within the Ezinqoleni settlement, which is located some 40km west from Port Shepstone along the N2 National Highway. The major land uses in the area are tribal settlements, smallholdings and commercial farming.

The main economic sectors include:

- Agriculture;
- Tourism; and
- Services.

Umuziwabantu Local Municipality

Umuziwabantu Local Municipality is located on the western boundary of the Ugu District area. It lies at the foot of the Ingeli Mountain Range and the Umtamvuna River marks the southern boundary. It shares its borders to the north, west and south with the Eastern Cape and to the east with the uMzumbe and Ezinqoleni Municipalities.

The municipality covers a total area of approximately 1088km^2, and about 13% of the District's population resides in Umuziwabantu Local Municipality. Significant features include an urban development (the town of Harding), farmland, commercially-grown forests, and traditional authority areas.

Vulamehlo Local Municipality

Vulamehlo Local Municipality is bordered by Umdoni to the east, Mkhambathini and Richmond to the north, and Ubuhlebezwe to the west. The municipal area covers 960km² is predominantly tribal, with common tribal land patterns. There are, however, also a few scattered pockets of privately owned land throughout the municipal area.

The dispersed, low-density settlement pattern makes the provision of physical and social infrastructure (roads, water, electricity, clinics, schools, and police stations) and the costs of installing, maintaining and operating the infrastructure very high.

[5] Ugu District Growth and Development Strategy, 2012.

Apart from the town of Harding, which is the seat of the municipality, 56% of the municipal area is occupied by individually-owned commercial farms and the Weza afforestation region. The six tribal authority areas (KwaMachi, KwaJala, KwaMbotho, KwaFodo, Dumisa and Bashweni) make up 42% of the municipality's land The main economic sectors include: • Manufacturing; • Agriculture; and Timber	The Vulamehlo Municipality is one of the localities within the Ugu District that is hardest hit by high unemployment levels, poverty and negative economic growth rate. The main economic sectors includes: • Agriculture; • Manufacturing; • Tourism; and Services.
Umzumbe Local Municipality The Umzumbe Local Municipality is the largest local municipality in the District with an area of 1260km^2. About 22% of the District's population resides in Umzumbe Local Municipality. The municipality is located along the coastal strip of the Indian Ocean between uMthwalume and Mfazazana. Umzumbe Municipality is highly active in the areas of tourism, heritage and agricultural produce. The municipality also boasts numerous development opportunities, available to people of Umzumbe and to outside investors. The municipality has placed tourism at the top of the agenda. The main economic sectors include: • Agriculture; and **Tourism.**	**Umdoni Local Municipality** The Umdoni Local Municipality covers total area of 238km^2. It is made up of 10 wards, most of which are rural areas. Umdoni Municipality covers the areas of Amahlongwa, Amandawe, Umzinto, Ghandinagar, Shayamoya, Park Rynie, Scottburgh, Hazelwood, Asoka Heights, Malibu Heights, Pennington, Sezela, Ifafa, Bazley, Mtwalume, Malangeni and Esperanza. The municipality can be divided into three major land uses, being commercial agriculture, traditional authority areas and coastal urban nodes. The coastline stretches approximately 40km. The main economic sectors include: • Commercial Agriculture.

2.1.2 Spatial Profile

The District has a dual space economy with a coastal zone that is largely urbanized and an impoverished rural interior consisting of commercial farms (mainly sugar and bananas) as well as subsistence farms. An estimated 50% of the total land area is made up of traditional authority areas. Uncontrolled development (especially in rural areas) is a concern in the District.

There is an apparent disparity in terms of development between rural areas and formal urban settlements along the coastal strip. Areas along the coast are better developed with regards to infrastructure including transport, electricity, water and sanitation compared to inland rural areas.

Natural structuring elements exist in the District such as the coastline, rivers, streams, hills, mountains and so forth. Thus, the District has numerous protected areas such as the Oribi Gorge Nature Reserve and Vernon Crookes Nature Reserve to name a few.

The Ugu DM's IDP the most significant issue relating to the spatial development sphere is the increased illegal and uncontrolled development, and the subsequent need for improved enforcement of development controls.

2.1.3 Environmental Profile

There is evidence of degraded natural assets and resources due to uneven environmental management. However, the District is committed to adopting a green approach to activities taking place in the District. Serious concerns have been raised with regards to over exploitation of resources, loss of coastal forests, loss of bushlands and grasslands, loss of ecosystem services, air pollution, soil erosion, decreased soil fertility, overgrazing, decreased ecological linkages, as well as uncontrolled urban and rural sprawl.

The district has made significant inroads with regards to integrated environmental management through the development of Strategic Environmental Assessments, Environmental Management Framework, Integrated Waste Management Plan, Air Quality Management Plan, Air Quality Management by-laws. Despite significant process the Ugu DM acknowledges that some gaps remain. With specific reference to an integrated Coastal Management programme; Invasive Alien Species Management Plan and a Health and Hygiene Education Strategy.

The Ugu DM's IDP (2015) provides a detailed trends analysis outlining the environmental challenges faced by the district. The challenges highlights vulnerabilities relevant to the climate change risk assessment and environmental sustainability will share various mutually reinforcing objectives with the districts strategic approach to climate change adaptation.

2.1.4 Economic Profile

The District has a relatively diversified economy with economic development potential in the agriculture, tourism, mining, retail and manufacturing sectors. Port Shepstone which is the main commercial centre and source of employment is a Secondary Node and the eThekwini-Ugu Corridor is a primary node. Approximately 40% of individuals in the district are not economically active and the majority of unemployed people are youth.

Agriculture

The Agricultural Sector in the District is largely driven commercial farming (sugar, bananas and macadamias; livestock), followed subsistence farming (livestock, poultry, homestead gardening and dryland cropping on rural trust land. The districts also has large forestry plantations, although processing does not take place within its borders.

The Agricultural Sector is a significant economic driver for the district, but in recent years it has been characterized by negative growth rates and a steady increase in job losses. The District's agricultural sector faces many constraints such as, decreasing investment, rising production costs, a change of land use from agriculture to other land use. Climate change poses a significant risk to the agricultural sector, primarily linked to increased rainfall variability and water security. However, potential opportunities for agriculture exist and an enabling environment can be realized through effective information management, planning and implementation.

While climate change is considered as future concerns, there have been observed impacts on the agricultural sector due to increased climate variability. For example, there are two commercial sugar mills located in the district. While demand is likely to require the mills to continue running at full capacity, water shortages has caused operational disruptions in recent times. Recent rainfall patterns has also brought the feasibility of continued dry-land cropping into question.

Mining

Mining does not contribute significantly to the economy of the District but supplies other industries with products such as animal fodder, fertilizer, paint, paper and plastic. The District's main mining industries produce limestone related products. The district has the only marble delta within KwaZulu Natal mined for cement and calcium carbonate. Illegal sand mining also takes place in the District.

While not contributing significantly to the economy, mining activities in the District does have a significant spatial and environmental footprint. Care must be taken to ensure mining applications are in line with municipal spatial and environmental plans.

Industry

Manufacturing is one of the largest contributors to the District's economy but performance in the sector has fluctuated over the past decade. Industries and manufacturing activities are clustered around Port Shepstone and Marburg because of the available serviced land and connectivity to the N2 network. Manufacturing activities taking place in the District include clothing, metal products, textiles, cement production, food, beverages and wood products.

Potential does exist however for the establishment of small-scale manufacturing activities within decentralised nodes, specifically for products that provide backward linkages to the agricultural sector.

Tourism

Tourism is a key contributor to the District's economy and is guided by the Ugu South Coast Tourism Entity. The tourism sector and its potential is largely linked to the region's natural assets, mild climate and proximity to major centers. However, because the District is not fully exploiting its potential the tourism sector's growth is constrained. Currently, the tourism sector is driven by domestic tourists, with infrastructure and facilities related limitations being cited as possible reasons for a lack of international appeal. Environmental degradation related to climate change and weather-related hazards has been highlighted as a potential risk factor for the tourism industry[6]

[6] Ugu DM. 2012. Ugu District Growth and Development Strategy.

2.1.5 Service Delivery

Water

The District Municipality is a water service authority (WSA) and is therefore responsible for providing access to basic infrastructure and services to provide drinking water of good quality. The District has five main catchment areas: The Mlazi and Lovu catchments; the Mkomazi catchment, the South Coast catchment (Mzumbe, Mtwalume and Mpambanyoni Rivers), the Mtamvuma catchment and the Umzimkulu catchment.

The District has achieved Blue Drop Awards for the Umthwalume, Umzinto and Umthamvuna systems. Bhobhoyi and Umtamvuna Supply Zones supply water to the formal urban strip. Rural areas are supplied by stand-alone water schemes. Umgeni Water supplies the District with bulk water in the northern areas and operates the Umzinto and Umthwalume Water Works. In the 2013/2014 year the District had 9 837 657 cubic meters of unaccountable water losses[7].

The percentage of households in the six different local municipalities served with piped water are as follows:

- 50% of households in the Hibiscus Coast Local Municipality
- 17% of households in the Ezinqoleni Local Municipality
- 18% of households in the Umuziwabantu Local Municipality
- 14% of households in the Umzumbe Local Municipality
- 17% of households in the Vulamehlo Local Municipality
- 53% of households in the Umdoni Local Municipality

Sufficient water for both household and agricultural use is necessary in order to facilitate sustainable livelihoods. A future demand assessment undertaken during the Infrastructure Audit clearly shows that future water demand is greater than the current infrastructure capacity of the district. Accordingly, water resource management is a key priority for the District and impact of climate change on the district's water resources must be addressed.

Estimates indicates that the municipality will need to at least double its current infrastructural capacity to meet water supply demands. This will require the implementation of innovative and sustainable solutions such as water conservation, demand management, rainwater harvesting, re-use of waste water and desalination.

Sanitation

Approximately 18% of households use flush toilets connected to a sewerage system, 7% have flush toilets with a septic tank, 9% have a chemical toilet, 18% have a pit toilet with ventilation, 34% have a pit toilet without ventilation, 2% have a bucket toilet, 7% have other modes of waste disposal and 5% of households has no sanitation facility. Sanitation infrastructure backlogs are widespread especially in rural areas but providing access to decent sanitation is part of Ugu's mission. The level of sanitation delivery in urban areas is mainly driven by economic factors.

Electricity

In general the district is well supplied in terms of electricity. Remaining backlogs to electricity provision is mainly caused by the lack of bulk infrastructure. The percentage of households with access to electricity in the six different local municipalities at the time of the 2011 census are as follows:

- 85% of households in the Hibiscus Coast Local Municipality
- 80% of households in the Ezinqoleni Local Municipality

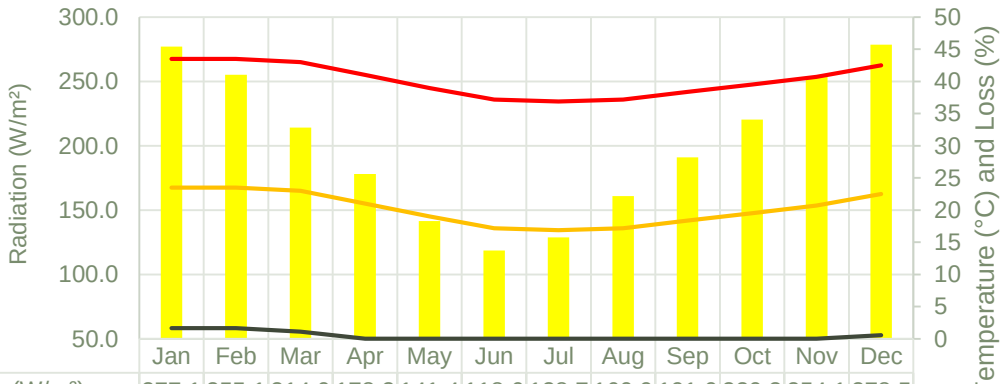
[7] Ugu DM. 2013/2014. Annual Report.

- 80% of households in the Umuziwabantu Local Municipality
- 49% of households in the Umzumbe Local Municipality
- 37% of households in the Vulamehlo Local Municipality
- 37% of households in the Umdoni Local Municipality

The electricity sector does provide opportunities for supply and demand-side interventions including renewable energy and green building design.

Solar potential

Ugu District receives the majority of its daily solar radiation during the summer months (Figure 3). At times of peak generation solar facilities can augment any additional electricity capacity back into the national grid. At this time there are also higher ambient temperatures and there will likely be a decrease in generation efficiency at these times. During winter months less radiation is available and generation capacity is reduced. At such times additional capacity may be needed from the national grid to meet consumer demand.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Solar radiation (W/m²)	277.1	255.1	214.0	178.2	141.4	118.6	128.7	160.9	191.0	220.3	254.1	278.5
Ambient Temperature (°C)	23.5	23.5	23.0	21.0	19.0	17.2	16.9	17.2	18.4	19.5	20.7	22.5
Solar temperature (°C)	43.5	43.5	43.0	41.0	39.0	37.2	36.9	37.2	38.4	39.5	40.7	42.5
Efficiency loss (%)	1.7	1.7	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6

Figure 2: Monthly Solar radiation climatology (W/m²)

It should be noted though that temperature of photo voltaic cells will impact the efficiency of energy production[8]. Solar panels operate on average 20°C warmer than the ambient temperature. Studies have shown that generating efficiency decreases by 1.1% for each 1°C above an operating temperature of 42°C[9]. Therefore with an ambient temperature of 20°C, the solar panels are operating at approximately 40°C with 0% efficiency loss. However in Port Shepstone the summer time temperatures reach an average of 23-24°C which results in an operating temperature of approximately 43-44°C and an average efficiency loss of 1.1 – 2.2%. During heat waves and extreme temperatures, this loss is even greater. Efficiency of generation is increased during cooler temperatures[10]. The near cloudless winters of Ugu will receive the benefit from the decreased temperatures, though will receive less solar radiation. Ugu district does have an opportunity turn to greener renewable energy production but an in-depth cost/benefit analysis must be undertaken in combination with the climate change analysis as part of a prefeasibility study before any significant investment is undertaken.

[8] Omubo-Pepple, V.B., Israel-Cookey, C., Alaminokuma, G.I. Effects of Temperature, Solar Flux, and Relative Humidity on the Efficient Conversion of Solar Energy to Electricity (2014) European Journal of Scientific Research:

[9] Renewable Energy UK: Effect of Temperature on Solar Panels

[10] Butay, D.F., Miller, M.T. (2008), Maximum Peak Power Tracker: A Solar Application, Worcester Polytechnic Institute

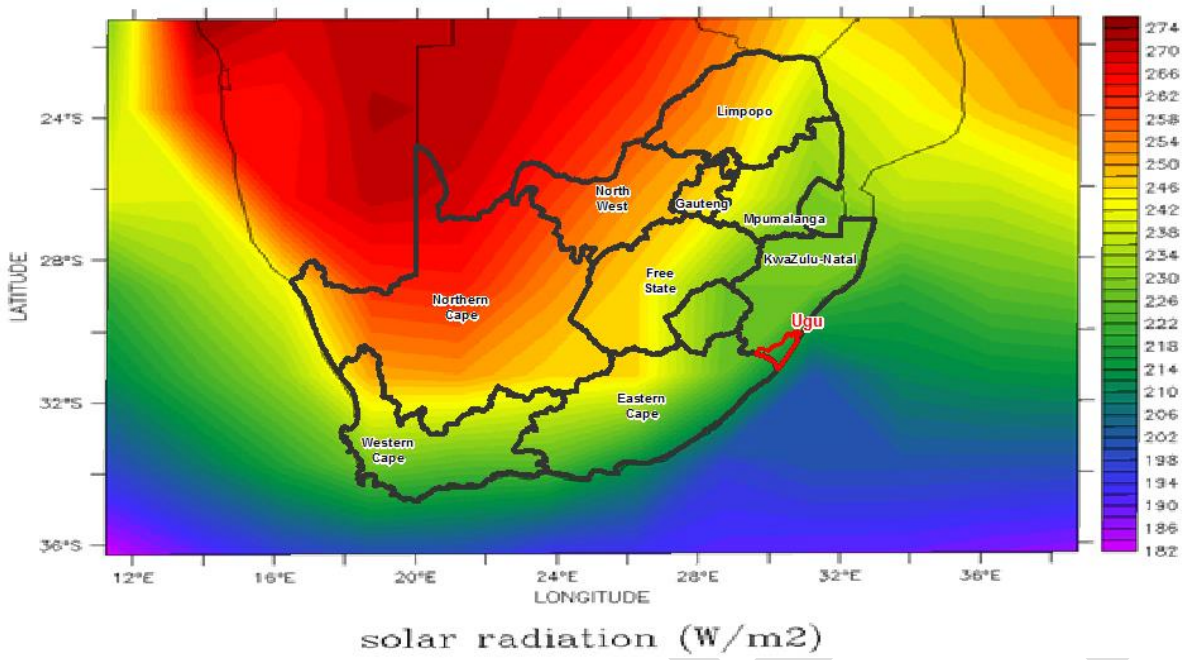


Figure 3: South African solar radiation Climatology (W/m²). Red areas have higher average annual radiation.

Road Transport

The provincial road network provides a high proportion of the road network in Ugu, Networks of local roads constructed and maintained by the six local municipalities exist in urban areas, but funding for the construction of new roads is limited. Local roads within the more urban centres are constructed and maintained by local municipalities. Rural municipalities are heavily reliant on the provincial Department of transport for budget.

Existing road infrastructure is generally poorly maintained. Issues have been identified regarding the poor condition of roads servicing large populations, which may be exacerbated by projected climate changes

Health

About 75 structures exist in the District for primary health care. These structures include mobile clinics, clinics, community health centres, district hospitals, regional hospitals and one specialised TB hospital. There are some communities that do not have access to these primary health care structures.

HIV/Aids and TB is widespread throughout the District with the Hibiscus Coast Local Municipality having the highest number of HIV positive people. The large increase in HIV incidence is a major cause for concern, as not only is there major pressure on existing health facilities and resources, but it has also resulted in an increase in child-headed households, higher dependency levels, increasing levels of vulnerability to external shocks, lower productivity levels, deepening poverty, and a reduction in the potential labour force within the region.

The high rates of disease such as HIV/Aids and TB increase the population's vulnerability to additional stressors such as increased temperatures and occurrence of vector borne diseases such as malaria. It is highly like that projected climate change impacts will place additional pressure on the health status of the district's population and subsequently the region's health services.

2.1.6 General Vulnerability

In the context of uneven resource distribution, variable institutional capacity, compromising environmental systems and the importance of agriculture, tourism and manufacturing to livelihoods and economic stability, the Ugu District Municipality has significant vulnerability to the potential impacts posed by a changing climate. However, the district goals of sustainable and equitable service provision and providing a safe and healthy environment for all provides the platform for mainstreaming adaptive, climate resilient development. Climate resilience should be implemented into day to day institutional operations of basic service delivery as well as when considering long term human settlement planning, urban development, municipal infrastructure, water and energy demand management and local disaster management. Adaptation to the present and likely future impacts of climate change, is a key opportunity to meet the district development goals.

General vulnerabilities identified bases on the initial situational analysis are:

- Changes and impacts to water resources;
- Agricultural sustainability and food security;
- Biodiversity, ecosystems and sensitive natural environments
- Impacts on storm water infrastructure and other infrastructure located in areas of flood potential;
- Impacts on human health due to extreme temperature and prevalence / occurrence of vector borne diseases;
- Impacts on the transportation sector and infrastructure.
- Energy utilisation and potential impacts on electricity infrastructure;

Vulnerability analysis is expanded further in the Municipal Risk Rating on page 51.

2.2 Strategic Climate Change Response

2.2.1 International Level

The latest assessment of climate change risks and vulnerabilities at a global level are contained in the International Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC, 2015). Addressing the climate change problem will require a concerted global effort. Although there are various other role-players, the primary international body dedicated to addressing and coordinating climate change adaptation is the United Nations Framework Convention on Climate Change (UNFCCC).

In addition, areas of international law and practice are currently being applied to address climate change adaptation although the applications are complex and not yet adequately understood.

It is suggested that closer integration and mainstreaming of climate change adaptation into international development is required to achieve greater efficiency in the application of available resources and capacity[11]. To date sufficient coordination and cooperation has been lacking which leads to fragmented implementation of international level climate change adaptation and a disproportionate focus on reduction of greenhouse gases rather than adaptation.

The emphasis, as is evidenced at the recently completed Congress of the People (COP21) in Paris (December 2015), is changing to address the deficient resilience and development planning to which the most vulnerable counties are subject. An initiative called ‘Anticipate, Absorb, Reshape’ seeks to enhance a country’s ability to anticipate hazards, to absorb and cope with the shocks of hazards, and reshape development objectives to reduce and mitigate against climate related risks. The target areas

[11] IPCC. 2014. Summary for Policy Makers. In: Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

of this initiative are low lying coastlines and areas expected to be subjected to significant rainfall changes, particularly droughts and floods. The initiative is mandated to provide tangible results, spearhead applicable research and develop new procedural tools to reduce vulnerability to climate change through the provision of finance, knowledge and operational partnerships.

Other highlights from COP21 include:

- The International Solar Alliance enables developing countries with rich solar resources to better utilize the abundant, free natural resource.
- Least Developed Countries Fund to support climate adaptation in countries that can't afford it.
- Phasing out of subsidies for fossil fuel usages through promoting policy transparency, reform and targeted support for the poorest countries using fossil fuel.
- Multinational think-tank tasked with researching the large scale reduction of greenhouse gas emissions in developing countries.
- Transformative Carbon Asset Facility will assist countries implement carbon cutting initiatives.
- Mission Innovation launched to "dramatically accelerate public and private global clean energy innovation"[12]
- A recommitment to the halting/reversing deforestation and massively increasing forest restoration while promoting equitable rural economic development.

2.2.2 National Level

National systems are integral to a country's capacity to adequately address the challenges pose by climate change. In acknowledgement, the National Government has implemented a variety of climate change related policies, strategies and plans.

The **National Climate Change Response White Paper** acknowledges climate change as one of the country's greatest threats to sustainable development and builds on the legally binding obligations contained in the UNFCCC and Kyoto Protocol as well as to a number of outcomes agreed to at COP15 in Copenhagen in 2009. The Climate Change White Paper outlines the National Government's climate change response visions and outlines the requirements for achieving effective climate change adaption and mitigation in terms of resources, coordination, finance and monitoring requirements which can be used to drive implementation. It mandates local government to develop a climate change response strategy to tangibly implement the national policy of building climate resilience on a local scale. In addition the White Paper has set in motion the development of sectoral climate change adaptation plans with the ultimate goal of integrating climate change adaptation with sustainable development policies.

Legislative motivation for the implementation of climate resilience and no-regret practices into sustainable development initiatives can be derived from the White Paper. Furthermore the White Paper sets the framework from which priority flagship climate change response programmes derive authority. These programmes are discussed in greater detail in the National Climate Change Response White Paper and include:

- The Climate Change Response Public Works Flagship Programme;
- The Renewable Energy Flagship Programme;
- The Energy Efficiency and Energy Demand Management Flagship Programme;

[12] COP21: UN chief launches initiative to build climate resilience of world's most vulnerable countries - http://www.un.org/

- The Transport Flagship Programme;
- The Waste Management Flagship Programme;
- The Carbon Capture and Sequestration Flagship Programme; and
- The Adaptation Research Flagship Programme.

In a development context Climate change is addressed in the National Development Plan (NDP) acknowledging South Africa's vulnerability and identifying climate change response as key to achieving national objectives. From a climate change perspective the NDP emphasizes the implementation of mitigation measures and the need for a greener economy and highlights agriculture as a priority area for focusing adaptation efforts.

Climate change response and sustainable development are interrelated concepts. Accordingly it is important to acknowledge the National Strategy for Sustainable Development and its strategic objectives as local governments begin to formulate their climate change responses.

A set of structures and mechanisms have been set up at national level to assist with coordination on climate change issues:

- The Inter-Ministerial Committee on Climate Change (IMCCC) – Executive level committee to ensure the coordination and alignment of climate change actions with national policies and legislation;
- Forum of South African Directors-General (FOSAD) – responsible for guiding climate change response actions on a cluster basis;
- Intergovernmental Committee on Climate Change (IGCCC) – responsible for facilitating the sharing of information, consultation, agreement, assistance and support among the spheres of government with respect to climate change and government's response to climate change.

2.2.3 Provincial Level

Climate change impacts all spheres of Government highlighting the importance of enhanced coordination and policy alignment. According to the National Climate Change Response Policy the political and technical structures required to facilitate policy and strategy alignment between the spheres of government has been established through the Intergovernmental Relations Act

The KwaZulu-Natal provincial Government realizes that climate change is a complex cross-cutting issue which cannot be addressed by one government department alone. The effective integration of adaptation and mitigation measures require the acknowledgement and prioritization of climate change within many government departments within all spheres of government and across the administration as a whole.

Although current fiscal arrangements do not always allow for or incentivize the mainstreaming of climate change response into local government activities, local government is a critical role-player in achieving climate resilience through the effective execution of their mandated duties. These duties include:

- Human settlement planning;
- Urban development;
- Provision of municipal infrastructure and services;
- Water and energy demand management; and
- Local disaster response.

A Provincial climate change vulnerability assessment was completed in 2009. It provided insights on potential impacts and vulnerable sectors, priority risks, information gaps and existing response measures. The study has been shared with municipalities across the province to inform municipal level climate change response and awareness campaigns.

The Climate Change Response has been included as a strategic goal in the Provincial Growth and Development Strategy (PGDS), acknowledging the potential impact of climate change on economic growth, food security and sustainable resource management[13]. The PGDS indicates a clear provincial commitment towards climate resilience in line with the NDPP 2030. The PGDS specifically mentions the ability of the Mvoti-Mzimkhulu Water Management Area (WMA) to water demand as a motivating factor for an effective climate change response.

Subsequently the KwaZulu-Natal Provincial Department of Economic Development and Tourism developed the KZN Green Economy Strategy (2013). The KZN Green Economy Strategy is supported by an online platform (www.kzngreengrowth.com).

Additional supporting structures relevant to the provincial response to climate change, includes:

- KZN Council for Climate Change and Sustainable Development established in 2012 to coordinate climate change management activities in the province;
- KZN Renewable Energy Working Group;
- Central KwaZulu-Natal Climate Change Compact (CKZNCCC) formed to facilitate information sharing and collaboration on climate change adaptation projects.

The emerging roles and responsibilities of local government in terms of climate change adaptation remains unclear. These roles and responsibilities need to be incorporated into existing applicable policies and legislation, relating to the functions and powers of local government in order to enable a sustainable future climate change response.

2.3 Local Level: Ugu District Municipality

In South Africa, local governments' approach to climate change still exhibits various gaps that are preventing them from being particularly effective or innovative in actively dealing with climate change. In the Ugu District, as is generally the case across the country, the need exists for operative municipal level policies and mechanisms that address the challenges and opportunities posed by climate change. This is only possible if elected and appointed officials reach consensus to treat climate change and required adaption as a top priority.

The Ugu District has expressed commitment to following initiatives in support of Climate Change Response:

- Air pollution monitoring;
- Air Quality Management plan;
- Air Quality Management bylaws;
- Community based greening initiatives;
- Invasive Alien Species Forum;
- Education and awareness campaigns – schools and communities;
- Implementation of the Environmental Management Framework;
- Municipal environmental policy that promotes Green offices and green procurement;
- Provincial Climate Change Vulnerability Assessment;
- National Climate Change Response Policy.

It should be noted that although to date the Ugu DM has taken positive steps working towards achieving initiatives climate change remains a secondary priority, competing with other short term critical issues. Intent to prioritise climate change adaptation is further hindered by insufficient acknowledgement of the reality of climate change by relevant stakeholders.

[13] KwaZulu-Natal Provincial Planning Commission. 2011. Provincial Growth and Development Strategy.

The majority of the climate change related initiatives and actions in the Ugu DM has been implemented under the guise of Air Quality and Biodiversity Management and in moving towards a *green economy*, rather than being explicitly linked to climate change and climate change response.

Based on the current status quo climate change response actions remains largely reactionary or response driven and uncoordinated within the Ugu DM and local municipalities.

Apart from the Ugu DM's responsibilities in terms of Climate Change Response, community level responses will also play an important in the District's approach to climate change. Across the district there is already evidence that people are developing adaptation strategies to water stress and lack of resources, especially in the agricultural sectors. This is encouraging as the agricultural sector, on commercial and subsistence level, is of critical importance to the Ugu DM. While adaptation strategies such as traditional seed banks and cultivation of traditionally drought resistant crops are being observed, a large number of farmers are still not fully comprehending the potential impacts of climate change, how this is impacting the climate baseline from which the season weather acts and not taking appropriate action before, during or after experiencing the particular anomalous events associated with climate change. Examples of this would be the observed shift in rainfall seasonality (onset and cessation) and the reluctance of farmers to utilise and adapt planting timing and/or variety to seasonal forecasts.

2.4 Policy Context

The legislative provision for promoting adaptive sustainable climate change strategies is enshrined in the Constitution of the Republic of South Africa (1996) from which all other legislation in the country is derived. Section 24 (a), guarantees everyone an environment that is not harmful to his or her health or well-being. The subsequent clause advocates for sustainable development in which social and economic development is pursued for the present generation without compromising opportunities for future generation. Furthermore, Section 152 (1) (d) implores local government authorities to promote a safe and healthy environment (Constitution of the Republic of South Africa 1996).

The National Environmental Management Act (Act No. 107 of 1998) is another important piece of supportive legislation and addressing climate change, recognising the "sustainable development requires the interrogation of social, economic and environmental factors in planning, implementation and evaluation of decisions to ensure that development serves present and future generations".

The primary policy document distinctly relating to climate change is the National Climate Change Response White Paper (2011) which has been aligned to the above mentioned legislation as well notable as international conventions including UNFCC.

The National Development Plan also endorses climate change response as imperative to strengthening the nations' resilience and requires local, provincial and national governments to embrace climate adaptation by identifying and putting into effect appropriate policies and measures (NDP 2011: 180).

The Disaster Management Amendment Act No. 16 of 2015 mandates all levels of government prepare a disaster management plan which among other requirements stipulates the assessment of expected climate changes, impacts and risks. Furthermore measures and indications of how local government will invest in disaster risk reduction and climate change adaptation, including ecosystem and community-based adaptation approaches

A number of relevant strategies, plans and frameworks from various levels of government have been considered in the development of the Ugu District Climate Change Response Strategy. The most relevant of these have been listed below.

International

- UNFCC;
- Kyoto Protocol;
- International Carbon Action Partnership; and the
- Sustainable Development Goals;

- Sendai Framework
- Durban Charter.

South African

- Constitution of the Republic of South Africa (Act 108 of 1996);
- The National Climate Change Response Policy (2011);

- Regulations for the establishment of a Designated National Authority for the Clean Development Mechanism (2005)
- Carbon Emissions Motor Vehicles tax (2010)
  - Disaster Management Act (Act 57 of 2002);
  - National Water Act (Act 36 of 1998);
  - The National Development Plan 2030 (2012);
  - National Environmental Management: Air Quality Act (Act 39 of 2004);
- National Environmental Management: Air Quality Act (39/2004): List of activities which result in emissions which have or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage (2010)
- National Environmental Management: Air Quality Act (39/2004): Atmospheric Emission License Regulations (2010)
  - The National Strategy for Sustainable Development and Action Plan (NSSD1) (2011 – 2014);
  - South Africa National Carbon Sink Assessment (2015);
- Integrated Coastal Management Act (2008);
  - Conservation of Agricultural Resources Act, 1983;
  - National Forests Act, 1998;
  - National Environmental Management: Protected Areas Act, 2003;
  - National Environmental Management: Air Quality Act, 2004;
  - National Environmental Management: Biodiversity Act, 2004;
  - Strategic Plan for Smallholder Producers;
  - The Strategic Plan for South African Agriculture;
  - Strategic Plan 2012/13-2016/17 for the Dept. of Agriculture, Forestry and Fisheries;
  - Integrated Growth and Development Plan: Agriculture, Forestry and Fisheries;
  - Integrated Resource Plan;
  - Industrial Policy Action Plan: 2012/2013 - 2014/15;
  - Dept. of Rural Dev. and Land Reform, Strategic Plan 2011-2014 (amended 2013);
  - Spatial Planning and Land Use Management Act

KwaZulu Natal Province

- Provincial Climate Change Vulnerability Assessment
- KZN Provincial Growth and Development Stagey
- KZN Green Economy Strategy;
- Durban Adaptation Charter;

- Department of Agriculture and Rural Development, Strategic Plan 2015-2022

Ugu District

- Integrated Development Plan;
- Ugu District Growth and Development Strategy;
- Air Quality Management Plan;
- Environmental Management Framework and Plan;
- Coastal Management Programme;
- Disaster Management Plan;
- Spatial Development Framework; and
- Ugu Water Master Plan (currently being developed)

2.5 Institutional Capacity

A municipal climate change response has been identified in the national policy for inclusion into IDP planning[14]. Accordingly the council will have to endorse the integration of climate change into the IDP process. The IDP office has to mandate a suitable line department to drive climate change considerations during the drafting of the IDP. On a district level this responsibility has been assigned to the Environmental and Health management Portfolio.

According to national policy, the department tasked with driving climate change, will be responsible for the following;

- Appointing a 'champion' official to drive the climate change planning process;
- Gathering necessary information and liaising with other departments and institutions where necessary;
- Liaising with the IDP Office on integration of the process into IDP review timeframes;
- Participation on the IDP drafting team; and
- Establishing a steering committee from a cross sector of relevant departments to address the issues or participate in an existing committee that addresses similar issues.

2.5.1 Ugu District

District municipalities administer and make rules for a district, sharing the responsibility for local government with local municipalities in their area to facilitate equal access to resources and services, with specific reference to disadvantaged communities. The district municipality provides support to local municipalities who don't have the capacity to provide services to their communities.

Some of the functions and powers of district municipalities include:

- To plan for the development for the district municipality as a whole;
- Bulk supply of water that affects a large proportion of the municipalities in the district;
- Bulk supply of electricity that affects a large proportion of the municipalities in the district;
- Bulk sewerage purification works and main sewerage disposal;
- Waste disposal sites for the whole district municipal area;
- Municipal roads for the whole district municipal area;
- Regulating passenger transport services;

[14] Republic of South Africa. 2011. National Climate Change Response White Paper.

- Municipal health services for the whole area;
- Firefighting services for the whole area;
- Control of fresh produce markets;
- Promoting local tourism for the whole area; and
- Municipal public works.

District councils have a primary role in assisting local authorities through providing policy guidance, information and hazard assessment data. All of these functions and powers can be affected by or linked to climate change. However, the lack of clearly defined roles and responsibilities, a lack of capacity and resources, and a general lack of awareness have resulted in inadequate climate change management objectives and priority actions. As such, current climate change response management actions remains reactionary or response driven, and often uncoordinated within the Ugu District and local municipalities. Many of the local municipalities feel the responsibility should lie with the District assisted by a number of provincial and national organs of state.

2.5.2 Local Municipalities

Although some efforts have been made, the local municipalities of the Ugu District as a whole do not have clear co-ordinated objectives with regards to climate change response management. This can be attributed to the lack of climate change awareness within current institutional structures and the subsequent failure to acknowledge climate change response as a top priority.

Even though their functions and powers will certainly influence or be affected by climate change, climate change is not currently considered as a core function and none of the local municipalities have allocated funding specifically for climate change response. The majority of the local municipalities simply do not currently possess the institutional or financial resources to manage climate change issues effectively either separate of other functions or as part of their existing functions. This is illustrated by the fact that none of the local municipalities have an official climate change champion with clearly defined roles and responsibilities who is endorsed by the IDP office.

Subsequently, local municipalities will rely heavily on input from the Ugu District and provincial structures, to assist them in improving their resilience. From this reliance, the Ugu District has the opportunity to direct the climate change response and adaptation in a co-ordinated and priority centric manner in response to high vulnerability and coping capacity deficiency.

Table 1 Current Institutional Capacity for Climate Change Response

Municipality	Dedicated Environmental Officer	IDP Office endorsed Climate Change Champion	Unofficial Climate Change Champion	Climate Change Response included as component of IDP	Municipal Policy addressing climate change
Ugu District	Yes	No	Yes	Yes (limited)	No
Hibiscus Coast	Yes	No	No	No	No
Umzumbe	Yes	No		No	No
uMuziwabantu	In Progress	No		No	No
Vulamehlo	No	No		No	No
uMdoni	Yes	No		No	No
Ezinqoleni	No	No		No	No

Where needed, local municipalities may formally request assistance from the Ugu District for climate change response management. If the Ugu District is unable to provide such assistance it may in turn request the assistance of the relevant provincial or national departments.

2.6 Potential Stakeholders

Climate change is everybody's business and Ugu District climate resilience can only be achieved through active participation of all relevant stakeholders. It is anticipated that many climate change response projects will be executed on a partnership level and in such cases the Ugu District and local municipalities should be in a position to harness private, public and academic sector networks in addressing climate change.

Stakeholder engagement seeks to create a broad platform for encouraging partnerships and constructive dialogue and action between stakeholders during the decision making process, policy development and/or implementation.

Public Sector

Local government will rely on National and Provincial Government for support in addressing climate change. Climate change is a cross-cutting risk that will impact on the operations of all governmental departments and the entire administrative system, including parastatal entities. Effective vertical and horizontal coordination will be required to ensure climate change response is aligned with national policy and implemented effectively. Improved institutional capacity will play an important role in ensuring policy formulation adequately addresses climate change response. Existing skills must be consolidated and buy-in from different departments and spheres of government facilitated. This can be achieved by addressing climate change in a way that focusses on sustainable and effective service delivery. The development and emphasis of green buildings and providing for climate resilience in public sector infrastructure projects sets the example and places the public sector as a leading climate adaptation role model.

Private Sector

As contributors to carbon emissions but also to private sector funding and climate change response actions, business and industry are important stakeholders in building climate resilience. Partnerships between local government and the private sector will be critical for the Ugu District transition towards climate resilience. Furthermore, as the private sector has a vested interested in development and industry, it is exposed to the risks associated with climate changes, i.e. agricultural sector, droughts, flooding, health, etc. For instance, failure to adapt and plan in the insurance sector will render significant financial losses for the industry. It is therefore in the best interests of private sector businesses to champion climate mitigation and adaptation implementation in adherence to the climate change response strategy.

Civil Society

Civil Society has the important responsibility to critically evaluate public and private sector initiatives in their effectiveness to meet climate resilience criteria. Civil society along with local government should continue to raise awareness and hold individuals, institutions and authorities accountable for climate change mitigation and adaptation or the lack thereof. Civil society can also act independently on smaller scales to increase climate resilience through sustainable no-regret projects, rather than relying on government or institutional intervention. Examples include implementation of crop rotation and intercropping, domestic greywater re-use, small scale afforestation or sustainable fishing practices. Any implemented actions should align with the climate change response strategy objectives.

Academic Institutions

Academic institutions are in a position to increase community resilience by providing the science and research necessary to inform public policy. Establishing partnerships with local academic institutions, to allow for the generation of locally relevant climate change information, will contribute to improve the Ugu District's capacity to address climate change.

2.7 Mainstreaming aspects

The Ugu District and its local municipalities have a crucial role to play in facilitating climate resilience through the performance of mandated responsibilities. These include human settlement planning, urban development, provision of municipal infrastructure and basic services, water and energy demand management and local disaster management.

Mainstreaming of climate change response implies that local government adopt, expand and enhance the climate risk measures into their normal planning processes and existing everyday activities and functions[15]. Adaptation to climate change will require standalone policies and integration into development planning tools such as IDPs. A review of current legislation and policy should assist in defining climate change related roles and responsibilities to assist with the process of mainstreaming climate change response.

[15] IPCC. 2014. Summary for Policy Makers. In: Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

3 Climate Analysis

3.1 Background

Climate is the overarching generalised long term set of atmospheric, ocean and land cover conditions that provide the bounding context for the occurrence and likelihood of meteorological events experienced within a localised area. As such, when considering the likely climate changes first and foremost at a local scale will prove ineffectual. The approach that should be undertaken is the assessment of the general large scale climate change as the anomaly baseline. From this large scale anomaly climate, assessment should then account for the factors influencing local weather variability such as topography, landuse, synoptic influences and ocean currents, and how the large scale change may be manifest on a more specific footprint scale. The data used for the analysis of the climate parameters such as heat waves or changed precipitation profiles is downscaled from the IPCC AR5 models to an approximately 45km x 45km grid while additional spatial resolution is garnered from the SimClim data which takes into account the locally influencing climatic factors to a scale of 5km x 5km.

Adaptive response must be undertaken in accordance with the projected changing climate parameters. This chapter presents an overview of the meteorological climate changes that are likely to occur over Ugu DM over the next four decades. The modelling is done with the aim of informing the decision-making processes.

The scale of the future climate impacts will vary based on the anthropogenic mitigation of factors responsible for currently experienced changes. The mitigation scenarios account for several variances of potential global economic and environmental development and are quantified as the Representative Concentration Pathways (RCP). The four RCP scenarios depicted in Table 2 are estimated concentrations of CO_2, CH_4 and N_2O based on a combination of assessment models, global carbon cycle, and atmospheric chemistry and climate models. They also integrate assumed land use changes and sector-based emissions of greenhouse gasses from present day levels.

Table 2 Representative Concentration Pathways

	CO2 (ppm)	CH4 and N2O (ppm)	Resulting radiative forcing (W.m-2)	Scenario
RCP 2.6	421	54	2.6	Best case
RCP 4.5	538	92	4.5	Best case - Medium scenario
RCP 6.0	670	130	6.0	Worst case - Medium scenario
RCP 8.5	936	377	8.5	Worst case

These RCPs were used as input for the coupled model ensembles of the IPCC Assessment Report Five [16](AR5).These RCPs show the change from pre-industrial insolation watts per m² resulting from the emissions. RCP 2.6 represents the mitigation scenario leading to a very low forcing level – best case – emissions stabilise from 2010 – 2020 and decrease thereafter (best case scenario with global focus on the environmentally sustainable practices). RCP 4.5 – likely best case – emissions stabilise

[16] IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

from 2040 and decrease thereafter. RCP 6.0 – likely worst case – emission stabilise from 2080 and decrease thereafter. RCP 8.5 represents the very high greenhouse gas emission scenario – emissions don't stabilise, worst case scenario with a focus on economic advancement at the expense of environmental sustainability. These emission scenarios give light to the varying potential climatic futures based on human development goals in the present and near future.

Using climate projection data requires the acknowledgement of various uncertainties. The IPCC projections rely on forty different GCMs with different accuracies forecasting to the varying RCP scenarios. These RCPs are themselves estimates of potential future thermal forcings as informed by adherence to emission policies and potential future technologies. The downscaling of the IPCC data required robust constraining parameters to present a more accurate local projection. In areas where observational data is limited, these constraining parameters have increased uncertainty. Results obtained and recommendations made based on these data should be used as a guideline to adapt/mitigate to a potential future climate rather than a definitive one.

Statistical probability analysis of the climate data is undertaken on the variables of maximum temperature, minimum temperature, precipitation, and surface humidity among others. The observational data sets used include;

- Climate Research Unit - CRU TS v3.23 at 0.5°x0.5° spatial resolution and monthly temporal resolution from the year 1901 to 2014.
- National Oceanic and Atmospheric Administration - National Centers for Environmental Prediction – NOAA NCEP CPC 0.5°x0.5° spatial resolution and monthly temporal resolution from the year 1960 to 2016.
- National Oceanic and Atmospheric Administration - National Centers for Environmental Prediction – NOAA NCEP CPC African Rainfall Climatology, satellite based observations at 0.1°x0.1° spatial resolution and daily temporal resolution from the year 1983 to 2016.
- SimClim IPCC historical downscaled data 5x5km spatial resolution monthly temporal resolution from the year 1995 to 2015.
- Swedish Meteorological and Hydrological Institute – SMHI Cordex CMIP5 historical experiments at 0.5°x0.5° spatial resolution and daily temporal resolution from the year 1951 to 2005

The projected datasets used include**;**

- SimClim IPCC AR5 downscaled data 5x5km spatial resolution monthly temporal resolution from the year 2015 to 2100.
- Swedish Meteorological and Hydrological Institute – SMHI Cordex CMIP5 IPCC AR5 projected experiments at 0.5°x0.5° spatial resolution and daily temporal resolution from the year 2006 to 2100 for the 9 IPCC climate models used in AR5.

3.1.1 Climate change in the South African context

Climate change in South Africa shows projected rainfall variations (Figure 4 (i)) with a distinct gradient of increasing to decreasing precipitation going east to west over the country. The increase in precipitation over Kwa-Zulu Natal and the north eastern parts of the Eastern Cape is caused partially by the enhanced evaporation from the warm Agulhas current and orographic influence of the Drakensberg mountain range. The areas of Northern Cape and Western Cape will experience less rainfall. There is a marked increase in both day and night time temperatures (Figure 4 (ii) & (iii)) with the most major change toward the inland regions of the country. Temperature increases are still present in areas closer to the coast but are reduced by the mitigating influence of the large bodies of water.

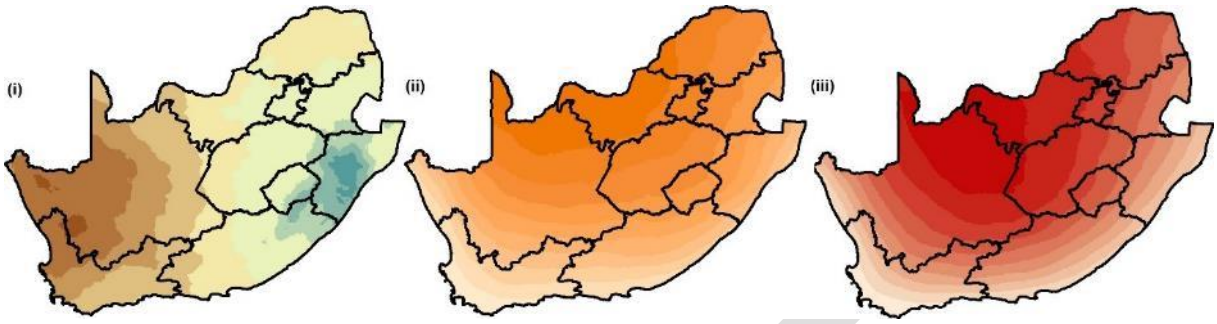


Figure 4: Spatial anomaly pattern. RCP4.5 2050 anomaly from climate baseline. (i) precipitation; more rain(blue), less rain (brown), (ii) night temperature; darker orange (warmer), (iii) day temperature; darker red (warmer)

These large scale changes will have dramatic influences on varying meteorological parameters. It is projected that there will be an increase in the number of days exhibiting extreme day time temperatures; as well as the number and duration of heat wave events. Furthermore, a greater number of warm nights will increase general discomfort, reduce overnight frost and morning dew.

The rainfall parameters are more complex but there is general agreement that areas where either increasing or decreasing rainfall volumes are expected, rainfall will be focused into a shorter timeframe. Some areas are exhibiting a shifting in the rainfall onset and cession timing. The rain season is decreasing in length; in the frontal areas of the western and southern areas of the country, winter rainfall is compressed and the dry summer is extended; to the east and north, the convective rainfall is clustered into fewer summer months and the shoulder seasons of autumn and spring exhibit more summer like temperatures and reduced rainfall. While it is generally expected that there will be a decrease in the number of rainfall days each year, it's highly likely that there will be an increase in precipitation intensity and the occurrence of more extreme events when it does rain. This is particularly true in the summer convective rainfall areas. There will also be an increase in dry spell duration between rainfall events.

3.2 Ugu District Municipality climate analysis

Climate status:

The climate of Ugu DM can be categorised into three distinct climate zones (Figure 5). These are coastal, inland north and inland south.

- The coastal climatology is influenced largely by the proximity to the warm Agulhas Ocean current. The thermal heat retentive capacity of the ocean reduces the diurnal temperature range and thus results in more mild temperatures along the coastal areas (Figure 8). The warm ocean current along the eastern coast provides water that is more predisposed to evaporation. Coastal areas therefore experience high humidity and significantly more precipitation (Figure 7) than inland and west coast areas.
- The inland climate zones do not receive the mitigation effect of proximity to the ocean and therefore have a larger diurnal temperature range. This is particularly noted in the northern inland areas which as the highest annual average daytime temperature. The inland southern areas partly cover higher altitude areas and will therefore have a reduced annual average temperature (Figure 8) with increased altitude inland. The precipitation profile is very similar between the inland northern and southern areas and both exhibit reduced precipitation from that which is noted toward the coast (Figure 7).

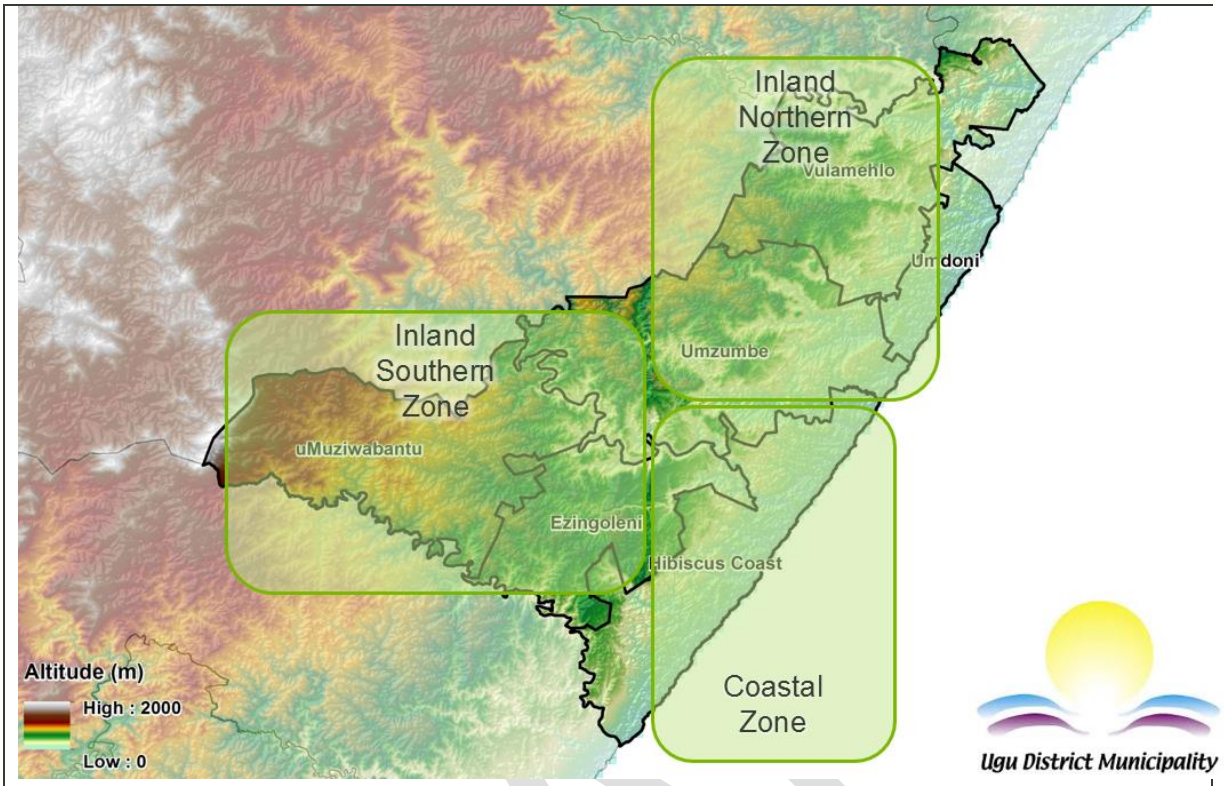


Figure 5: Three distinct climatic zones, Coastal, Inland north and Inland South

Climate changes influences:

The climate system is a balance of varying thermal, pressure and moisture characteristics of the atmosphere and ocean. Insolation (incoming solar radiation) travels through the atmosphere, largely unobstructed and warms the earth and ocean surface. The heat is re-radiated upwards in the form of long wave terrestrial radiation to the atmosphere. Fossil fuel emission increases through development from pre-industrial levels have resulted in increased levels of greenhouse gasses resident in the atmosphere. The fossil fuel emissions trapped in the atmosphere strongly absorb the longer infrared wave lengths of terrestrial radiation, particularly CO2, N2O and water vapour. The absorbed heat is re-emitted in all directions, including back down to earth, where it is re-absorbed by the earth surface and re-emitted again, therefore keeping the heat in the system. These gases are found naturally in the atmosphere and make our planet warm enough for us to survive, however the additional CO2 and N2O have increased at a rate beyond what the atmosphere and the carbon system can recycle, such that what has been emitted has increased the heat adsorption of the atmosphere.

Temperature differentials and balancing of the thermodynamic gradient in the atmosphere are the driving forces behind global short term weather as well as long term climate. Therefore the change noted already in the baseline temperature will have dramatic effects in all aspects of the meteorological system. The temperature change alters the global pressure systems which in turn impacts air circulation, winds, atmospheric moisture, ocean currents and rainfall distributions. As this is an open system not limited by country boundaries, the non-polluter suffers with (sometimes more than) the polluter. Simply put, this is causing the increase in temperatures globally and the changes to the short term meteorology and the subsequent climate base lines. The changes experienced are not uniform in space and time. There is both spatial and temporal variation in the impacts associated with climate change.

Basin assessment:

Precipitation and water availability is paramount to the communities, agricultural areas and natural vegetation within Ugu. Catchments however do not follow administrative boundaries and therefore a cursory assessment of the river basin the feeds the rivers going through Ugu is needed.

The upper catchment to the north west of the Mvoti to Umzimkulu basin contributes significant volume of Ugu's rivers. There many dams located in this area due to heightened rainfall volume and high relief. Closer to the coast there is also significant rainfall and a few dams are also present in these areas however this contribution doesn't extend along the full catchment. The anomalous RCP4.5 precipitation scenario depicts an increase in the annual average volume of approximately 1% (Figure 6). The projected years of 2050 and 2060 show a very similar spatial distribution. This increase will aid in feeding the rivers in the basin. It should however be noted that the projected rainfall events will likely be of shorter duration and more intense events and therefore peak discharges in the lower courses of the river will likely increase. It will also place additional pressure on dam infrastructure by quickly reaching or exceeding capacity and then a discharge may be required. There will however be a long duration between rainfall events and therefore water stress is likely to remain.

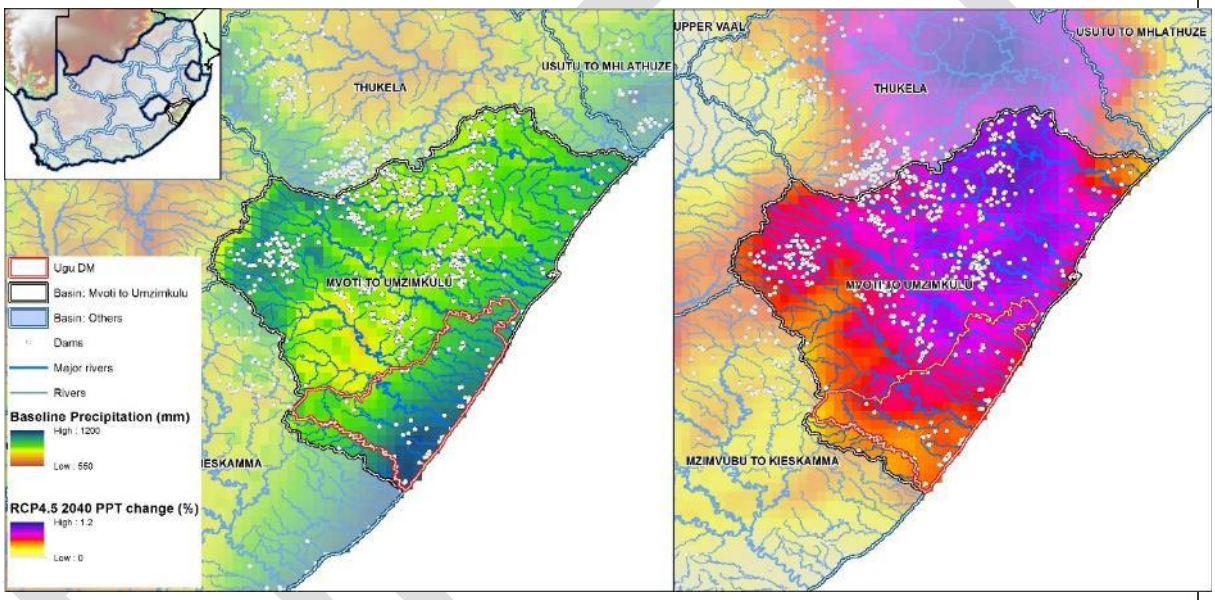


Figure 6: Mvoti to Umzimkulu Basin. Observer Precipitation left, RCP4.5 2040 anomolus precipitation (%)

Increasing annual rainfall

The majority of Ugu's precipitation occurs along the coast and to the south, with slightly less seen inland (Figure 7 - left). There is also significant variability in the same month between years, particularly in late summer (Figure 7 - left). Climate change under RCP4.5 shows a very slight increase (<1%) in annual average precipitation over Ugu (and along the eastern side of South Africa) with the majority of change noted to the north east of the district (Figure 8 - left). The monthly variability depicted by the monthly envelope (Figure 8 - right) shows the range of one standard deviation from the mean monthly rainfall. The anomaly bars show the change from mean in mm per month for the decades 2020's, 2030's, 2040's and 2050's. Increased precipitation volumes are seen in late spring and early summer, while decreased values are shown in the mid to late summer months. The anomaly is suggesting an overall average potential shift in the rainfall regime to occur earlier in the year than has been observed previously impacting agricultural seasons. This change will likely find a new equilibrium and stabilise with a flattening of the peak precipitation to encompass the earlier months.

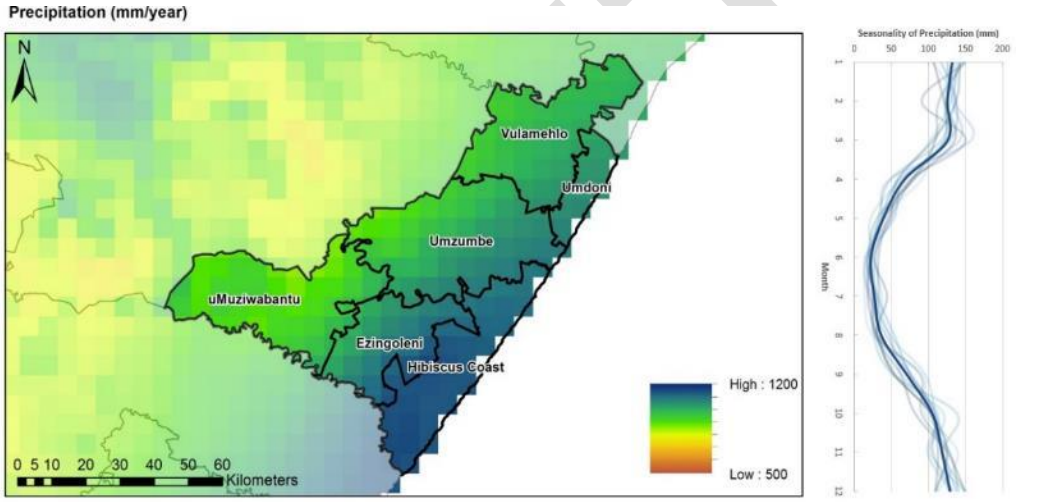


Figure 7: Observed precipitation and monthly variability over Ugu DM

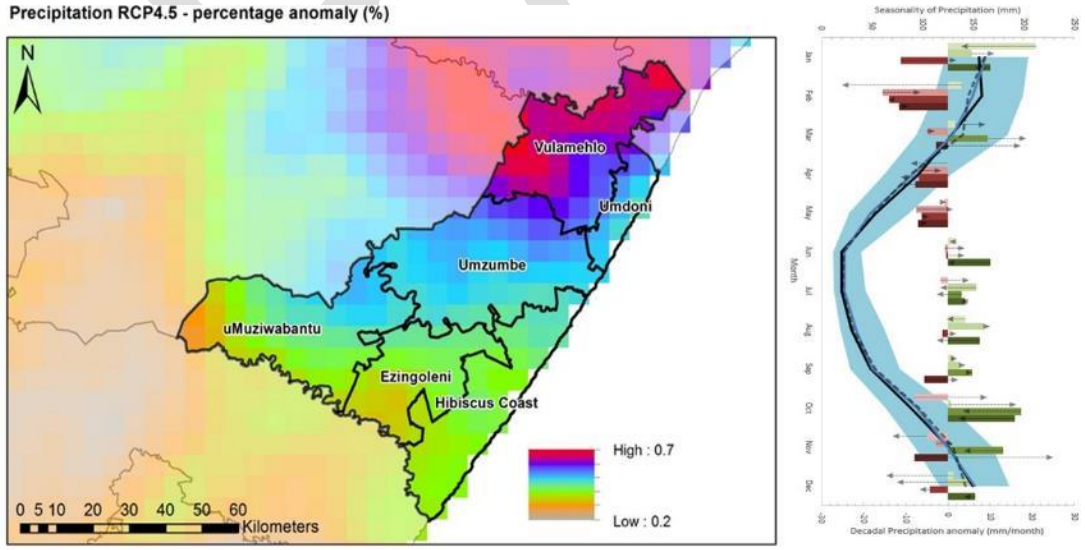


Figure 8: RCP4.5 Projected and anomalous future precipitation over Ugu DM

Increased summer rainfall intensity

The number of rainfall days (>0.2mm/day) is remaining mostly consistent across the three climate zones with the peak during the summer months of December, January, February (DFJ), followed by the spring months of September October November (SON), Autumn; March, April, May (MAM) and lastly winter; June, July, August (JJA) with the fewest rainfall days (Figure 9– top). The projected likely number of days (both lower likely and upper likely), which correlates to the 40th to 60th percentiles, matches well with the past number of rainfall days.

Assessing the more extreme rainfall days (>35mm/day) however shows an increase in the likely occurrence of these higher magnitude days during summer along the coastal areas (Figure 9– bottom). The other areas place the likely range within the past observed number of extreme events range (see Appendix - Figure 39). Though however extreme events are most likely to occur within this "likely range" over different years, it is possible that there can be a number both above and below this range and vary between years.

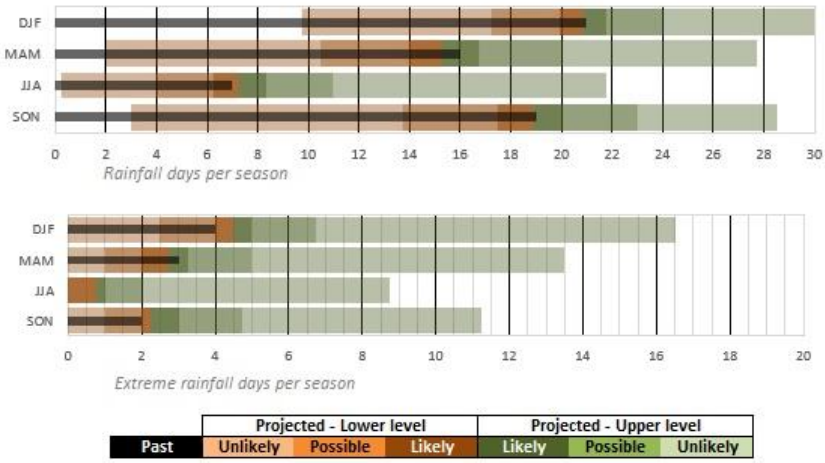


Figure 9: Number of rain days (top set) and extreme rainfall days (bottom set) per season for Coastal area

The precipitation profile) depicts the occurrence frequency of different magnitude rainfall events. The coastal area (Figure 10 – top) has the highest likelihood of larger magnitude events over all seasons. The summer and autumn months in each area show a similar profile to each other, although summer months show a shift towards more likely higher threshold events in the future than was previously observed (see Appendix - Figure 40 – top set). The remaining rainfall thresholds in the seasonal profile are also increased. The autumn months don't show as clear a trend over all the stations. Winter and spring months appear to have a dampened profile in the future

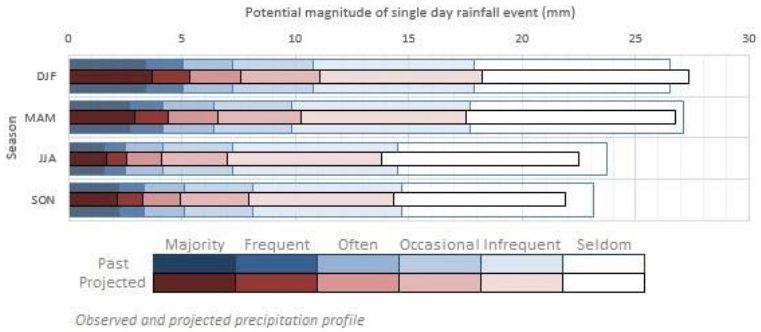


Figure 10: Past and projected Rainfall Profile of the Coastal areas

Increasing rainfall variability

The precipitation climate graph (Figure 11) in the future is shown to take the same general shape in the future as that which was observed in the past climate, however there are monthly departures from the mean climatology indicating a potential variability range in future decades. These anomalies vary significantly in each area and hardly present a unified direction of change over subsequent decades in the same month when looking at each climate zones' precipitation climate graph (see Appendix - Figure 40 – bottom set).

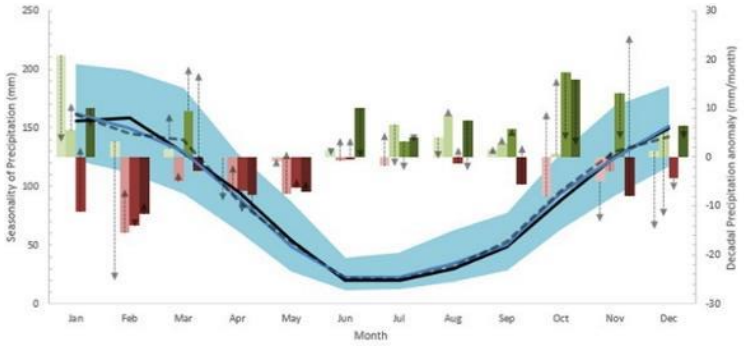
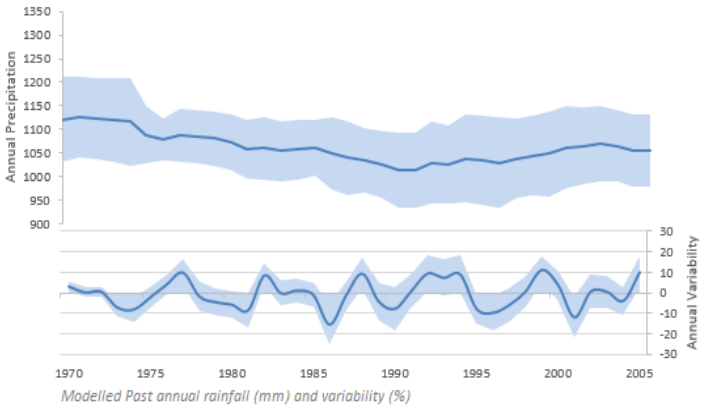


Figure 11: RCP4.5 projected monthly anomaly from monthly mean per decade 2020, 2030, 2040, 2050 (bottom set : green and red bars, black arrows represent RCP8.5) for Ugu DM

Assessing the time series of precipitation from the three climate zones shows variation over time in the annual precipitation volumes over the observed period (Figure 12 – top set) and projected future (Figure 12– bottom set). The standard deviation presents the range of possible annual precipitation volumes that could be considered within a normal range. The annual variability is shown for each climate zone for past and future volumes (see Appendix - Figure 37), represents the potential change between consecutive years from a 5 year rolling mean volume. For example in the past coastal data there is a variability of -13% in 1986 and +9% in 1988 (Figure 12– top set). This is a turnaround of 22% in total yearly precipitation over just 2 years. Slightly smaller ranges are noted in the inlands past variabilities. While there is no significant change in the projected future variabilities, there are more direction changes between positive and negative shifts from the annual mean in a shorter time. The variability direction shift is increasing meaning greater disparity in annual precipitation over a shorter time frame.



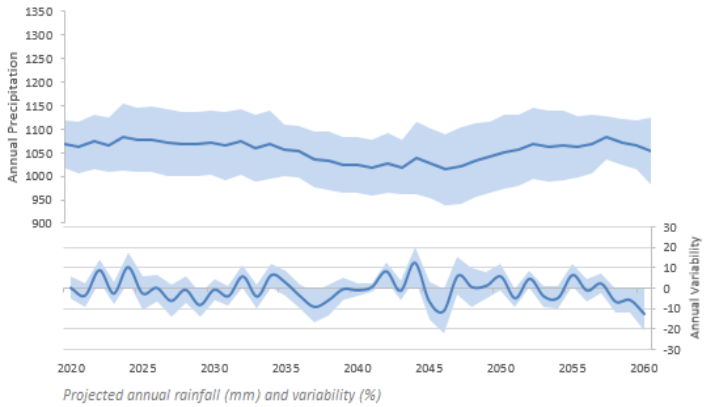


Figure 12: Annual average precipitation volumes and yearly variability potential for Coastal area, Modelled past (top set), RCP4.5 Projected future (bottom set)

The variability is a measure in mm away from climate mean each month simulates in the past and for the future climate under RCP4.5 (Figure 13). The greater the distance from the radial centre, the more variability from mean. The highest variability is focused in the late summer months of February and March for each of the climate zones. The coastal zone shows the most variability of all the zones followed by inland north and inland South with the least variability (see Appendix - Figure 38). The variability is higher in the projected future data for each of the climate zones; all with a focus of variability in the late summer months. The greater variability in the future is due in part to a warmer atmosphere under climate change conditions, being able to retain an increased moisture volume and needing greater cooling before condensation (and precipitation) occurs. This is also why there is a greater dry spell duration and more intense, shorter rainfall events.

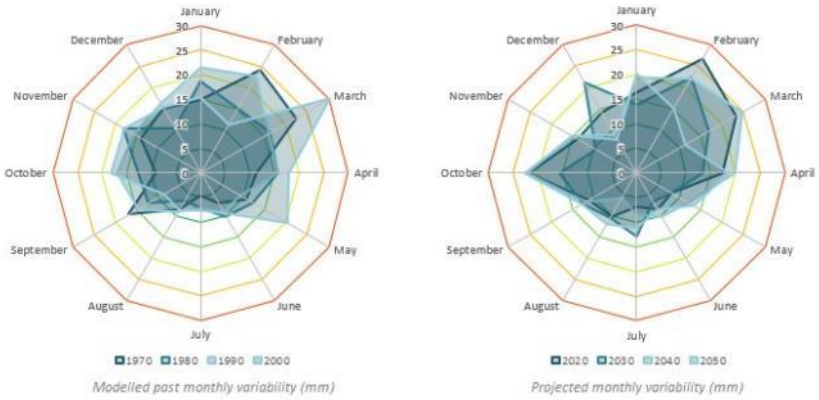


Figure 13: Monthly variability potential (mm volume) for Coastal areas, Modelled past (left), RCP4.5 Projected future (right)

Drought potential

Figure 14 shows the yearly total (top pf each set) and seasonal (bottom of each set) percent departure from past results. Again it is shows the low likely (dark brown) and high likely (dark green) ranges as well as possible and unlikely but still possible ranges. In a drought year the total precipitation is -33% or less than the climatological mean. Where the low likely and high likely ranges (darker shades) are below the 0% (past average), this will indicate an enhanced drought potential. One such incidence is the lower values for the likely range noted in the 2030's (in all areas) which expresses that the potential for drought is higher. The lighter "possible range" variability can occur without being a climatological anomaly. Therefore future planning should certainly account for the depicted possible range which is approximately -20%.

What can be noted further is the seasonal discrepancies (bottom of each set) which shows a mild increase in likelihood over the past for DJF; there is also a likelihood that below observed volumes will be present in MAM and SON impacting the shoulder seasons. The reduced rainfall in JJA months biases the change from mean to show large disparity in potential volumes.

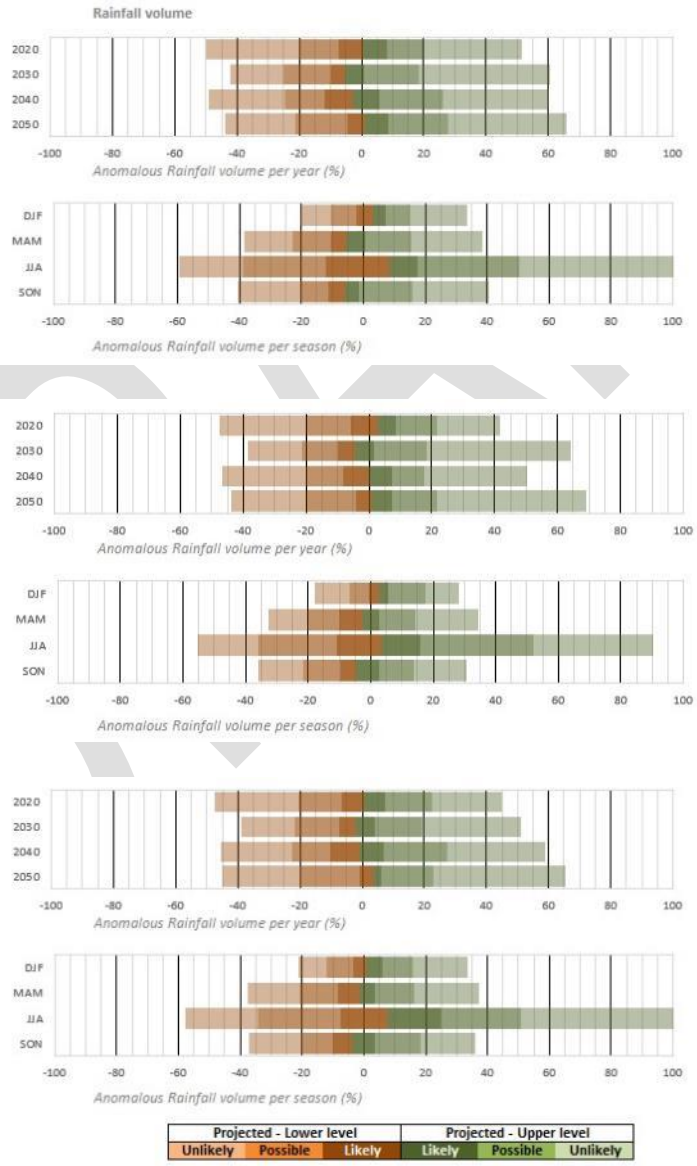


Figure 14: Potential future decadal (top of each set) and seasonal (bottom of each set) anomaly for each climate zone, Coastal (top two panels), Inland South (centre two panels) and Inland North (bottom two panels)

Spatial temperature increases

The spatial average temperature profile for Ugu DM (Figure 15 - left) shows increased temperatures to the north (Vulamehlo, Umdoni) and inland areas (Umzumbe) of the DM. The higher elevation areas show a decreased average annual temperature, while the southern inland and coastal areas show more mild temperatures (Ezingoleni, Hibiscus Coast). There is some variability in yearly temperature profiles (Figure 15 - right) however the profile remains mostly consistent and has minimal monthly variation from the mean.

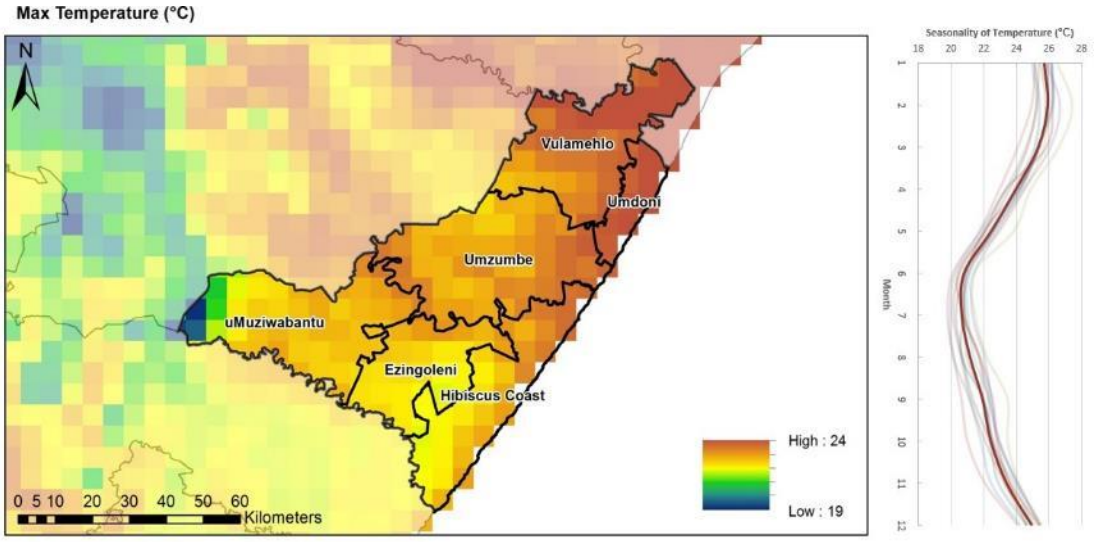


Figure 15: Observed day time temperatures over Ugu DM

The projected temperature anomaly show a uniform temperature change cross -section from the coastal to further inland areas (Figure 16 - left). The coastal areas exhibit the smallest temperature increase (+0.7°C) due to the ocean mitigation effects. While further inland there is a larger anomaly from the present day mean temperatures (+0.8°C). This profile is at the year 2030 under the RCP4.5 scenario. Years projected further into the future and under RCPs 6.0 and 8.5 will show significantly higher anomalies. The projected monthly profile (Figure 16 - left) shows the monthly temperature profile increased under RCP4.5 and RCP8.5 as well as the decadal increases in the monthly anomalies.

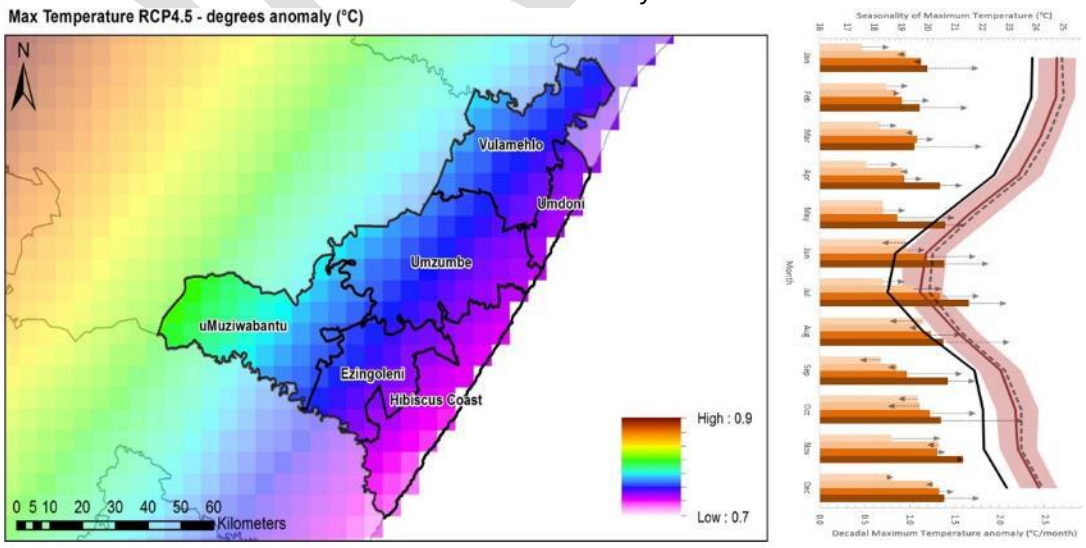


Figure 16: Projected (RCP4.5 - 2030) temperature spatial anomaly (left), monthly temperature profile black line (past), red line (projected RCP4.5), dashed line (projected RCP8.5), decadal anomaly bars for 2020's, 2030's, 2040's, 2050's for RCP4.5, arrows (RCP8.5)

Increase of temperature profile for day and night time

The general increase in average temperatures will change the probability occurrence of all temperature thresholds. The highest frequency events has shifted from 22°C in the 1960's to present day and is projected to be over 23°C by 2050 (Figure 17 - right) in the Inland north area. Other areas follow similar progression over time.

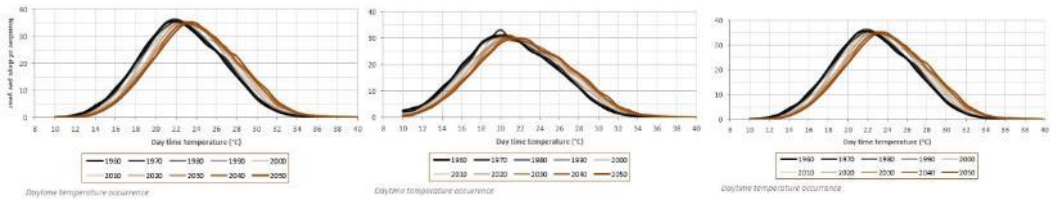


Figure 17: Temperature profile shifting over time for coastal (left), Inland South (centre) and Inland North (right) climate zones.

This increase is not uniform across all months. The retention of atmospheric heat will increase the heating effect of the cooler winter months more than the already warm summer months. The Inland north area shows anomalous temperatures in summer (December, January and February) of approximately 1°C from the warm past temperatures (Figure 18). The winter months (June, July, August), having a lower average temperature experience the increased atmospheric temperature to a greater extent and show anomaly of 1-1.5°C. Other climate areas exhibit a similar wintertime anomaly.

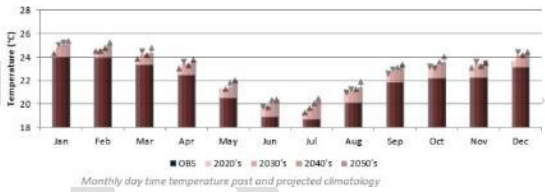


Figure 18: Inland North anomalous projected temperature changes for 2020's, 2030's, 2040's, 2050's (lighter red bars), from the past temperatures (dark bars) for RCP4.5, arrows show further change under RCP8.5

Night time temperature profile is similarly affected (Figure 19). The most observed temperatures (40th to 60th percentile) shift from the range of 6°C – 9.5°C to the range of 7.4°C – 11.5°C for Winter months (when the cooler land is heated to a greater extent by the warmer atmosphere) in the Inland North area. This same trend is noted in the other seasons, but to a lesser degree of change.

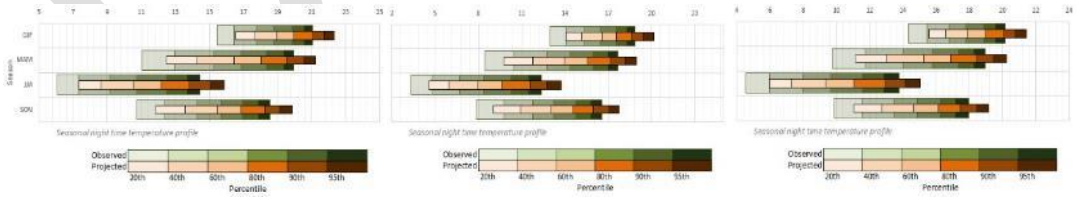


Figure 19: Night time temperature profile, past (green shades) and projected RCP4.5 (future orange shades) for Coastal (left), Inland South (centre) and Inland North (right)

Increased heat waves and extreme temperature days

As the entire temperature profile is shifting towards higher average day and night time temperatures, it is expected that there is a significant increase in the number of summer time heatwave events (5 days or more of higher than average monthly temperature). By the middle part of the century, there will likely be approximately 40% more heatwaves per year than was experienced in the period 1990 – 2000 for the Inland North areas (Figure 20). Other areas will follow this trend, however the Inland North areas experience the highest average temperatures and therefore the heat waves will be more extreme in those areas than in others.

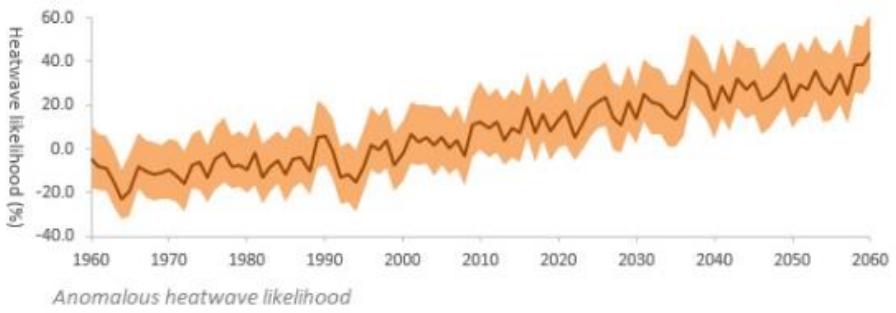


Figure 20: Anomalous change over time (from 1990-2000) of heatwave likelihood for the Inland North areas from RCP4.5

The shift of the temperature profiles and in the presence of higher likelihood of heat waves, the occurrence of extreme temperature days (+35°C) is set to increase (Figure 21). These extreme days are noted in the Spring and Summer seasons for the three areas and are likely to occur at least twice and potentially more than four times in summer in the coastal and Inland north areas. Spring months also show an increase in occurrence but to a lesser extent than is noted in the summer months. The Inland South areas also shows an increased number of events in summer and spring but this change is not as significant as is noted in the other areas.

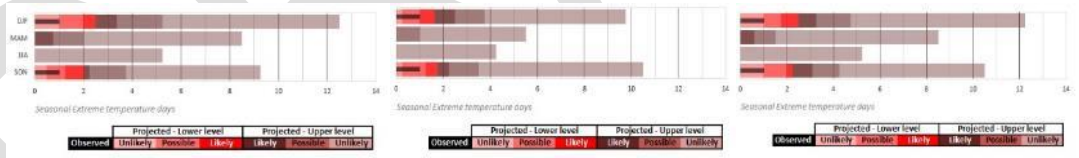


Figure 21: Number of extreme temperature days per season, past (thin bars) and projected RCP4.5 (thick red bars) for Coastal (left), Inland South (centre) and Inland North (right)

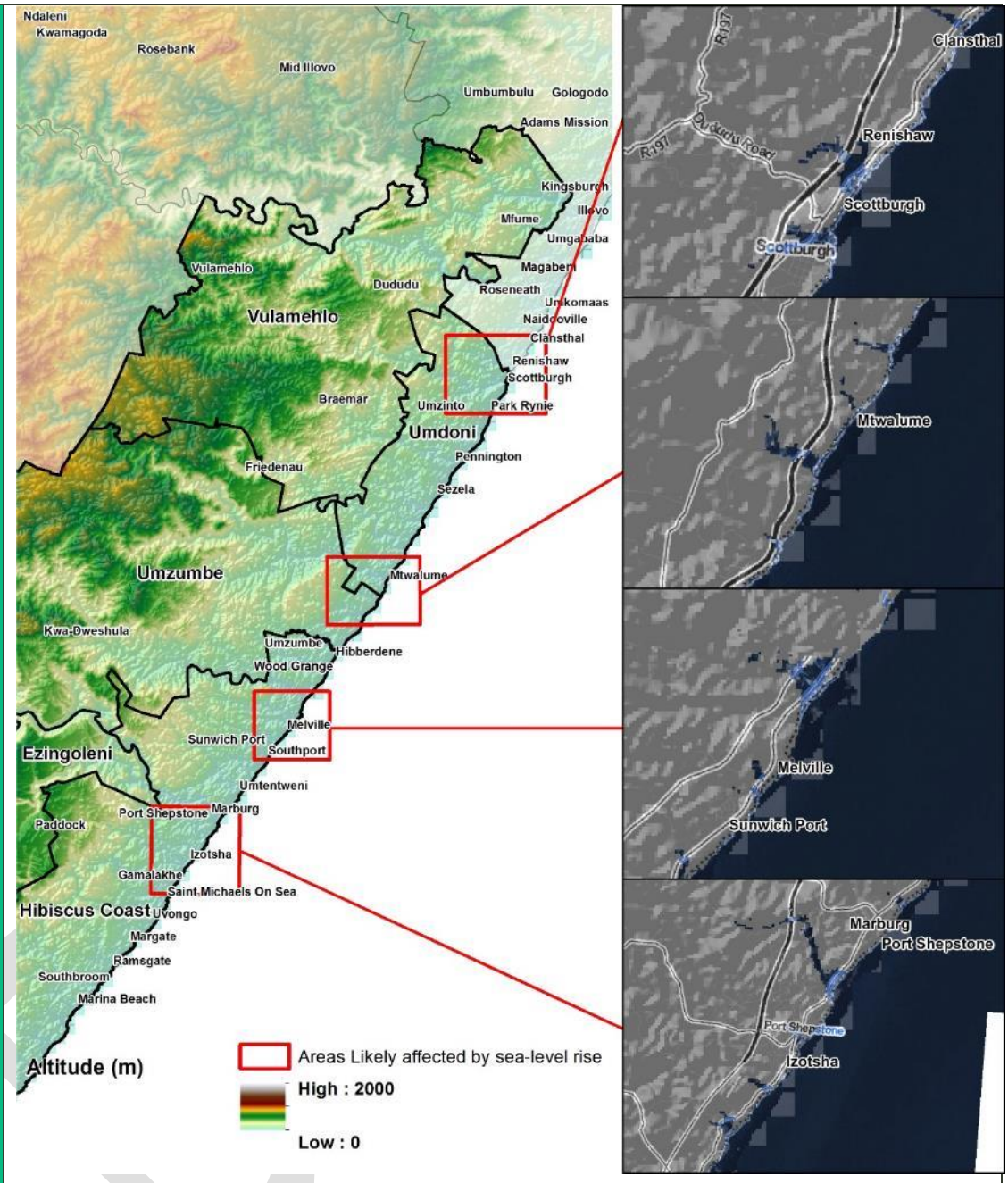


Figure 22: Areas projected to be impacted by Sea-level rise under the RCP8.5 scenario

Sea level will increase the inundation and saline intrusion risk to low-lying coastal areas. Also at risk are estuaries and river mouth areas. The increase in ocean storms that is projected to take place in the Indian Ocean will drive heightened storm surges that when exacerbated by rising sea level could damage areas of lower elevation and rivers. The damage caused may result in loss of land as well as ecological damage and risk to community livelihoods. Figure 22 indicates areas and infrastructure that are at particular risk from the impacts of sea-level rise.

Seasonal spatial changes in Temperatures and precipitation

Spatial Climate Changes are projected to be heightened further inland of the DM for both day and night time temperatures (Figure 23). The changes are slightly more prominent in the autumn and winter season, particularly for minimum temperatures. The rainfall is set to increase in all season for the full DM other than in winter in the very western inland areas which will see a decrease in precipitation. The highest increase in precipitation is noted in the northern areas in spring but in summer it's roughly a consistent increase. These changes are likely to be enhanced the further into the future projections are done, particularly for future temperatures. Precipitation volumes are less certain though all studies are predicting an increase in the precipitation volume on the east coast of south Africa going into the future. How that will be manifest in terms of spatial variability, extreme events and seasonality is less certain.

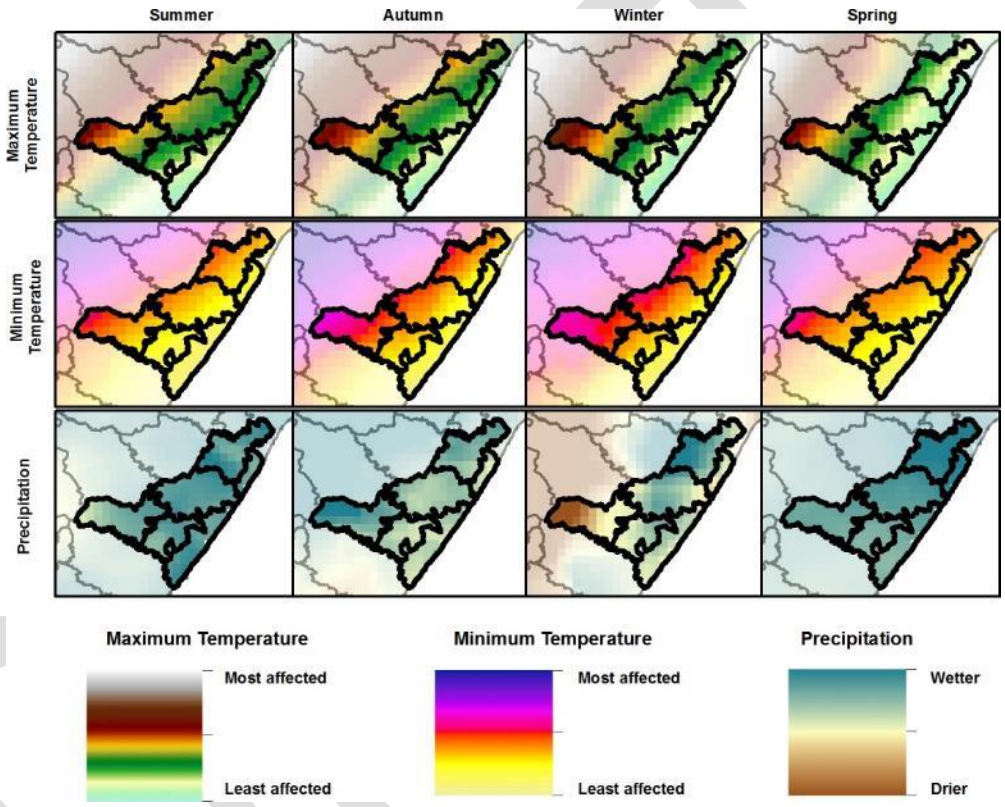


Figure 23: Projected changes per season for the Ugu DM for max temperature, Minimum temperature and Anual rainfall.

4 Risk Profile

4.1 Introduction

The results of the climate analysis give above indicate that a change in the climatic conditions of the Ugu District tis inevitable, with the District likely to experience higher temperatures, altered rainfall patterns and an increased frequency of natural. Currently decision-making processes, policy and infrastructure development are largely based on historical climate data. However, the evidence is clear and we can no longer assume climatic patterns to remain constant.

By Identifying climate change risks the Ugu District will be better able to prioritize and manage risk by applying relevant mitigation and adaptation strategies. The purpose of this Chapter is to provide an overview of the risks climate change poses to the District and its people to inform decision making and planning processes.

In assessing the Ugu District's climate change risk profile the report drew on a combination of approaches, considering the impact oriented risk-hazard approach while also drawing additional approaches addressing the social, cultural, and economic factors in the assessment of overall risk. The outputs have been mapped using GIS in order to provide a spatial overview of the Ugu District's levels of vulnerability, coping capacity and hazard exposure based on relevant indicators. Based on the modelling and analyses of future climatic patterns, as discussed in the previous chapter, climate change projections the possible short to long term risks posed to various sectors were considered.

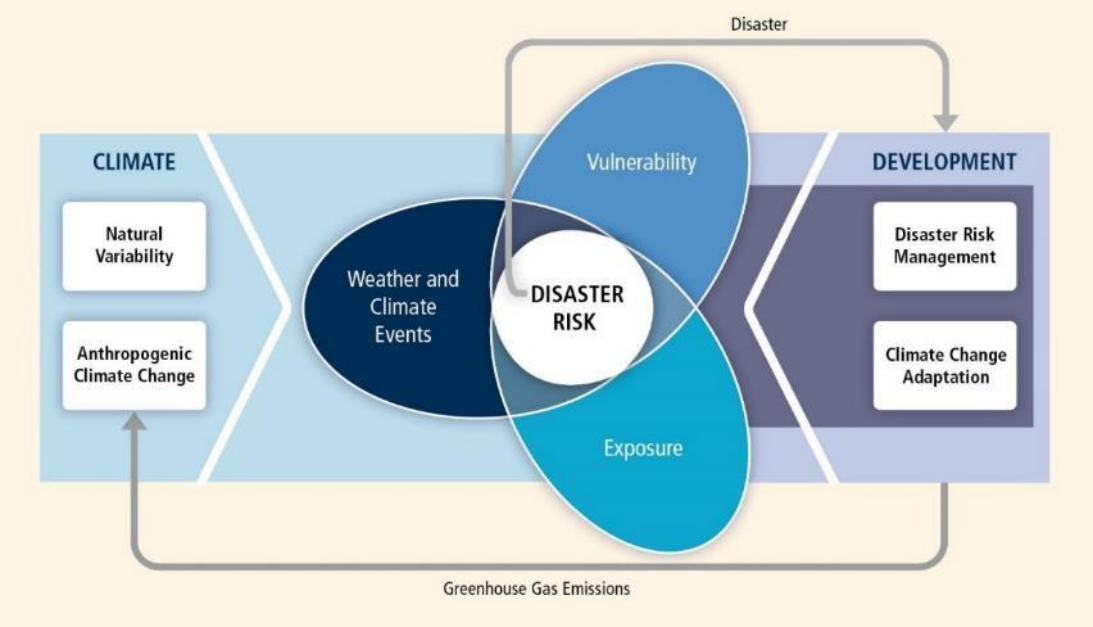


Figure 24: Linking Climate change to disaster risk through development management and adaptation

4.2 Capacity, vulnerability and Climate hazard mapping

4.2.1 Risk assessment

The relative risk based on the hazard potential, vulnerability and capacities indices, will vary spatially within a study area. Risk mapping seeks to analyse multiple spatial and temporal source datasets with the intention of better conveying the interactions between and impact on communities, infrastructure and assets from potential risk/hazard events. Multi-criteria analysis that will indicate population clusters that have strong capacity to cope or area that have a higher vulnerability to disasters associated with climate change impacts (i.e. flooding/extreme temperatures).

Spatial analysis provide the basis for risk mapping by combining the cumulative hazard, vulnerability assessments and localised capacity.

4.2.1.1 Hazard Indices

The climate hazard index is based on the potential impact from varying climatic hazards (i.e. increased rainfall intensity in a particular season, extreme temperatures, etc.). The impacts is measured from the likelihood of the climate change, the forecastability/predictability and the severity of the changed hazard.

Likelihood (statistical measure)

Based on the probability as stated in the projected climate parameters, i.e. increased average temperatures are certain while changing dry spell duration is less certain.

Forecastability / Predictability (meteorological measure)

The degree to which a climate parameter anomaly can be forecast with sufficient warning to adapt to its affects, i.e. short term events like extreme rainfall events are difficult to forecast with a long lead time, whereas a shift in rainfall seasonality can be predicted a few months in advance.

Climate severity (statistical measure)

The severity in the range of potential change in the projected climate parameters, i.e. a projected single extra day exhibiting extreme temperatures is less severe than a projected 33% decrease in annual rainfall.

4.2.1.2 Vulnerability Indices

The vulnerability of an area is determined through assessing the risk to lives in densely populated areas, the potential impact to agricultural activities (commercial and subsistence), the status and ability of the environment to provide ecosystem services, and lastly the degree to which the climate is likely to change from the current baseline.

Population (census measure)

Should areas with the larger populations, such as cities and dense rural areas be subject to unmitigated climate changes; the increased number of individuals affected will result in additional stress to be placed on institutional resources. Severe impacts in areas of heightened population density will cause disruption/risk to more lives and therefore is more vulnerable.

Agricultural and plantation vulnerability (land use measure)

The land use indicates the proportion of a study area under commercial or subsistence agriculture or forestry. As the climate varies, suitability and viability of agriculture may be threatened. As such, an increased area under crop or forested may increase the vulnerability of an area.

Environmental resilience (land use measure)

The land use indicates the proportion of a study area as vegetated, indigenous areas and grasslands. The encroachment into these natural areas diminishes the ecological integrity and compromises natural resilience support services. The degree to which natural vegetation is removed is proportional to the vulnerability of an area.

Climate change potential (projected measure)

The combined annual impacts of changes to precipitation, day and night time temperatures highlights areas that will be subject to the largest anomaly from existing climates. Areas the largest cumulative change from observational climate will have the highest projected climate vulnerability. The climate potential does not denote positive or negative changes, only the measure of change. An area that will experience more annual rainfall may suffer less from drought but may also experience more flooding events.

4.2.1.3 Capacity to Cope / Manageability indices

An area with a high coping capacity will suffer decreased impacts from climate changes through its implemented adaptation measures and the policy capacity addressing climate change as a risk. Individual and institutional capacity is increased in areas with higher income and educational levels as well as areas benefiting from infrastructure and municipal services.

Measureable adaptation (area assessment and local feedback)

As climate change forcing originates largely outside of the study area, adaptation integrated into public and private projects is a more desirable way to build resilience and increase coping capacity. This measure is based on the assessment, research, and feedback from stakeholders and I&AP's.

Policy capacity (review of legislation and feedback)

Recognising climate change as a threat in legislation, mandating local government to build resilience as part of their service delivery, and having empowered climate change champions in place holding local and private sector responsible for in-action or negative actions will increase the manageability of climate changes locally.

Personal Capacity (census measure)

A person's ability to respond to, and mitigate against current, projected, and unforeseen negative impacts is their individual personal capacity. Individuals (and groups of people) that are either unemployed and/or without education have diminished capability to positively alter negative happenings. The opposite is true for groups that have higher income and/or higher education.

Income/employment thresholds		***Education level thresholds***	
i)	No income/unemployed	i)	No schooling
ii)	Income < R1600.00	ii)	Schooling <= grade 7
iii)	Income < R12801.00	iii)	Schooling <= grade 12
iv)	Income > R12801.00	iv)	Schooling > grade 12

Institutional Capacity (Area type and GDP)

Intuitional capacity is the degree to which a local authorities are able to respond to and mitigate against current, projected, and unforeseen negative impacts. Increased capacity is achieved from both a stable financial position as well as developed infrastructure. These act as proxy measures for the ability of an area to respond with appropriate and timeous intervention.

Area type capacity thresholds

i)	Sparse Rural infrastructure and GDP capacity	: 20%
ii)	Dense Rural infrastructure and GDP capacity	: 40%
iii)	Local/Niche/Service Town infrastructure and GDP capacity	: 60%
iv)	Regional Centre infrastructure and GDP capacity	: 80 %
v)	City (vicinity) infrastructure and GDP capacity	: 90%
vi)	City infrastructure and GDP capacity	: 100%

4.2.2 Risk calculation

The cumulative measures of hazards (H), vulnerability (V) and capacity (C) are formulated as follows:

- (H) x (V) / (C)

The exponential relationship of relative risk priority can be seen in **Figure 25**.

i) The relative risk rating (y-axis) is the potential risk any particular climate hazard poses to the area; 0 has zero risk rating (i.e. the area will experience zero to minimal impact), while 100 is the highest possible risk against a hazard (i.e. the area will experience major to catastrophic impact)

ii) The potential (x-axis) depicts all the possible hazard, vulnerability and capacity measure combinations applicable to an area as a percentile

a. Lower values (0.1 – 0.3) represent areas with low hazard potential and vulnerability, but with high coping capacity. This is the best possible scenario.

b. The middle values (0.3 – 0.75) represent areas with a combined medium hazard potential, vulnerability and coping capacity. This scenario accounts for much of the areas.

c. Higher values (0.75 – 1.00) represent areas with high hazard potential and vulnerability, but with low coping capacity. This is the worst possible scenario.

iii) The grey line shows the exponential relationship between the potential and the risk. Increasing the coping capacity or decreasing the vulnerability of an area will significantly decrease the risk rating and as such, the severity of the hazard.

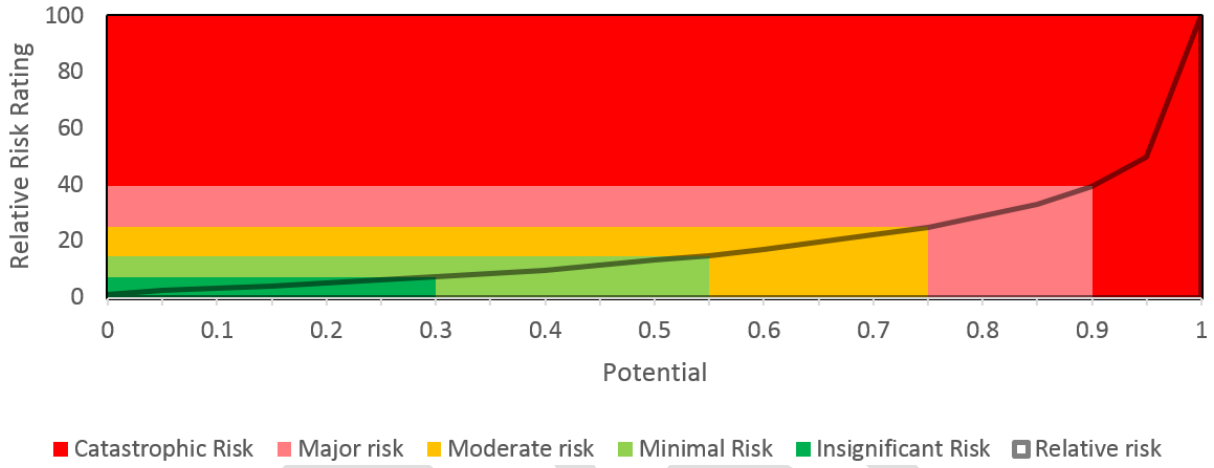


Figure 25: Relative Risk Priority

Relative Risk Priority	Potential	Relative Risk Rating (RRR)
Insignificant risk	Less than 30th percentile	RRR less than 7%
Minimal risk	Between 30th and 55th percentile	RRR between 7% and 15%
Moderate risk	Between 55th and 75th percentile	RRR between 15% and 25%
Major risk	Between 75th and 90th percentile	RRR between 25% and 40%
Catastrophic risk	Greater than 90th percentile	RRR above 40%

4.2.3 Risk mapping

The measures of statistical hazard index, measureable adaptation and policy capacity or done on a local municipal level, while the remainder are utilised at the mesozone scale[17] for analysis.

Applying the standard risk calculation to the measures of hazards, vulnerability and capacity spatially gives definition to the study area and highlight areas of significant risk. See **Figure 26**

[17] CSIR mesoframe– a demarcated grid of 25000 mesozones ~50km² each (www.gap.csir.co.za/techical-overview)

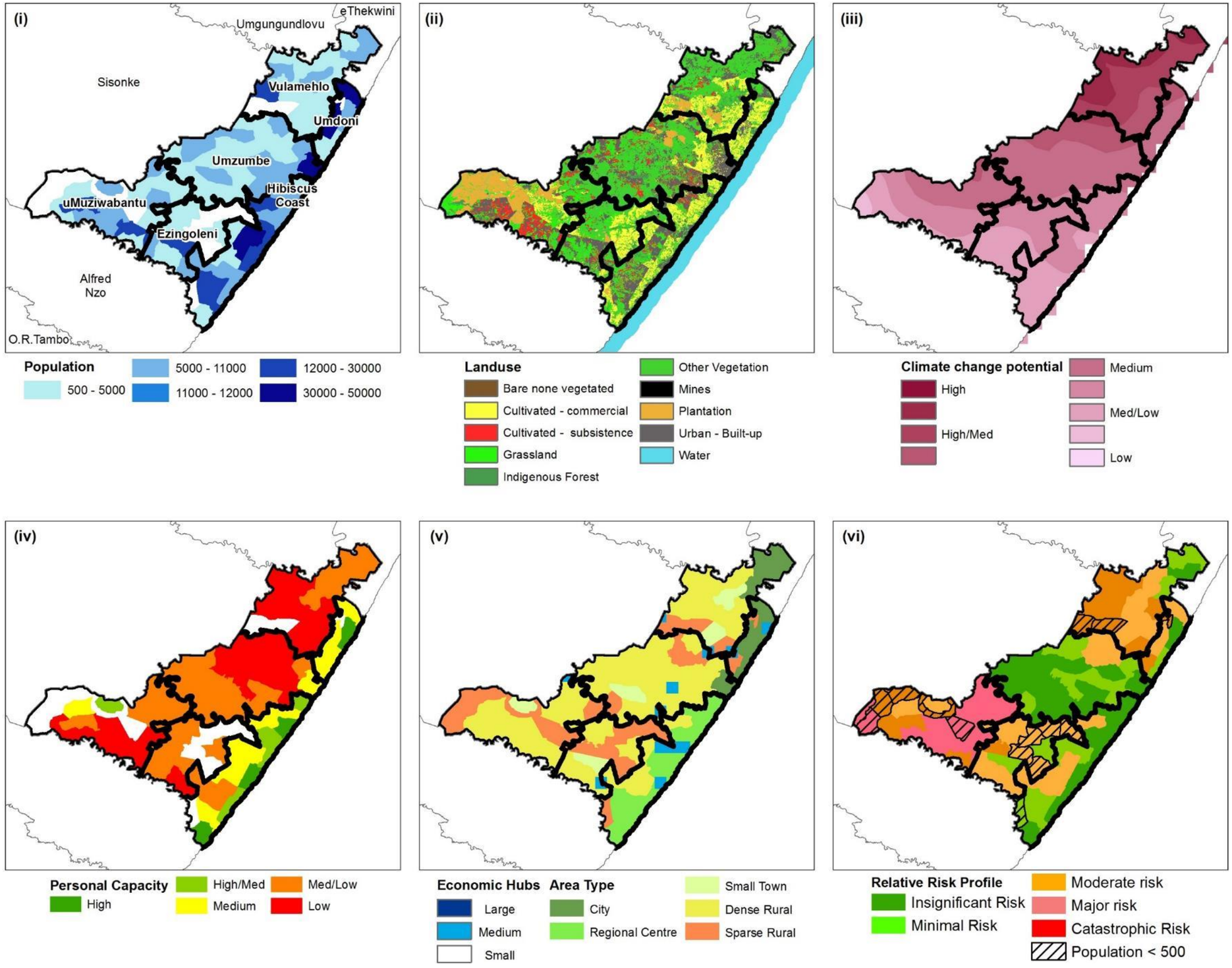


Figure 26: Vulnerability, Capacity and Relative Risk Profile

4.3 Municipal Risk Rating

The relative risk priority presents each municipality's risk to each of the main projected potential climate changes. These are calculated by looking at the likelihood, predictability and hazard severity of each climate impact and comparing it to the vulnerabilities on the ground and the capacity of the municipality and individuals to cope with these changes in the urban, rural, subsistence and commercial agriculture areas. The impact oriented risk-hazard approach also considers the social, cultural, and economic factors in the assessment of overall risk

4.3.1 Stockholder risk perception

The local level workshop engagements have reviled the perception of local stakeholders of the climate risk in the area. The quantitative assessment suggested that rural areas and subsistence agriculture had higher vulnerability over the urban and commercial agriculture areas. This disparity is exacerbated further through the capacity assessment

The qualitative assessments, presented below, suggests a similar picture with motivations for the vulnerabilities, capacities and hazard impacts.

Table 3: Perceived Risk Influences

○ **Factors influencing rural risk profile** **Vulnerabilities** • Population migration, children and elderly left in rural areas while working age population moves to urban areas. • Limited access to jobs (unskilled labour force), education/awareness of climate related impacts and resource competition. • Little to no infrastructure, service allocation and no access to finances/insurance. • Scattered settlements make combining services, resources, relief troublesome. • Exposed to natural hazards and disasters presently. Housing often mud huts. • Alien invasive contesting water resources, also providing additional fuel load for wildfires. • Environmental/soil degradation due to improper farming activities. • Low resilience to recover from hazard impact due to limited income and education. **Capacities** • Some awareness campaigns though policy education and compliance is very limited • Limited municipal investment and activity taking place. • Social cohesion between settlements. • More harmonious with natural systems and better at dealing with water pollution than urban areas. • Adoption of JoJo tanks for water storage. • Uptake of organic and permaculture farming practices

○ **Factors influencing urban risk profile**

Vulnerabilities

- Urban heat island affect causing discomfort in the urban areas.
- Local economy and food prices susceptible to impacts in the agricultural sector.
- Areas in close proximity to the ocean may be at high risk. Significant spending on infrastructure and development in these areas will be lost.
- Higher density of population living in inadequate housing being greater vulnerability to more people.
- Industrialization and land transformation are having a negative impact on the environment.
- Poor at dealing with pollution. Landfills and polluted water infiltration having negative effects.
- Impermeable surfaces increase the effects of flooding.
- High proportion of pensioners rather than working age professionals.
- General disregard for environmental policies.

Capacities

- Good infrastructure and service provision building the resilience of the urban areas.
- Greening of urban areas.
- Potentially more job opportunities in the urban areas.
- Better coping capacities potential through access to goods, services, education and finance.
- Greater disaster management capacity.
- Personal capacity is higher due to income and education.
- Generally dwellings have better construction materials and are more resilient.
- Enhanced social and community structures to come together in a crisis.

○ **Factors influencing commercial agriculture risk profile**

Vulnerabilities

- Food security related to high prices for basic goods;
- Poor uptake of sustainable agricultural practices;
- Reliance of natural water sources;
- Lack of adequate insurance;
- Environmental degradation;
- Poor environmental management practices;
- Disaster risk;
- Lack of compliance and enforcement of legislation

Capacities

- Use of fire breaks;
- Access to government assistance;
- Access to knowledge and resources for climate change adaptation;
- Significant level of awareness among commercial farmers;
- Established public and private support structures for commercial farmers.

- **Factors influencing subsistence agriculture risk profile**

Vulnerabilities

- Lack of education and awareness;
- Access to and uptake water harvesting and storage methods;
- Poor irrigation practices;
- Lack of resources for adaptation;
- Low income;
- Lack of support structures;
- No access to insurance
- Environmental degradation;
- Lack of compliance and enforcement of legislation;
- Existing fluctuations in prices of raw materials, e.g. seeds;
- Responses are mostly reactive.

Capacities

- Social support within community;
- Some farmer support projects, but limited.

Table 4: Hazard Impacts

Precipitation impacts. Increasing volumes, intensity and variability.

- Agriculture
  - Both potentially positive and negative impacts on agricultural yields.
  - Impacts to agriculture, alter crop suitability and timing.
  - Floods impacting commercial and subsistence agriculture.
- Tourism
  - Tourism decreased due to negative weather perception (rain, cloud and wind).
  - Beach degradation impacting tourism potential.
- Biodiversity
  - Both potentially positive and negative impacts to biodiversity. Rainfall regime may favor alien invasive species.
  - Environmental degradation though enhanced erosion and sedimentation.
  - Biodiversity may be impacted and result in species migration.
- Communities
  - Property and infrastructure damage due to increased stress on storm water systems, roads and bridges.
  - Negative impacts to traffic flow.
  - Poorly developed areas may be negatively affected through enhanced flood potential impacting disaster management capacity.
  - Fast runoff may put pressure on dam storage.
  - Reduces productivity of construction and development.
  - Positive contribution to the water table.
  - Enhanced water capture opportunity.

Drought potential

- Agriculture
  - Reduced crop yield for both commercial and subsistence farmers.
  - Inability to give water to livestock.
  - Increased food prices.
  - Irrigation demand increases

- Biodiversity
  - Limited adaptability may favour other species.
  - Decreased water quality.
  - Impacts to aquaculture.
  - Increased completion for water for game vs human usage.
  -
- Communities
  - Communities reliant on rivers for drinking water.
  - Insufficient drinking water in urban areas
  - Malnutrition and disease increases.
  - Impacts livelihood strategies.
  - Pressure on disaster management resources.
  - Enhanced vulnerability of population.
- Tourism
  - Negative impacts on tourism if water supply is compromised.

Temperatures increasing in general and extremes

- Agriculture
  - Crop suitability may vary due to temperature change.
  - Increased evaporation and reduced soil moisture.
  - Livestock and crop stress.
  - Irrigation demand increases.
  - Enhanced fire potential.
  - Impacts food security.
- Biodiversity
  - Enhanced fire potential.
  - Potential species migration and alien invasive species.
  - More evaporation from rivers and evapotranspiration.
- Communities.
  - Pressure on disaster management resources.
  - Increased demand of cooling. Pressure on energy sector.
  - Lower population productivity.
  - Impacts to human health.
  - Increased demand on water resources.
  - Infrastructure damage due to thermal expansion
  - Effects on the Elderly and those with chronic conditions.
- Tourism
  - Increased perception of area as holiday destination.
  - Enhanced ecotourism opportunities.
  - Potentially more drowning incidents

Ocean impacts

- Agriculture
  - Subsistence fishing changes in fish migration/distribution will impact food security
  - Salt intrusion into the water table.
- Communities.
  - Affects negatively those business/dwellings that are built close to ocean.
  - Erosion damages to Infrastructure.
  - Inundation of developments.
  - Relocation requires significant investment.
- Biodiversity
  - Habitat loss.
  - Inundation of vegetated areas, river mouths and estuaries.
  - Damage to environmental buffer zones
- Tourism
  - May open up new areas for beach activity but may also reduce these areas.

The feedback from the stakeholder engagements highlighted and reinforced the understanding that Rural and subsistence farming have reduced resilience compared to urban areas and commercial agriculture (Table 5).

.Table 5: Vulnerability and Capacity of different area types

		Rural	Urban	Commercial Agriculture	Substance Agriculture
Vulnerability	Population	High	Medium	n/a	n/a
	Agriculture	n/a	n/a	Medium	Very High
	Environmental	Medium - High	Medium	Medium	Medium
	Impact Climate change potential	Very high	Medium	Medium - High	Very high
Capacity	Personal	Low	Medium	Medium	Low
	Intuitional	Low	Medium	Medium	Low
	Measureable adaptation	Low	Medium	Low – Medium	Low
	policy compliance	Very low	Medium	Low – Medium	Very Low

4.3.2 Settlement typology vulnerability

The area type often dictates the perception of vulnerability, however the settlement demographics[18] indicate that generally urban settlements are more resilient than the rural areas, the exception to this being informal settlements. The households of the rural areas have more individuals resident thereby increasing vulnerability. Urban areas have a lower age household head (44, average of urban and urban informal) than rural areas (48). This is due to the rural-urban migration of the younger work seeking adults. These individuals (particularly non-informal areas) also earn significantly more monthly, have the lowest unemployment (24%) and are more economically active and able to cope financially than households of the rural areas. Increased vulnerability is shown through the greatest proportion of female headed households (56%) occurrence in rural areas. Transport is also a major concern to the working population. Both urban and rural areas have reduced walking dependence and have alternate transport means. However when using public transport, the average cost per trip is

[18] CSIR - stepSA.org municipality Delivery demand wallchart

higher than the informal areas. In the informal areas though, there is a greater reliance on walking as the primary transport means.

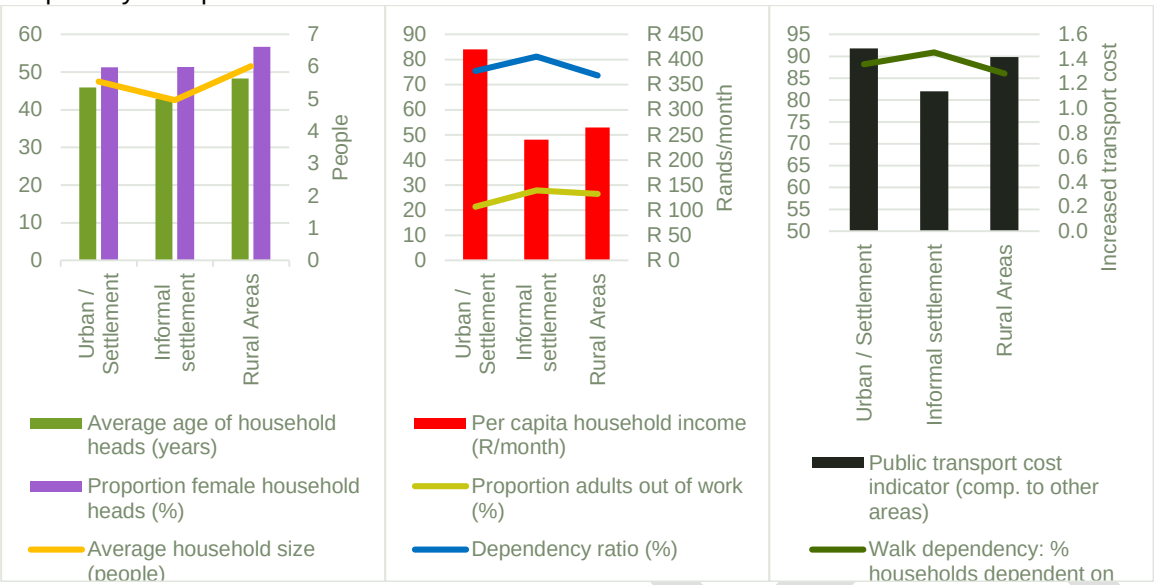


Figure 27: Ugu settlement vulnetrability

Local municipality disparity (Figure 29)
The Ugu District municipality profile (DCoG 2011) summarises the vulnerabilities of Ugu DM. DCoG has classified Ezinqoleni, uMuziwabantu, Umzumbe and Vulamehlo as most vulnerable in terms of functionality, socio-economic profile and backlog status. These areas also have the highest poverty rating of approximately 70%.

Table 6: Ugu District Municipality profile (DCoG 2011)

Local Municipality	Classification	Poverty Rate (63.7% Ugu total)
Ezinqoleni	Most vulnerable	75.60%
Hibiscus Coast	Second highest performing	47.49%
Umdoni	Second highest performing	43.42%
uMuziwabantu	Most vulnerable	72.75%
Umzumbe	Most vulnerable	74.77%
Vulamehlo	Most vulnerable	68.19%

The ratio of urban / settlements, informal settlements and rural areas between the municipalities will influence the spatial vulnerability of the district.

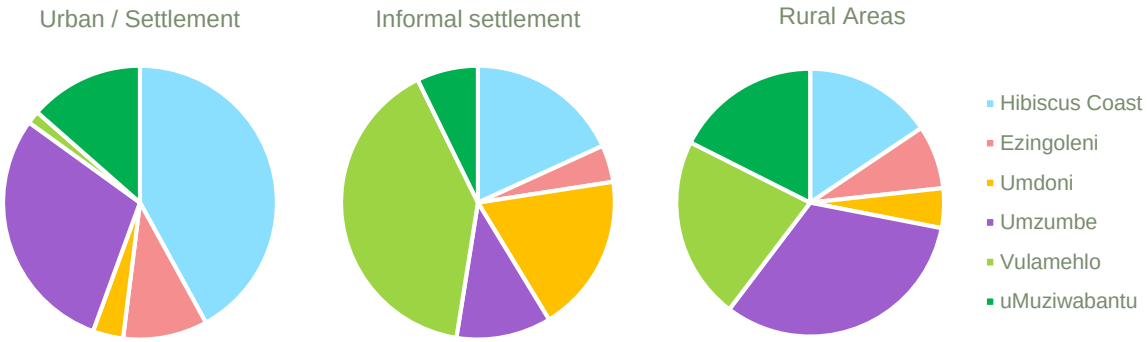
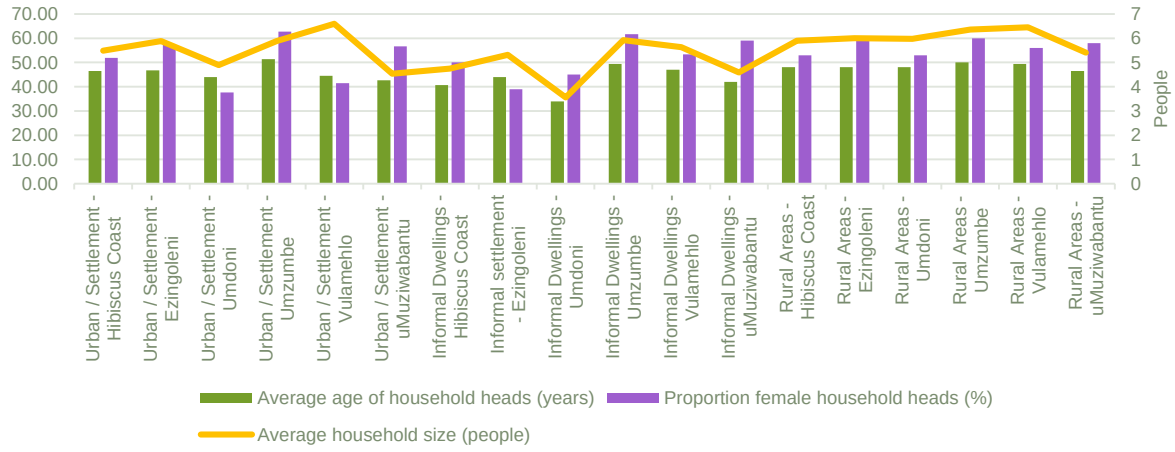


Figure 28: Proportion of Local municipality settlement type by household[19]

When considering the urban / settlement (non informal) areas of Hibiscus Coast, Umdoni, and to a lesser extent uMuziwabantu (lower prevalence) have a lower average household size, female headed household ratio and average age than the Ezingoleni, Umzumbe and Vulamehlo municipalities. They also have lower proportion of unemployed persons (exception of Ezingoleni), lower dependency ratio (exception of Ezingoleni), fewer individuals that rely on walking for transport and lower cost of public transport. They can also boast a higher average monthly income. These factors increase the resilience of Hibiscus Coast, Umdoni, and uMuziwabantu over Umzumbe and Vulamehlo municipalities in the urban setting.

The informal profile follows a similar spatial trend with the exception of Umdoni and Ezingoleni which has increased vulnerability in terms of per capita income, dependency ratios and unemployment levels.

The rural areas show higher resilience with in uMuziwabantu municipality which has a very low dependency ratio and unemployment rates. Umzumbe has the highest proportion of female headed households, average age of household heads and very high dependency ratio, compromising the resilience of the municipality.



[19] CSIR - stepSA.org municipality Delivery demand wallchart

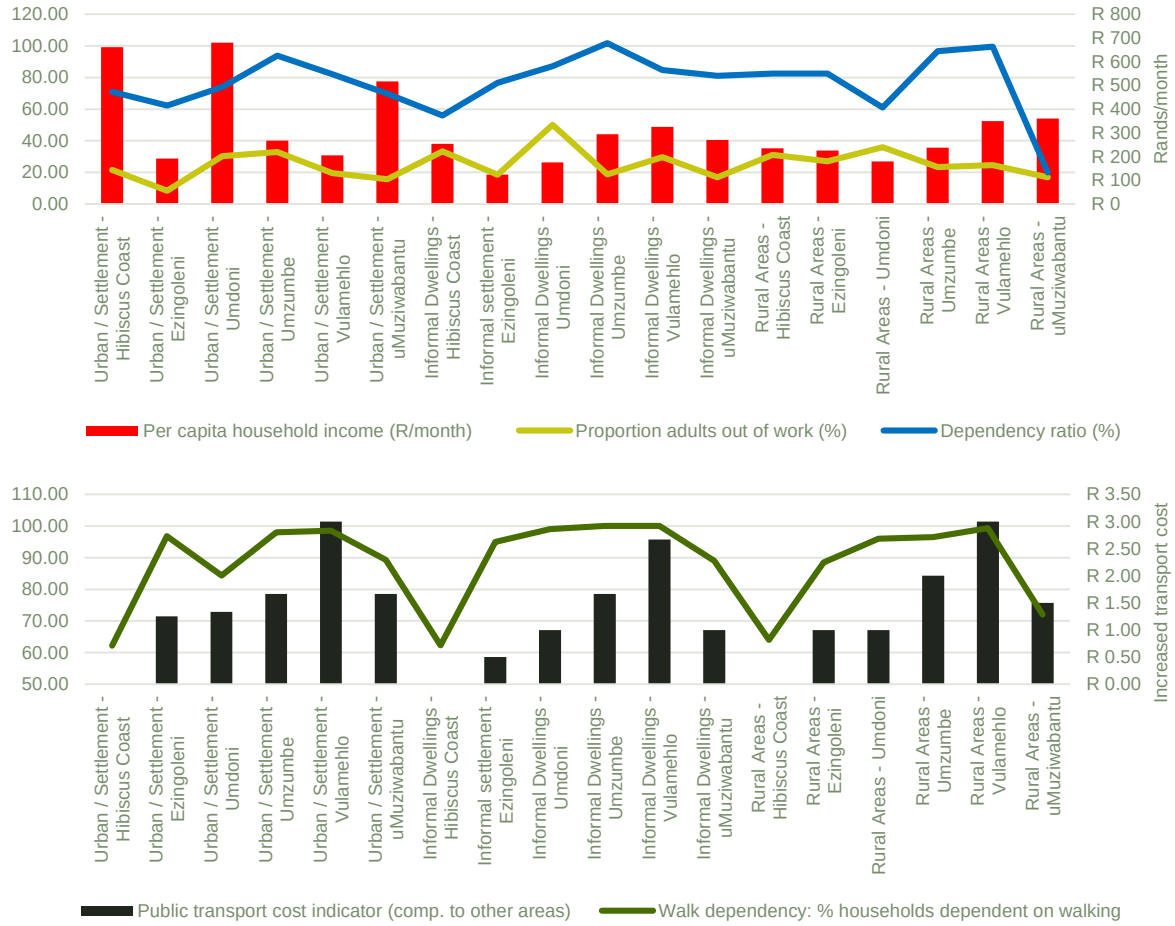


Figure 29: Demographic vulnerability profiles

Vulnerability in Agriculture

KZN as a whole is considered highly exposed (risk that an event may occur) to droughts/floods and predicted climate change (Gbetibouo 2009[20]). KZN also has significant sensitivity or a degree of influence from impacts of climate change and low levels of adaptive capacity. They further suggest that "coastal ecosystems are the most highly threatened systems in the world" (Gbetibouo 2009).

Table 7: Agricultural vulnerabilities

Subsistence / smallholder farms	Commercial agriculture
impoverished sector, dominated by low-input, labor intensive production	large-scale, commercially oriented, capital-intensive, export-led
Land holdings in the former homelands are generally very small	wide variety of crops
Low irrigation ratio	High reliance on irrigation
Livestock currently exceeds the grazing carrying capacity in many areas	Limited land degradation
Limited access to resources, land, credit and technical know-how	Better infrastructure increasing crop quality, resource availability, accessibility and credit.

[20] Gbetibouo, G.A., Ringler, C., 2009, Mapping South African Farming Sector Vulnerability to Climate Change and Variability, IFPRI Discussion Paper 00885.

Climate change will increase the burden of those who are already poor and vulnerable	Climate changes may impact yield and reduce profitability as climate varies.
More sensitive to climate change and variability because they have less capital-intensive technologies and management practices.	Less exposed to climate impacts and variability through access to credit, technology and knowledge.

Agricultural type varies significantly between the municipalities. The majority of all agricultural land in Ugu engages in commercial farming (78%). This commercial area is focused primarily in Umdoni (40% total farming area) and in by followed by uMuziwabantu for the highest proportion of subsistence agriculture (13% total farming area). Commercial farming dominates the remaining municipalities with between 7% to 9% total land for commercial activities to 1% to 3% for total land for subsistence agriculture area.

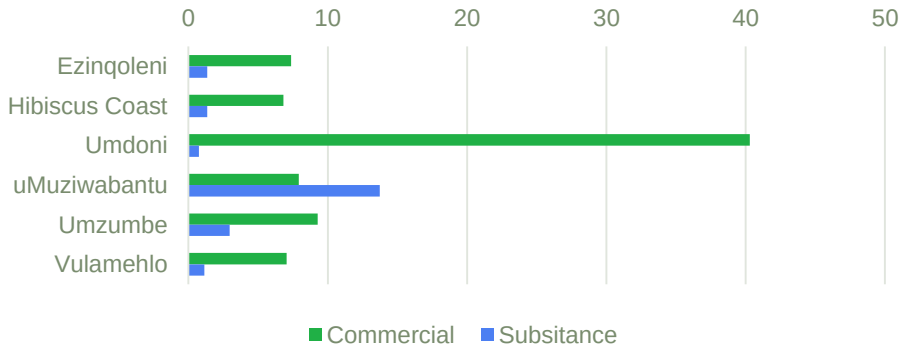


Figure 30: Total agriculture area per municipality and farming type (%)

4.3.3 Risk Classification

The risks are classified from least serious to most serious as Insignificant, Minimal, Moderate, Major and Catastrophic Risks. They integrate the workshop risk profiles as well as the situational analysis measured trough the CSIR, stepSA and Census data. The range of time variability is a general estimate of time frames into the future from which these climate change impacts may be reasonably assumed to reach significant levels of impact. For example, the expected and very likely increased temperatures will be felt with relative predictability, gradually for at least the next 10 years. While the increased temperatures are ultimately a large risk, the anomaly from climate year on year is minimal. However, the time range to experience increased rainfall intensity in summer is significantly more variable and large impacts of this change may be manifest in a shorter time frame; between repeated seasons or within a single year. The status of each variable will meet one of the following scenario types:

	Scenario	Risk profile	Priority response
	Severely negative	Catastrophic Risk	Immediate priority, adaptation urgently needed
	Negative	Major risk	High priority, adaptation needed before conditions deteriorate further
	Medium	Moderate risk	Medium priority, adaptation should follow higher priority actions
	Positive	Minimal Risk	Medium to low priority, should be closely monitored, may become significant
	Very positive	Insignificant Risk	Low priority, no immediate action needed but should be monitored

These Relative Risk Priorities are used in the sectoral vulnerability analysis to preset municipal priority risk to the varying climate changes, the associated on the ground impacts and appropriate strategic response. Further expansion of the impacts associated with the climate change risks is presented in following sections of the report.

4.3.4 Hibiscus Coast Local Municipality

Hibiscus Coast LM		Relative Risk Priority		Hazard Indices			Vulnerability Rating			
Climate change impacts	Range of time variability	Rural Areas: Commercial farming	Urban Areas: Substance Farming	Likelihood	Predictability	Hazard severity	Population clusters	Agricultural vulnerability	Environmental resilience	Cumulative Climatic hazards
Increase annual rainfall	> 10 years	Moderate risk / Moderate risk	Moderate risk / Moderate risk	Almost certain	Forecastable	Significant impact	There are large population clusters in this LM with high population density. Climate impacts are therefore likely to disrupt more people.	There is commercial agriculture in this LM but is not very sensitive irrigation deficit	This LM is transformed and has commercial agriculture and there is little natural vegetation. Environmental resilience is medium to low	Little climate changes projected to take place in this as the change is mitigated by the proximity to the ocean.
Increased rainfall intensity in summer	> 10 years	Major risk / Major risk	Major risk / Major risk	Almost certain	Highly variable	Significant impact				
Seasonal rainfall shifts	> 10 years	Minimal Risk / Minimal Risk	Insignificant Risk / Minimal Risk	Likely	Highly variable	Minimal Impact				
Drought potential	> 10 years	Moderate risk / Moderate risk	Moderate risk / Moderate risk	Likely	Mildly predictable	Significant impact	**Manageability / Capacity to Cope indices**			
Increased temperatures	> 10 years	Minimal Risk / Minimal Risk	Minimal Risk / Minimal Risk	Almost certain	Forecastable	Medium impact	**Measureable adaptation**	**Policy capacity**	**Personal Capacity**	**Institutional Capacity**
Increased extreme temperature days	> 10 years	Major risk / Moderate risk	Moderate risk / Major risk	Almost certain	Mildly predictable	Significant impact	Social structures allow for better adaptations for the rural and subsistence areas such as usage of water storage and organic farming awareness and mitigation activities. There are maps available for both rural and urban areas to help with planning activities	The LM focuses on climate change in the IDP and the SDF and sees the need to have this mind-set in development.	The population of this LM have a combined high capacity. This is derived from their level of education and personal income	The institutional capacity is high as there are several economic hubs, urban infrastructure and a focus on development
Increased heat wave incidence	> 10 years	Major risk / Moderate risk	Moderate risk / Major risk	Almost certain	Mildly predictable	Significant impact				
Decreased number of cold nights	> 10 years	Insignificant Risk / Insignificant Risk	Insignificant Risk / Insignificant Risk	Almost certain	Forecastable	Minimal Impact				

4.3.5 Umzumbe Local Municipality

Umzumbe LM		Relative Risk Priority		Hazard Indices			Vulnerability Rating			
Climate change impacts	Range of time variability	Rural Areas: Commercial farming	Urban Areas: Substance Farming	Likelihood	Predictability	Hazard severity	Population clusters	Agricultural vulnerability	Environmental resilience	Cumulative Climatic hazards
Increase annual rainfall	> 10 years	Minimal Risk / Minimal Risk	Minimal Risk / Minimal Risk	Likely	Forecastable	Medium impact	This LM has the lowest average population density. Climate change impact will likely affect a smaller number of people.	There is some commercial agriculture. The vulnerability is medium. The most vulnerable would be the subsistence farmers.	While there are areas that have been transformed, the majority of the area is either grassland or larger vegetation. The environmental resilience it good.	Combined climate changes are considered Medium to high, particularly further north.
Increased rainfall intensity in summer	> 10 years	Minimal Risk / Minimal Risk	Minimal Risk / Minimal Risk	Possible	Highly variable	Minimal Impact				
Seasonal rainfall shifts	> 10 years	Major risk / Moderate risk	Moderate risk / Major risk	Likely	Highly variable	Medium impact				
Drought potential	> 10 years	Major risk / Major risk	Moderate risk / Major risk	Likely	Mildly predictable	Significant impact				
Increased temperatures	> 10 years	Moderate risk / Moderate risk	Moderate risk / Moderate risk	Almost certain	Forecastable	Medium impact				
Increased extreme temperature days	> 10 years	Catastrophic Risk / Major risk	Major risk / Catastrophic Risk	Almost certain	Mildly predictable	Significant impact				
Increased heat wave incidence	> 10 years	Major risk / Moderate risk	Moderate risk / Major risk	Almost certain	Mildly predictable	Medium impact				
Decreased number of cold nights	> 10 years	Minimal Risk / Minimal Risk	Minimal Risk / Minimal Risk	Almost certain	Forecastable	Minimal Impact				

Manageability / Capacity to Cope indices			
Measureable adaptation	Policy capacity	Personal Capacity	Institutional Capacity
There is very low adaptation rates. There is no (or very slow) delivery of training or support for local rural areas and subsistence farmers. They lack knowledge regarding sustainability and have no adaptation strategy.	The LM focuses briefly on climate change in the IDP. No substantial integrated planning or enforcement.	The population of this LM have a combined low capacity. This is derived from their level of education and personal income.	The institutional capacity is low - medium, there are a few small economic hubs focused in the more populated areas but also significant undeveloped areas.

4.3.6 uMuziwabantu Local Municipality

uMuziwabantu LM		Relative Risk Priority		Hazard Indices			Vulnerability Rating			
Climate change impacts	Range of time variability	Rural Areas: Commercial farming	Urban Areas: Substance Farming	Likelihood	Predictability	Hazard severity	Population clusters	Agricultural vulnerability	Environmental resilience	Cumulative Climatic hazards
Increase annual rainfall	> 10 years	Moderate risk / Moderate risk	Moderate risk / Moderate risk	Almost certain	Forecastable	Medium impact	There are a few dispersed population clusters averaging to a medium population density Impacts are likely to disrupt fewer people.	There are large areas dependant on commercial and subsistence agriculture. There is medium to high irrigation deficit focused inland	This LM is transformed and has commercial plantations and there is little natural vegetation. Environmental resilience is low.	Medium climate changes are projected to occur, primarily in the northern areas.
Increased rainfall intensity in summer	> 10 years	Major risk / Major risk	Moderate risk / Major risk	Likely	Highly variable	Medium impact				
Seasonal rainfall shifts	> 10 years	Major risk / Major risk	Major risk / Major risk	Almost certain	Highly variable	Medium impact				
Drought potential	> 10 years	Major risk / Major risk	Major risk / Major risk	Likely	Mildly predictable	Significant impact	**Manageability / Capacity to Cope indices**			
							Measureable adaptation	Policy capacity	Personal Capacity	Institutional Capacity
Increased temperatures	> 10 years	Moderate risk / Moderate risk	Moderate risk / Moderate risk	Almost certain	Forecastable	Medium impact	There is little to no knowledge of adapting to climate hazards and capacities are low. Some areas are undertaking water harvesting and sharing seeds but with is very limited.	The LM focuses briefly on climate change in the IDP. No substantial integrated planning or enforcement.	The population of this LM have a combined medium to low capacity. This is derived from their level of education and personal income.	The institutional capacity is low - medium, there are a few small economic hubs focused in the more populated areas but also significant undeveloped areas
Increased extreme temperature days	> 10 years	Major risk / Major risk	Moderate risk / Major risk	Almost certain	Mildly predictable	Medium impact				
Increased heat wave incidence	> 10 years	Major risk / Major risk	Moderate risk / Major risk	Almost certain	Mildly predictable	Medium impact				
Decreased number of cold nights	> 10 years	Minimal Risk / Minimal Risk	Minimal Risk / Minimal Risk	Almost certain	Forecastable	Minimal Impact				

4.3.7 Vulamehlo Local Municipality

Vulamehlo LM		Relative Risk Priority		Hazard Indices			Vulnerability Rating			
Climate change impacts	Range of time variability	Rural Areas: Commercial farming	Urban Areas: Substance Farming	Likelihood	Predictability	Hazard severity	Population clusters	Agricultural vulnerability	Environmental resilience	Cumulative Climatic hazards
Increase annual rainfall	> 10 years	Moderate risk / Minimal Risk	Minimal Risk / Moderate risk	Likely	Forecastable	Medium impact	This LM has the medium to low population density focused in the urban areas. Climate impacts impact will likely affect a large number of people in a smaller area.	There are large areas of commercial agriculture and there is sensitivity to rainfall variability. Vulnerability is medium to high.	This LM has large areas under commercial crops but also large grassland/vegetation areas. This LM has a medium resilience	Combined climate changes are considered high in this LM compared to the remaining district
Increased rainfall intensity in summer	> 10 years	Moderate risk / Moderate risk	Moderate risk / Moderate risk	Possible	Highly variable	Medium impact				
Seasonal rainfall shifts	> 10 years	Major risk / Moderate risk	Moderate risk / Major risk	Likely	Highly variable	Medium impact				
Drought potential	> 10 years	Major risk / Major risk	Major risk / Major risk	Likely	Mildly predictable	Significant impact	**Manageability / Capacity to Cope indices**			
							Measureable adaptation	Policy capacity	Personal Capacity	Institutional Capacity
Increased temperatures	> 10 years	Moderate risk / Moderate risk	Moderate risk / Moderate risk	Almost certain	Forecastable	Medium impact	There is very low adaptation rates and little implementation of technology. There is no (or very slow) delivery of training or support for locals and they lack knowledge regarding sustainability and have no adaptation strategy.	The LM focuses on climate change and sees it as a challenge to sustainable growth. This is a good start, but needs follow-through	The population of this LM have a combined low capacity. This is derived from their level of education and personal income.	The institutional capacity is medium. This LM has a mix of urbanised and rural areas. More formalised areas to the north east.
Increased extreme temperature days	> 10 years	Major risk / Moderate risk	Moderate risk / Major risk	Almost certain	Mildly predictable	Medium impact				
Increased heat wave incidence	> 10 years	Major risk / Moderate risk	Moderate risk / Major risk	Almost certain	Mildly predictable	Medium impact				
Decreased number of cold nights	> 10 years	Minimal Risk / Minimal Risk	Minimal Risk / Minimal Risk	Almost certain	Forecastable	Minimal Impact				

4.3.8 uMdoni Local Municipality

uMdoni LM		Relative Risk Priority		Hazard Indices			Vulnerability Rating			
Climate change impacts	Range of time variability	Rural Areas: Commercial farming	Urban Areas: Substance Farming	Likelihood	Predictability	Hazard severity	Population clusters	Agricultural vulnerability	Environmental resilience	Cumulative Climatic hazards
Increase annual rainfall	> 10 years	Moderate risk / Moderate risk	Moderate risk / Moderate risk	Likely	Forecastable	Significant impact	This LM has a high population density clustered to the west. Impacts in this area will have a larger disruption.	There is significant commercial agriculture in this LM and has a medium sensitivity to rainfall variations	This LM is transformed and has significant commercial agriculture and there is little natural vegetation. Environmental resilience is low	Climate will change in this LM but the impacts are less than other areas.
Increased rainfall intensity in summer	> 10 years	Major risk / Major risk	Major risk / Major risk	Likely	Highly variable	Significant impact				
Seasonal rainfall shifts	> 10 years	Moderate risk / Moderate risk	Moderate risk / Moderate risk	Likely	Highly variable	Medium impact				
Drought potential	> 10 years	Moderate risk / Moderate risk	Moderate risk / Moderate risk	Likely	Mildly predictable	Significant impact	**Manageability / Capacity to Cope indices**			
Increased temperatures	> 10 years	Moderate risk / Minimal Risk	Minimal Risk / Moderate risk	Almost certain	Forecastable	Medium impact	**Measureable adaptation**	**Policy capacity**	**Personal Capacity**	**Institutional Capacity**
Increased extreme temperature days	> 10 years	Major risk / Major risk	Major risk / Major risk	Almost certain	Mildly predictable	Significant impact	Strong adaptation and technology in the commercial areas and better landuse management has increased the adaptive capacity of the area.	The LM focuses on climate change in the IDP and the SDF and sees the need to have this mind-set in development	The population of this LM have a combined high capacity. This is derived from their level of education and personal income	The institutional capacity is high as there are several economic hubs, urban infrastructure and a focus on development
Increased heat wave incidence	> 10 years	Major risk / Major risk	Major risk / Major risk	Almost certain	Mildly predictable	Significant impact				
Decreased number of cold nights	> 10 years	Minimal Risk / Insignificant Risk	Insignificant Risk / Insignificant Risk	Almost certain	Forecastable	Minimal Impact				

4.3.9 Ezinqoleni Local Municipality

Ezingoleni LM		Relative Risk Priority		Hazard Indices			Vulnerability Rating			
Climate change impacts	Range of time variability	Rural Areas: Commercial farming	Urban Areas: Substance Farming	Likelihood	Predictability	Hazard severity	Population clusters	Agricultural vulnerability	Environmental resilience	Cumulative Climatic hazards
Increase annual rainfall	> 10 years	Moderate risk / Moderate risk	Moderate risk / Moderate risk	Almost certain	Forecastable	Medium impact	There is one main population centre. The remaining areas have medium to low density population. Higher density results in impact to a greater number of people.	There are areas of large scale agriculture. Reliance on potential irregularity of rainfall may increase vulnerability.	There are transformed areas and also large areas of commercial agriculture, this is however balanced by area under grassland or other vegetation and the area has medium environmental resilience	While there will be climate changes in the LM, these are significantly less than in other areas of the DM.
Increased rainfall intensity in summer	> 10 years	Major risk / Moderate risk	Moderate risk / Major risk	Likely	Highly variable	Medium impact				
Seasonal rainfall shifts	> 10 years	Major risk / Major risk	Major risk / Major risk	Almost certain	Highly variable	Medium impact				
Drought potential	> 10 years	Major risk / Major risk	Major risk / Major risk	Likely	Mildly predictable	Significant impact				
Increased temperatures	> 10 years	Moderate risk / Moderate risk	Moderate risk / Moderate risk	Almost certain	Forecastable	Medium impact				
Increased extreme temperature days	> 10 years	Major risk / Moderate risk	Moderate risk / Major risk	Almost certain	Mildly predictable	Medium impact				
Increased heat wave incidence	> 10 years	Major risk / Moderate risk	Moderate risk / Major risk	Almost certain	Mildly predictable	Medium impact				
Decreased number of cold nights	> 10 years	Moderate risk / Moderate risk	Moderate risk / Moderate risk	Almost certain	Forecastable	Medium impact				

Manageability / Capacity to Cope indices			
Measureable adaptation	Policy capacity	Personal Capacity	Institutional Capacity
There is some assistance from the communities and institutions with training however this is happening slowly. There is poor adherence to and knowledge of legislation. Communities adopting water harvesting techniques to	The IDP stresses responses to climate change as a PGDS Strategic Goal. Beyond that there is little policy specifying climate change actions.	The population of this LM have a combined low capacity. This is derived from their level of education and personal income	The institutional capacity is low as there as areas are predominantly classified as rural and lacking infrastructure.

4.4 Climate Change Impacts

The Ugu District is already familiar with climate related extremes in the form of droughts and flooding, posing a significant risk to the region's economy, ecosystems and population. However the impacts of a changing climate will stretch beyond the impacts of extreme events. Considering the socio-economic and environmental challenges currently faced by the Ugu District, increasing costs associated with the projected climate change impacts will compromise growth and development goals.

Climate related extreme events and long term impacts has already and will continue to place a significant financial burden on public sector service delivery, compounded by prevailing socio-economic and environmental factors contributing to overall vulnerability. This burden will continue to increase, if climate change is not adequately addressed across district through effective response strategies.

A summary of the likely climate change impacts associated with a range of possible climate risks for the Ugu District are summarized in Table 8: Summary of likely climate change risks and impacts for the Ugu District Municipality. These impacts were assed based on the results of the capacity, vulnerability and hazard mapping described above as well as in consultation with a number of key stakeholders and observations of the current socio-economic conditions.

Table 8: Summary of likely climate change risks and impacts for the Ugu District Municipality

Climate Risk	Likely Climate Change Impacts
Higher mean annual temperatures	• Increased evaporation and decreased water balance; • Reduced crop quality and food security.
Higher maximum temperatures, more hot days and more heat waves	• Increased heat stress on humans and livestock; • Increased incidence of heat-related illnesses; • Increased mortality and serious illness, particularly in older age groups; • Increased heat stress in livestock and wildlife; • Decreased crop yields and rangeland productivity; • Extended range and activity of some pests and disease vectors, specifically malaria; • Increased threat to infrastructure exceeding design specifications relating to temperature (e.g. road surfaces, electrical equipment, etc.); • Increased electric cooling demand increasing pressure on already stretched energy supply reliability; and • Exacerbation of urban heat island effect.
Higher minimum temperatures, fewer cold days and frost days	• Decreased risk of damage to some crops and increased risk to others such as deciduous fruits that rely on cooling periods; • Reduced heating energy demand; • Extended range and activity of some pests and disease vectors; and
Increased rainfall variability and subsequent drought potential	• Decreased average runoff, stream flow, groundwater recharge; • Decreased water security and potential increases in cost of water resources; • Decreased water quality; • Decrease in shoulder season length threatening sensitive crops; • Increased fire danger (drying factor); and

Climate Risk	Likely Climate Change Impacts
	• Impacts on rivers and wetland ecosystems.
Intensification of rainfall events	• Increased flooding; • Increased challenge to storm water systems in settlements; • Increased soil erosion; • Increased river bank erosion and demands for protective structures; • Increased pressure on disaster management systems and response; • Increased risk to human lives and health; and • Negative impact on agriculture such as lower productivity levels and loss of harvest which could lead to food insecurity.
Increased mean sea level and associated storm surges	• Salt water intrusion into groundwater and coastal wetlands; • Increased storm surges leading to coastal flooding, coastal erosion and damage to coastal infrastructure; and • Increased impact on estuaries and associated impacts on fish and other marine species.

The consequences of the projected climate change impacts will not be limited to their physical impacts. Climate change patterns and projected impacts will also have a significant impact on government's ability to perform their mandated roles and responsibilities. The interactions between climate change and government functions will be complex and more comprehensive risk assessments may be required to further assist decision making processes and prioritizing adaptation activities.

The following table describes the potential effects climate change impacts may have on certain functions of local government. The information contained in the table is not based on a comprehensive assessment, but represents expert opinions on the potential effects.

ASSETS/SERVICE DELIVERY	POTENTIAL CLIMATE CHANGE IMPACTS
Infrastructure	
• Roads	• Changes in rates of deterioration of municipal road infrastructure due to changes in precipitation and temperature; • Inundation of roads in during intensified rainfall events, resulting in deterioration or destruction; and • Interruption of road traffic and disruption of emergency transport routes due to extreme climatic events.
• Storm water systems	• Increased intensity of precipitation may cause intrusion into waste water networks; • Capacity of existing flood defences and drainage systems may be exceeded; • Changes in mean and peak flow rates of rivers; and • Reduced precipitation may have negative impacts on functioning of storm water systems.
• Coastal Infrastructure	• Increased coastal erosion and inundation;

ASSETS/SERVICE DELIVERY	POTENTIAL CLIMATE CHANGE IMPACTS
• Buildings	• Increased or permanent inundation of infrastructure and utilities; • Impacts on private and public harbours and boat ramps; and • Increased erosion or deterioration of coastal defences.
• Recreational Facilities/Community Assets	• Altered cooling cost; • Increased risk of damage from fires or extreme hydro-meteorological events; and • Higher rates of deterioration and increased maintenance costs. • Loss of public property due to inundation/flooding; • Impacts on tourism along due to changes in biodiversity, water availability; • Increased operating cost and maintenance of public property due to extreme weather events; • Reduced water quality and quantity for irrigation; and • Potential for closures due to extreme weather and/ or pollution levels.
Public Safety	
• Health (Figure 31) and Disaster Management	• Changes in geographical range and seasonality of vector-borne diseases specifically Malaria and Dengue; • Increased incidence of food and water-borne diseases due to increased temperatures; • Health impacts related to extreme precipitation and temperature events; • Intrusion of contaminants and pollutants into water sources due to excessive/intensified rainfall; • Increased demands on emergency response and recovery resources; • Public dissatisfaction with the government's response could lead to conflict; and • Adverse impacts on public safety and tourism, could impact regional economic performance.
Planning and Development	
• Development Planning	• Uncertainty over long-term land-use planning and infrastructure design; • Needs and costs for retrofitting; • Loss/destruction of private property and community assets; • Increased insurance costs; • Increased pressure on risk management and response resources; • Untimely decommissioning of infrastructure; • Adverse impacts on public safety and tourism, could impact regional economic performance; • Impacts on existing community structures and livelihoods • Required alteration to development plans, risk assessment procedures and zoning; and • Increased pressure on educational resources to facilitate adaptation.

ASSETS/SERVICE DELIVERY	POTENTIAL CLIMATE CHANGE IMPACTS
Economic Development	• Impacts on local economy and food security due to impacts on agriculture and water supply; • Increased insurance costs; • Increase in food prices; • Losses incurred by industries directly dependent on agricultural production (e.g. fertiliser manufacturers); • Reduced tax revenues because of potential reduced expenditures; • Increased maintenance cost for community and private assets; • Economic consequences of impacts on the Tourism Sector; • Business closure and potential for job losses due to interruptions resulting from water shortages, inundation, flooding, blackouts, etc.; • Altered agricultural regimes and practices, such as crop diversification due to reduced water availability of heat stress; and • Climate change impacts may cause alteration of traditional sources of rural revenue.
Natural Resource Management	
• Agriculture	• Projected climate change may lead to inferior crop yields and poor veld conditions; • Reduction in and degradation of animal habitats; • Lack of livestock feed and drinking water; • Increase in disease outbreak and increased vulnerability to predation; • Increased risk of soil erosion; • Annual and perennial crop losses; • Damage to crop quality; and • Disruption of animal breeding and/or crop cycles.
• Biodiversity	• Changes in the distribution of invasive species and associated loss of biodiversity and subsequent altered veldfire intensity; • Changes in the geographical distribution of indigenous fauna and flora; • Increased risk of species extinction; • Reduced ecosystem resilience; and • Increased stress on ecosystems and ecosystem services.
• Coastal Management	• Increased erosion and inundation; • Loss of private property and community assets; • Loss of beach width; and • Changes to wetland and estuary ecosystems due to sea level rise, erosion and saline intrusion.
Water and Sewerage Services	
• Storm water and Sewage	• Inundation of storm water and sewage systems; • Increased peak flow rates; • Changes in groundwater levels; • Shifting flood plains; and • Reduced dry weather flow rates.
• Wastewater	

ASSETS/SERVICE DELIVERY	POTENTIAL CLIMATE CHANGE IMPACTS
• Water supply	• Increased intensity of precipitation may cause intrusion into waste water networks; and • Potential for blockages and overflows. • Changes in the mean and peak flow rates of rivers and streams; • Reduced groundwater recharge; • Increased treatment due to poorer water quality (potential taste/odour/ dissolved iron and manganese problems); • Unreliable/insufficient water supply; • Increased risk of contamination; • Salination of water sources; and • Changes/shifting of groundwater used for irrigation.

Health implications

In the presence of increased temperatures and more variable and shifting rainfall patterns, the propagation and disposal of disease vectors will change. Often this will compromise communities that are unequipped and unprepared to the new timing and extent of these pathogens and disease vectors.

		Temperature ↑	Precipitation ↑	Precipitation ↓	Humidity ↑	Precipitation extremes ↑
Mosquito based	Malaria	Variable local effect ±	Variable local effect ±	Local effect −	Variable local effect ±	Variable local effect ±
	Dengue	Global effect +	Global effect +	Global effect −	Variable effect ±	Variable local effect ±
Tick-borne	Encephalitis	Possible +				
	Lyme	Possible +			Potentially +	
Vector-borne	Hemorrhagic Fever (renal syndrome)	Local effect +	Local effect +		Local effect +	
	Plague	Possible +	Possible +			
Vector transition potential		Decreased survival − Increased feeding rate, increased human contact + Expanded distribution + Increased population growth + Change in susceptibility to some pathogens +	Increases larval habitat and vector population size + Flooding can eliminate habitat − Flooding may increase snail habitat downstream +	Droughts could reduce snail populations − Increased breeding in dry river beds + Increased storage, increase container-breeding +	Increased humidity increases vector survival +	Heavy rainfall can wash away breeding sites − Heavy rainfall events can increase vector host-seeking and virus transmission +
Affect on Pathogen		Increased rate of extrinsic incubation + Increased transmission season + Expanded distribution +				
Vertebrate host transition potential		Warmer winter favours rodent survival +	Increased food availability and population size +	Decreased food can reduce populations − Rodents likely to move into housing areas, increasing human contact +		Increased risk of contamination with pathogens from rodents or their waste +

Climate factor
↑ Increase
↓ Decrease
Prevalence
+ Increase
− Decrease

IPCC AR3 - Working Group II: Impacts, Adaptation and Vulnerability - Chapter 9.7. Infectious Diseases
http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=358#tab92

Figure 31 - climate changes on disease prevalence

Sea level rise implications

Climate change will result in sea-level rise and potential coastal inundation, land loss and salt water intrusion in the coastal settlements (DEA, 2013). Additionally there are risks associated with increased severe storms, erosion, tidal influence and flooding that further impacts coastal settlements through

the loss of property and damage to infrastructure (DEA, 2013; Taylor and Peter, 2014). There are also indirect impacts in the coastal areas through the decline in marine fisheries and tourism revenue.

Climate change impacts are estimated to reduce the value of South African fisheries by approximately 18% with potential shifts in fish stocks impacting particularly on smaller coastal settlements and artisanal fishing communities. These impacts on marine diversity affect livelihoods and coastal economies (DEA, 2013). Extreme weather also endangers fishing boats (DEA, 2013). Small fishing ports may need to upgrade their infrastructure in order to be more resilient to climate hazards. Shipping movements will be affected causing expensive delays and changes in global trade.

Although South Africa is not considered to be particularly vulnerable to the impacts of sea level rise, as compared to other countries such as Bangladesh or Mozambique (Dasgupta, 2007), there are specific local municipalities along the coast that have a relatively significant amount of land that is considered to be at risk from possible sea level rise and increased storm surges (i.e. below 5.5 m above mean sea level), (DEA, 2015b). This does not include the possible additional impacts in terms of sea water intrusion into coastal aquifers that may impact some coastal communities and existing farming areas.

GIS analysis estimates 2,130 km² of coastline at risk (Figure 32) due to a 1m sea level rise scenario (bearing in mind inundation, wave swash and tidal influences can impact areas below 5.5m). The cumulative impacts of sea level rise and the increased wave swash will render significant areas unsuitable for human settlements. In Ugu DM the municipalities affected will be Hibiscus Coast, uMdoni and Umzumbe with extreme sea level rise impact areas of 15-26km², 3-7km²and 0-2km² respectively.

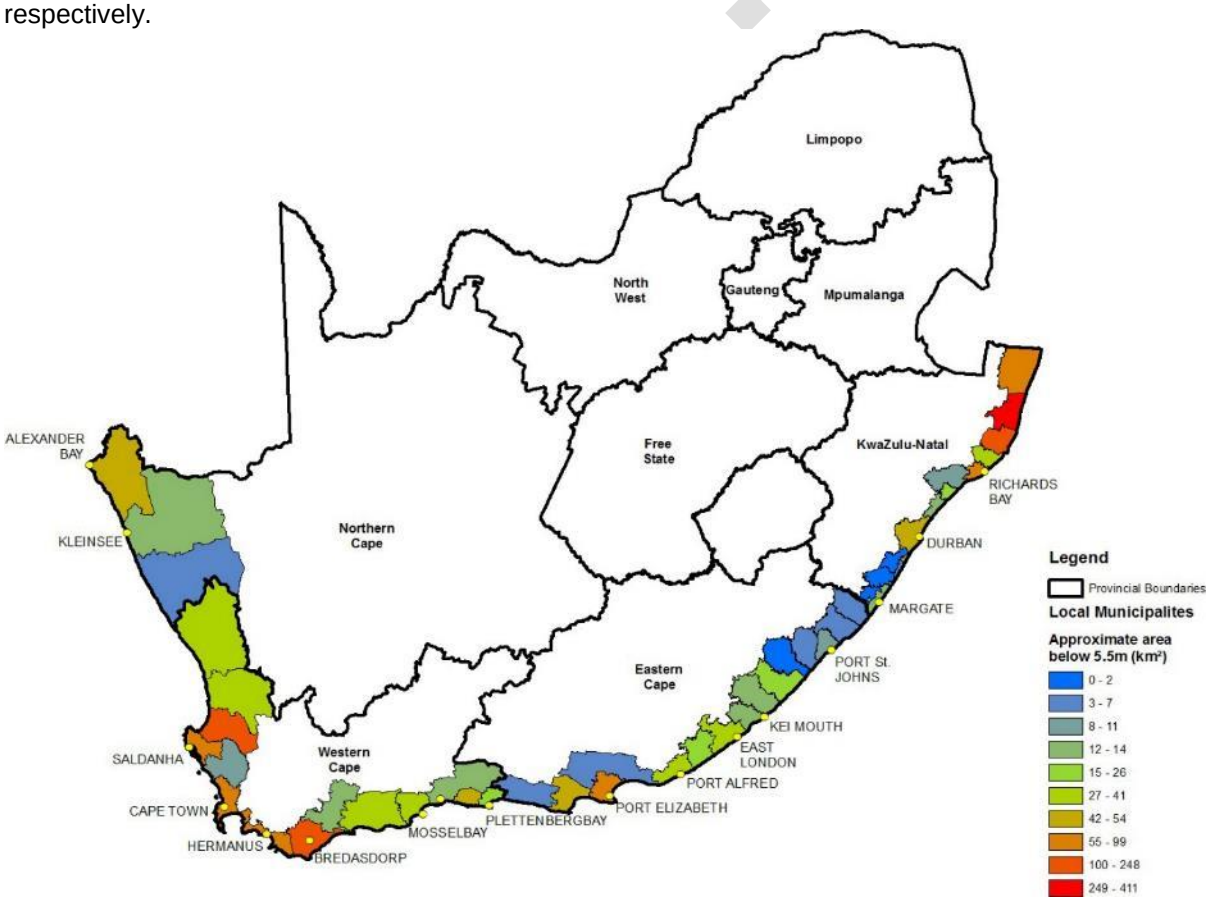


Figure 32: Exposure to eustatic sea-level rise across South Africa's local Municipalities based on extent of land under 5.5 metres (Source: Peter Wilson, Aurecon Group, 2014

This impact would have significant financial sectoral implications for human settlements in terms of infrastructure and property assets (Table 9).

Table 9: Summary of National Sea-level rise costs 2010-2100 under two scenarios (2010 prices)

	Low (0.5m eustatic rise and swash up to 5.0 metres by 2100)	High (1m eustatic rise and swash up to 5,5 metres by 2100)
Public Infrastructure	R11,3bn	R20,7bn
Real Estate and Private Assets	R154.4bn	R273.1bn
Tourism	R45.9bn	R91.8bn
TOTAL	**R211,5bn**	**R385,5bn**

The impact of sea level rise is likely to be felt more at a local level rather than whole cities or towns. For example, without any adaptation responses to sea level rise the beachfront area of Scottburgh will experience increased risk to infrastructure and developments such as the Crocworld or the Scottburgh Caravan Park, however areas further inland should be unaffected, other than potentially lost revenue from decrease tourism in the area. The coastlines of KwaZulu-Natal Coast have been identified as one of the most vulnerable coastal settlements (Theron and Rossouw, n.d.)

Table 10: Areas at risk due to sea level rise

Risk focus Area	Risk type	Infrastructure at risk	Property at risk
Izotsha	Inundation up the Zotsha river	Marine Drive and the R61 in extreme scenarios	Properties in Kinsley Drive, Shepstone Road and the developments to the east of Shelly Centre.
Melville	Inundation in Mzumbe river and surrounding area.	R102 and railway over Mzumbe river.	Community to the east of the R102 by Umzumbe railway terminal.
Mtwalume and Fafa	Inundation in the Mtwalume River and river mouth.	N2 and railway	Leuchars Drive, Sidney Gee lane, Marine Place
Scottburgh	Inundation of Mpambanyoni and Mahlongwa River	R102 and railway, Marine Terrace	Properties along Marine Terrace and Bermuda Way

4.5 Priority Sectors

Climate change impacts will affect almost all sectors (Figure 33). Local government will have to pay attention to time horizons and the evolution of risks associated with projected climate changes, and reassess the suitability of response options and projects over time. Climate change related insecurity in one sector may also be diffused to other sector through complex their complex interrelationships. A balanced approach with short, medium and long term adaptation interventions will be critical for reducing vulnerability to climate change impacts and achieving sustainable growth and development.

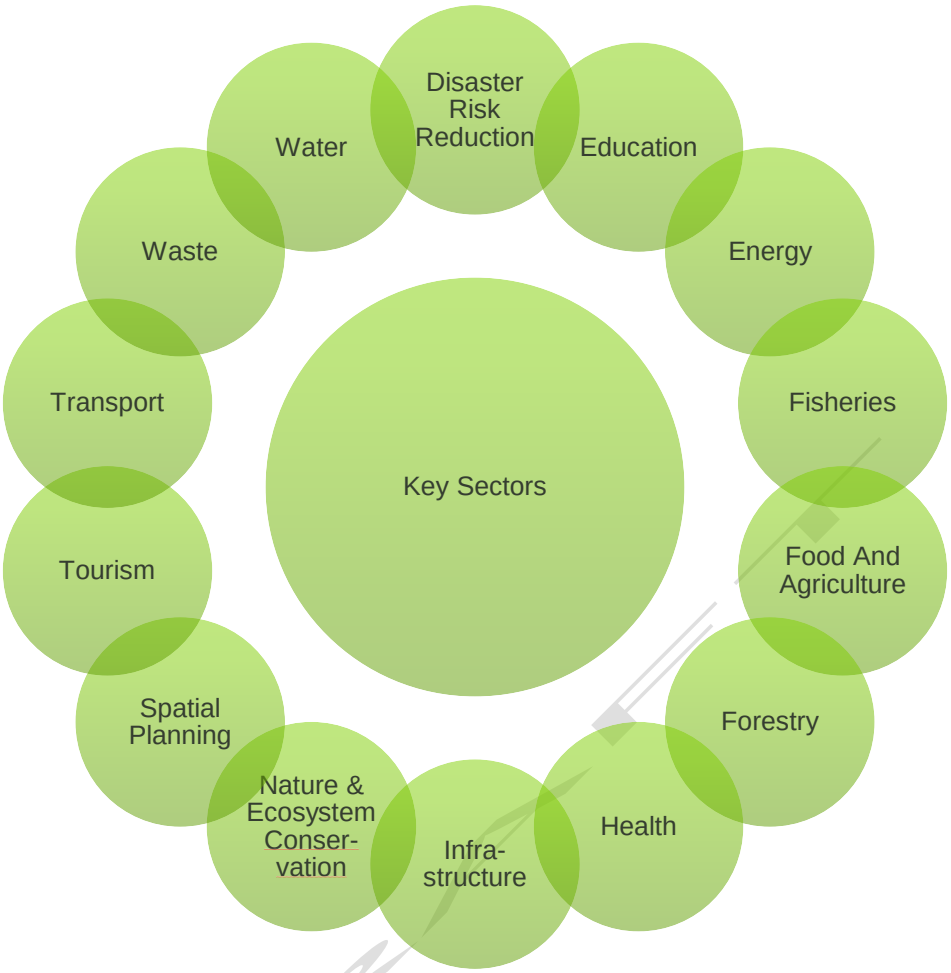


Figure 33 Sectors affected by climate change[21]

In order to implement an effective response to climate change, primary response efforts will be focused on priority sectors to assist with the mainstreaming of climate change response. The priority sectors should be reviewed on a regular basis to assess relevance in the context of future conditions.

Priority sectors have been identified based on the climate and potential significance of impacts, sectors' economic importance, significance of adaptation measures in the sector, time horizons of impacts and urgency of intervention, and potential social and environmental significance of climate change impacts. The identified priority sectors and urgency of response are given in Table 5.

[21] UN CC: Learn. 2014. Introduction to Climate Change Adaptation.

Table 11: Prioritization based economic, social and environmental criteria and temporal scales.

Sector*	Primary Impact Category	Urgency/Time horizon of impact Short Term – 2015-2020 Medium Term – 2020-2050 Long Term – +2050
Energy	Social	Medium Term
Municipal Infrastructure	Economic	Short term
Water Resources	Social/Environmental	Short & Medium Term
Terrestrial Biodiversity	Environmental	Long Term
Disaster Management	Economic/Social	Medium Term
Agriculture	Economic/Social	Short & Medium Term
Tourism	Social/Economic	Short, Medium & Long Term

Error! Reference source not found.. These are elaborated on in the following sections.

Table 12: Climate Change Risks for the Ugu District

Focus Area	Potential Risks
• Energy	• Increased energy demand related to heating and cooling; • Damage to distribution infrastructure due to extreme weather events and veldfires; and • Potential impacts of climate variations on renewable energy production.
• Infrastructure Projects including transport, buildings, water management, waste water treatment and waste management	• Changes in rates of deterioration due to changes in precipitation and temperature; • Inundation of roads resulting in deterioration or destruction; • Interruption of road traffic and disruption of emergency transport routes due to extreme climatic events; • Disruption of emergency routes; • Increased intensity of precipitation may cause intrusion into waste water networks; • Capacity of existing flood defences and drainage systems may be exceeded; • Reduction of drainage capacity due to sea level rise or storm surges; • Changes in mean and peak flow rates or rivers; • Reduced precipitation may impact on functioning of storm water systems; • Altered heating and cooling cost; • Increased risk of damage from fires or extreme hydro-meteorological events; • Higher rates of deterioration and increased maintenance costs; • Increased erosion and periods inundation; • Increased or permanent inundation of infrastructure and utilities; • Loss of public property due to inundation;

Focus Area	Potential Risks
	• Impacts on tourism due to changes in biodiversity, water availability; • Increased operating cost and maintenance of public property due to extreme weather events; • Reduced water quality and quantity for irrigation; and • Potential for beach closures due to extreme weather and/or pollution levels.
• Water resource quality and Conservation	• Inundation of storm water and sewage systems; • Increased peak flow rates; • Changes in groundwater levels; • Shifting flood plains; • Reduced dry weather flow rates; • Increased intensity of precipitation causing intrusion into waste water networks; • Potential for blockages and overflows; • Changes in the mean and peak flow rates of rivers and streams; • Unreliable/insufficient water supply; • Increased risk of contamination; • Salination of water sources; and • Changes/shifting of groundwater used for irrigation.
• Terrestrial Biodiversity	• Increased erosion and inundation; • Loss of private property and community assets; • Changes to river ecosystems due to erosion and flow rates; • Changes in the distribution of invasive species and associated loss of biodiversity and altered veldfire intensity; • Changes in the geographical distribution of indigenous fauna and flora; • Increased risk of species extinction; • Reduced ecosystem resilience; • Increased stress on ecosystems and ecosystem services; and
• Disaster Management/Health	• Changes in geographical range and seasonality of vector-borne diseases - Malaria; • Increased incidence of food and water-borne diseases due to increased temperatures; • Health impacts related to extreme events; • Intrusion of contaminants and pollutants into water sources due to excessive rainfall; • Increased demands on emergency response and recovery operations; and • Adverse impacts on public safety and tourism, impacting regional economic performance.
• Agriculture	• Projected climate change may lead to inferior crop yields and poor veld conditions;

Focus Area	Potential Risks
	• Reduction in and degradation of animal habitats; • Lack of livestock feed and drinking water; • Increase in disease outbreak and increased vulnerability to predation; • Increased risk of soil erosion; • Annual and perennial crop losses; • Damage to crop quality; and • Disruption of animal breeding and/or crop cycles. • Reduce employment opportunities in commercial sector; and • Increased livelihood and food insecurity among subsistence farmers.
• Tourism	• Water supply security compromised dissuades tourism • Increased perception may detract from beach going activities. • Changes to ecosystem may impact wildlife and natural beauty. • Potentially more drowning incidents • Beach erosion reduces the appeal to holiday makers. • Outdoor activities will be limited to the warmer seasons. • Extreme weather events can damage tourism infrastructure and have a negative impact on the nature reserves. • Damage to beach and sanitation infrastructure, potential loss of beach Blue Flag status[22].

[22]Ugu District Growth and Development Strategy: Final Report (December 2012).

4.5.1 Sectoral risk and impacts vs municipality risk profile.

Tables below summarize each of the climate change impacts that are likely to affect the different sectors. It presents the risk profiles of each local municipality against the identified likely climate change risk and impacts associated with the changed climate parameter. Further elaboration on the sectoral risk and impacts are given in section 4.5.2.

4.5.1.1 Energy

Energy	Ezingoleni		Hibiscus Coast		uMdoni		uMuziwabantu		Umzumbe		Vulamehlo		
Climate change impacts	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Risks and impacts
	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	
Increased rainfall intensity in summer	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	• Increased flooding potentially damaging electrical infrastructure • Increased average runoff, stream flow, groundwater recharge
	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	
Increased temperatures	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Minimal Risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	• Increased temperatures negatively impact solar power production • Increased electric cooling demand increasing pressure on already stretched energy supply reliability
	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	
Increased extreme temperature days	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Catastrophic Risk	Major risk	Major risk	Moderate risk	• Increased temperatures negatively impact solar power production • Increased electric cooling demand increasing pressure on already stretched energy supply reliability
	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Catastrophic Risk	Moderate risk	Major risk	
Increased heat wave incidence	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	Moderate risk	• Increased temperatures negatively impact solar power production • Increased electric cooling demand increasing pressure on already stretched energy supply reliability
	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	

4.5.1.2 Municipal Infrastructure

Municipal Infrastructure	Ezingoleni		Hibiscus Coast		uMdoni		uMuziwabantu		Umzumbe		Vulamehlo		
Climate change impacts	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Risks and impacts
	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	
Increased rainfall intensity in summer	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	• Increased flooding potentially damaging infrastructure • Increased challenge to storm water systems in settlements • Increased soil erosion, long term damage to infrastructure • Increased river bank erosion and demands for protective structures
	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	
Increased temperatures	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Minimal Risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	• Increased threat to infrastructure exceeding design specifications relating to temperature (e.g. road surfaces, electrical equipment, etc.) • Exacerbation of urban heat island effect
	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	
Increased extreme temperature days	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Catastrophic Risk	Major risk	Major risk	Moderate risk	• Increased threat to infrastructure exceeding design specifications relating to temperature (e.g. road surfaces, electrical equipment, etc.) • Exacerbation of urban heat island effect
	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Catastrophic Risk	Moderate risk	Major risk	
Increased heat wave incidence	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	Moderate risk	• Increased threat to infrastructure exceeding design specifications relating to temperature (e.g. road surfaces, electrical equipment, etc.) • Exacerbation of urban heat island effect
	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	

4.5.1.3 Water Resources

Water Resources	Ezingoleni		Hibiscus Coast		uMdoni		uMuziwabantu		Umzumbe		Vulamehlo		
Climate change impacts	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Risks and impacts
	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	
Increase annual rainfall	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Minimal Risk	• Increased average runoff, stream flow, groundwater recharge • Increased flooding potential • Increased challenge to storm water systems in settlements • Impacts on rivers and wetland ecosystems
	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Minimal Risk	Moderate risk	
Increased rainfall intensity in summer	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	• Increased flooding • Increased challenge to storm water systems in settlements • Increased soil erosion • Increased river bank erosion and demands for protective structures
	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	
Seasonal rainfall shifts	Major risk	Major risk	Minimal Risk	Insignificant Risk	Moderate risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	• Decrease in shoulder season length impacts water resources and increases dry spell duration • Planting regimes impacted through anomalous rainfall patterns
	Major risk	Major risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	
Drought potential	Major risk	Major risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Major risk	• Traditional planting regimes and variety impacted through anomalous rainfall patterns • Less over all water available for all sectors with potential water-shedding / increased water stress • Reduced water security / quality • Impacts on rivers / wetland ecosystems • Overexploitation of groundwater resources
	Major risk	Major risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	
Increased temperatures	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Minimal Risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	• Increased evaporation and decreased water balance
	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	

4.5.1.4 Terrestrial Biodiversity

Terrestrial Biodiversity	Ezingoleni		Hibiscus Coast		uMdoni		uMuziwabantu		Umzumbe		Vulamehlo		
Climate change impacts	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	**Risks and impacts**
	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	
Increase annual rainfall	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Minimal Risk	• Increased soil erosion • Increased river bank erosion and demands for protective structures • Impacts on rivers and wetland ecosystems
	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Minimal Risk	Moderate risk	
Seasonal rainfall shifts	Major risk	Major risk	Minimal Risk	Insignificant Risk	Moderate risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	• Decrease in shoulder season length threatening sensitive vegetation • Changes may disrupt growing patterns and may focus particular species over indigenous vegetation
	Major risk	Major risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	
	#N/A	#N/A											
Increased temperatures	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Minimal Risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	• Increased evaporation and decreased water balance • Anomalous temperature may bias in favour of particular species over indigenous vegetation
	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	
Decreased number of cold nights	Moderate risk	Moderate risk	Insignificant Risk	Insignificant Risk	Minimal Risk	Insignificant Risk	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	• Extended range and activity of some pests and disease vectors • Anomalous temperature may bias in favour of particular species over indigenous vegetation
	Moderate risk	Moderate risk	Insignificant Risk	Insignificant Risk	Insignificant Risk	Insignificant Risk	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	

4.5.1.5 Disaster Management

Disaster Management	Ezingoleni		Hibiscus Coast		uMdoni		uMuziwabantu		Umzumbe		Vulamehlo		
Climate change impacts	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Risks and impacts
	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	
Increased rainfall intensity in summer	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	• Increased flooding. risk to human lives and health • Increased challenge to storm water systems in settlements • Increased river bank erosion and demands for protective structures • Increased pressure on disaster management systems and response
	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	
Drought potential	Major risk	Major risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Major risk	• Less over all water available for all sectors • Potential water-shedding and increased water stress • Reduced water security • Decreased water quality • Exploitation and overexploitation of groundwater resources
	Major risk	Major risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	
Increased extreme temperature days	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Catastrophic Risk	Major risk	Major risk	Moderate risk	• Increased heat stress on humans and livestock • Increased incidence of heat-related illnesses • Increased mortality and serious illness, particularly in older age groups
	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Catastrophic Risk	Moderate risk	Major risk	
Increased heat wave incidence	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	Moderate risk	• Extended range and activity of some pests and disease vectors, specifically malaria • Increased threat to infrastructure exceeding design specifications relating to temperature (e.g. road surfaces, electrical equipment, etc.) • Increased heat stress in livestock and wildlife
	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	

4.5.1.6 Agriculture

Agriculture	Ezingoleni		Hibiscus Coast		uMdoni		uMuziwabantu		Umzumbe		Vulamehlo		
Climate change impacts	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Risks and impacts
	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	
Increase annual rainfall	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Minimal Risk	• Increased average runoff, stream flow, groundwater recharge • Increased flooding and crop damage potential • Increased soil erosion • Increased river bank erosion and demands for protective structures • Traditional planting regimes and variety impacted through anomalous rainfall patterns
	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Minimal Risk	Moderate risk	
Increased rainfall intensity in summer	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	• Increased flooding • Increased soil erosion • Increased river bank erosion and demands for protective structures • Increased risk to human and livestock lives and health • Negative impact on agriculture such as lower productivity levels and loss of harvest which could lead to food insecurity
	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	
Seasonal rainfall shifts	Major risk	Major risk	Minimal Risk	Insignificant Risk	Moderate risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	• Decrease in shoulder season length threatening sensitive crops • Traditional planting regimes impacted through anomalous rainfall patterns • Shorter rain periods impact the maturity of crops reducing the quality and yield
	Major risk	Major risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	
Drought potential	Major risk	Major risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Major risk	• Traditional planting regimes and variety impacted through anomalous rainfall patterns • Less over all water available for all sectors • Potential increased water stress • Decreased water quality
	Major risk	Major risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	

Agriculture	Ezingoleni		Hibiscus Coast		uMdoni		uMuziwabantu		Umzumbe		Vulamehlo		
Climate change impacts	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	**Risks and impacts**
	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	
													• Exploitation and overexploitation of groundwater resources
Increased temperatures	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Minimal Risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	• Increased evaporation and decreased water balance • Reduced crop quality and food security
	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	
Increased extreme temperature days	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Catastrophic Risk	Major risk	Major risk	Moderate risk	• Increased heat stress on humans and livestock • Increased incidence of heat-related illnesses
	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Catastrophic Risk	Moderate risk	Major risk	
Increased heat wave incidence	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	Moderate risk	• Decreased crop yields and rangeland productivity • Extended range and activity of some pests and disease vectors, specifically malaria • Increased heat stress in livestock and wildlife
	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	
Decreased number of cold nights	Moderate risk	Moderate risk	Insignificant Risk	Insignificant Risk	Minimal Risk	Insignificant Risk	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	• Extended range and activity of some pests and disease vectors • Reduced risk of cold-related deaths and illnesses
	Moderate risk	Moderate risk	Insignificant Risk	Insignificant Risk	Insignificant Risk	Insignificant Risk	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	

4.5.1.7 Tourism

Tourism	Ezingoleni		Hibiscus Coast		uMdoni		uMuziwabantu		Umzumbe		Vulamehlo		
Climate change impacts	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	Rural Areas	Urban Areas	**Risks and impacts**
	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	Commercial farming	Substance Farming	
Increase annual rainfall	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Minimal Risk	• Increased rainfall might change the perception as a tourist destination, particularly as most attractions are outdoors • Increased river bank and beach erosion decreases tourism appeal
	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Minimal Risk	Minimal Risk	Minimal Risk	Moderate risk	
Increased rainfall intensity in summer	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Moderate risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	• Increased flooding and damage to tourism infrastructure • Increased pressure on disaster management systems and response • Increased risk to human lives and health
	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	
Seasonal rainfall shifts	Major risk	Major risk	Minimal Risk	Insignificant Risk	Moderate risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	• Less over all water available for all sectors • Changes to weather during holiday period, may become unsuitable
	Major risk	Major risk	Minimal Risk	Minimal Risk	Moderate risk	Moderate risk	Major risk	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	
Drought potential	Major risk	Major risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Major risk	Major risk	• Less over all water available for all sectors, water insecurity will be a disincentive to travel • Decreased water quality
	Major risk	Major risk	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	
Increased extreme temperature days	Major risk	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Moderate risk	Catastrophic Risk	Major risk	Major risk	Moderate risk	• Increased heat stress on humans in outdoor areas • Increased incidence of heat-related illnesses • Activities may no longer be feasible in extreme temperatures
	Moderate risk	Major risk	Moderate risk	Major risk	Major risk	Major risk	Major risk	Major risk	Major risk	Catastrophic Risk	Moderate risk	Major risk	

4.5.2 Expanded sectoral impacts

The details below provide more information to the risks and vulnerabilities likely to be experienced in each of the major sectors within Ugu District. The risk and vulnerabilities between the various sectors will be different in each local municipality.

4.5.2.1 Energy Sector

It is clear that the projected impacts of climate change will be increasingly experienced in the years to come, with significant consequences for the electricity sector. Addressing climate change risks and guaranteeing a consistent supply of electricity will require the UGU DM to address the ageing electricity infrastructure and current levels of carbon emissions.

With regards to climate change impacts on the energy sector we are able to differentiate between direct and indirect impacts. Direct impacts will affect energy resource availability, power production, transmission and distribution. Indirect impacts include factors such as competition for shared resources and altered supply and demand trends. Direct impacts are generally more visible but the costs of indirect impacts often exceeds direct impacts

Even with current national policies favoring energy efficiency and renewable energy, energy demands are expected to continue increasing. Along with the expected demand for energy, price increases are also anticipated. Climate change variables are expected to increase energy demands to varying degrees as heating and/or cooling requirements increase, compounding the existing pressures on electricity supplies in the UGU DM.

Renewable energy will prove fundamental to increasing the resilience of the energy sector, both increasing the electricity systems resilience in the short term and mitigating climate change over the long term. However, the increased intensity of extreme weather events and temperatures has the potential to affect both traditional and renewable energy production and distribution infrastructure.

The risks posed to the energy sector will be dependent on vulnerability of related infrastructure and availability of resources. For example, following service disruptions caused by climate change related impacts and extreme events, restoring distribution will be dependent on road access and availability of resources and infrastructure components.

4.5.2.2 Municipal Infrastructure

An overview of the district and local municipal infrastructure at risk of climate change are presented in the table below.

Table 13: Municipal Infrastructure at Risk

Category	Infrastructure Elements
Transportation	Roads (Tarred and Gravel); Culverts; and Bridges.
Buildings	Residential and Commercial/Industrial
Critical Infrastructure	Fire Stations; Hospitals; Educational facilities; Police stations; Facilities for children and the elderly; Emergency medical services; and Water treatment facilities.
Storm & Wastewater Systems	Pipes; Manholes;

Category	Infrastructure Elements
	Storm water Management Facilities; Lift/Pumping Stations; and Outlets.
Water Distribution Network	Water mains under bridges.
Flood Protection Structures	Dams; Flood walls; Bridges and culverts; and Canals.
Human Settlements	Buildings and structures

At present little research has been done to assess the impact of climate change on infrastructure at the municipal level. Changing climate variables has the potential to significantly impact municipal infrastructure, and local governments will be required to consider climate change implications when planning future infrastructure projects. The Long-Term Adaptation Flagship Research Programme has specifically highlighted the potential impacts on the maintenance of road infrastructure. Ugu specific impacts can be seen in Figure 34.

The transport sector is highlighted due to the fact that it will face impacts related to every aspect of climate change. Extreme temperatures will test the limitations of construction materials. Longer dry periods will cause problems through increased subsidence, while more frequent intense rainfall events increase risk of flooding and erosion. This may impact the collapse of cuttings, embankments culverts, etc.

In general, the management of municipal infrastructure comes with many challenges which are often compounded for smaller municipalities with limited resources. These challenges are posed by the management of ageing infrastructure, population growth or decline, public demands, regulations, liability and risk management. The risk to infrastructure in the UGU DM can, to a large degree, be attributed to general maintenance and the lack thereof.

To date most of the municipalities in the UGU DM have implemented a reactive approach towards infrastructure management. In order to provide reliable levels of service in the face of climate change, municipalities will have to review their planning, design and asset management approaches in order to incorporate climate change considerations.

The LTAS assessment [23]shows the infrastructure potentially at risk from flooding events during future extreme rainfall events (Figure 34). It shows a significant proportion of bridge infrastructure along the coast in Hibiscus Coast and Umdoni, the majority of these are medium risk. The impermeable surfaces of the urban areas enhance this flood damage potential and these bridges are at risk from over topping and the subsequent damage caused. The inland LMs present a reduced number of assets at risk compared to the coastal areas

The inland areas UGU DM have a high to extremely high sedimentation yield though heightened river erosion potential[24]. This higher suspended and deposited load may compromise river integrity and storm water systems in the event of high rainfall events. These considerations should be accounted for when planning development and in the management of water resources such as reservoir sedimentation control.

[23] DEA (Department of Environmental Affairs). 2013. Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) for South Africa. Climate Trends and Scenarios for South Africa. Pretoria, South Africa.

[24] Msadala, V., Gibson. L., Le Roux, J., Rooseboom, A. Basson, G.R., (2010), Sediment Yield Prediction for South Africa: 2010 Edition, Water Research Commission, WRC Report No. 1765/1/10 ISNB 978-1-4312-0042-9

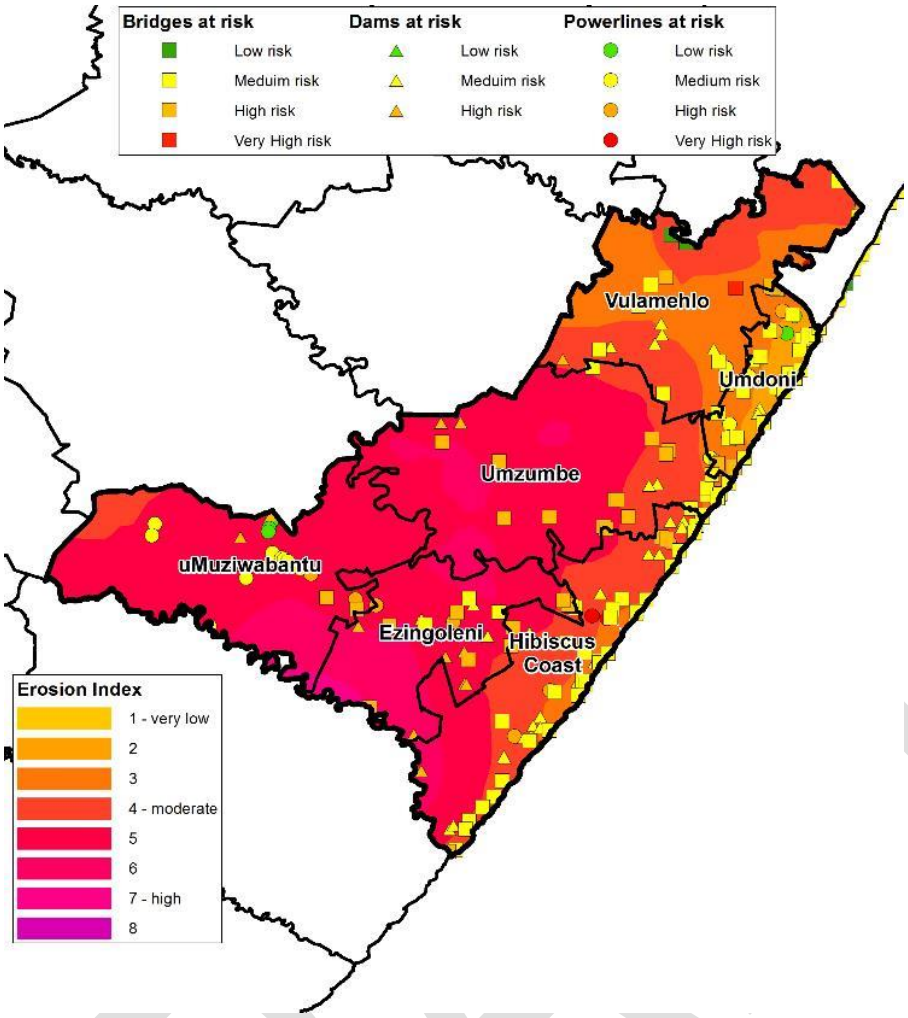


Figure 34: Ugu infrastructure at risk from flooding events and potential erosion index

4.5.2.3 Water Resources

With variations in rainfall patterns being projected and the local economies' dependency on water availability, water resource management will become a critical component of the UGU DM's climate change strategy. The UGU DM has significant amount rural settlements that have already received or have been earmarked for water schemes and relies on groundwater and river resources. The direct effect of climate change on groundwater resources depends upon the change in the volume and distribution of groundwater recharge. If drier, warmer conditions lead to the seasonal deficits in the moisture content of soils and less frequent, but more intense rainfall events occur, the groundwater recharge season may be shortened. In the long term the projected frequency and intensity of rainfall events in the district may reduce groundwater recharge, but the greater variability in rainfall could also mean more frequent and prolonged periods of high or low water levels.

The effects of climate change on groundwater in the UGU DM therefore may include:

- a long term decline in groundwater storage;
- increased frequency and severity of groundwater droughts;
- increased frequency and severity of groundwater-related floods;
- mobilisation of pollutants due to seasonally high water tables.

The impacts of climate change could increase the cost of providing water supplies, already rising as a result of deteriorating groundwater quality in some areas of the district. It is important to note that groundwater cannot be considered in isolation. The impacts of climate change not necessarily related to groundwater, such as changing land use and population density, will have a knock-on effect on groundwater, through changes in water demand.

Based on the drying and warming scenarios projected for the UGU DM, irrigation requirements will increase while water availability may decrease, emphasizing the need for sound catchment management strategies. Water availability will have a significant impact on the agricultural sector due to the reliance on irrigation. With the

assurance of water supply already low in areas of the UGU DM all farming activities and agricultural productivity will be significantly affected.

Scenarios of reduced water availability will also have implications for the management of water quality. As flows decrease, the water quality of river systems will decline rapidly downstream becoming increasingly mineralized. Intensified rainfall events projected as a potential climate change impact in the UGU DM, may also prove a particular problem for water quality, sanitation and soil erosion. Flooding may cause contamination of water sources due to the transportation of topsoil, animal waste, pesticides and fertilizers, sewage and other pollutants into water sources.

4.5.2.4 Terrestrial Biodiversity

Natural ecosystems have long demonstrated their adaptive abilities with regards to changes in the environment. Unfortunately the rate of climate change may exceeding the adaptive capacity of some ecosystems within the Ugu DM. In addition to climate change, natural environments within the Ugu DM are also under pressure from human activities, further compromising their ability to absorb the shocks associated with climate change. Therefore the resilience of natural resource systems will often be reliant on communities' ability to make the necessary behavioural adjustments.

The vulnerability of the Ugu DM's biodiversity to climate change is compounded by limited access to capital and technology, and lack of human and financial resources for implementing protective strategies. As indicated in table above projected climate change impacts relevant to biodiversity in the Ugu DM includes:

- Changes to ecosystems due to variable rainfall patterns and erosion;
- Changes in the distribution of invasive species and associated loss of biodiversity and altered veldfire intensity;
- Potential changes in the geographical distribution of indigenous fauna and flora;
- Increased risk of species extinction;
- Reduced ecosystem resilience; and
- Increased stress on ecosystems and ecosystem services.

The long term impacts of climate change on terrestrial biodiversity are complex and warrant more focussed research. Climate variations are expected to have a significant impact on agriculture within the UGU DM due to the adverse impacts on terrestrial systems and the provision of ecosystems services.

4.5.2.5 Disaster Management

An effective disaster risk management function within the district and local municipalities will be a fundamental component in improving resilience to climate change. On a national level South Africa possesses the necessary mechanisms to facilitate an integrated approach to disaster management. These mechanisms include the National Disaster Management Act (57 of 2002) and the National Disaster Management Framework (2005).

At present the District maintains a largely reactive approach towards disaster management, apart from limited awareness campaigns, especially at a local level. This can be largely attributed to a lack of institutional resources. Although the proper application of the Disaster Management Act and Framework could provide a platform for addressing climate change response and adaptation within the district, it is not currently utilized as such.

The link between disaster management and climate change cannot be ignored and much of the district's biodiversity, infrastructure, industries and communities will be increasingly prone to the impacts of natural disasters associated with climate change. This will place additional pressure on current disaster management resources.

Climate change is associated with the potential increase of the following hazards in the UGU DM

- Storms;
- Flooding;
- Drought;
- Epidemics; and
- Veldfires.

4.5.2.6 Agriculture

As is characteristic of South Africa, the UGU DM's agricultural economy consists of large commercial operation as well as smaller, mainly subsistence farming. Though there has been a decrease in the economic contribution of

agriculture over the last few years there is still development potential in the agricultural sector. The main commercial and employment center is Port Shepstone. The district produces 1/5 of all bananas eaten in South Africa. There also significant sugar-cane. Timber farming produces pine, gum and wattle[25].

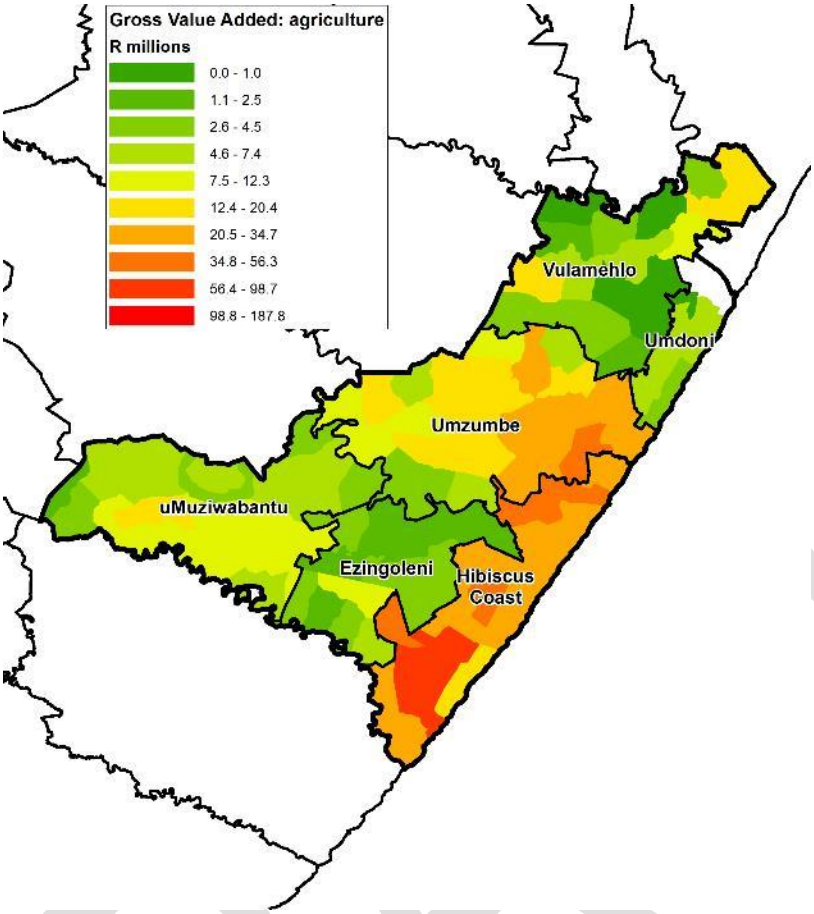


Figure 35: Agricultural sector value

Commercial

Commercial agriculture plays an important role in the UGU DM's economy, contributing both in terms of GDP and employment (**Error! Reference source not found.**). Research indicate that larger and more efficient commercial farms are less vulnerable to the impacts of climate change than smaller farms[26].The majority of the commercial farms in the district are well developed and although net revenues are likely to decrease farm management and access to technology will translate into improved adaptive capacity and serve to shield against climate change impacts if effective employed as adaptive strategies.

Subsistence

As an important source of livelihood support for a large portion of the population, agriculture as a sector will require prioritization in terms of climate change adaptation. Apart from employment in the commercial sector, large numbers of household practice agriculture in order to supplement household income and meet nutritional requirements.

Failing to address the risk posed to the agricultural sector will inhibit the impact of interventions to stimulate economic growth in the municipality's rural areas, further compounding food insecurity and poverty levels already characterising some of the local municipalities. The risks will generally be higher among rural households and households with less livelihood capital assets, (human, physical, financial, social and natural) who support their livelihoods via subsistence agriculture. Land reform and property rights has also emerged as a predictor of in terms of risk. High level investigation have shown that crop farmers are better off when the household owns the farm than if the land is part of a land reform project. In the case of livestock farming, more revenue is earned when the land is

[25] Department of Cooperative Governance and Traditional Affair, Ugu District Municipality Profile 2011.

[26] Turple and Visser. 2013. Chapter 4: The Impact of Climate Change on South Africa's Rural Areas. 2013/14 Submission for the division of revenue, FFC.

communal than when the land is privately owned, implying that communal access to large tracts of grazing lands for subsistence farmers increases marginal net benefits.[27] The adaptation strategies with the highest benefits in the will be rain fed crops/dry land farming, minimal tillage, and irrigation schemes based on water security. Thus priority should be given to investing in climate smart agriculture technologies which could include drought resistant seed varieties, small grains, and zero tillage farming systems in the UGU DM.
The spatial distribution of commercial and substance farming is given in Figure 36 below

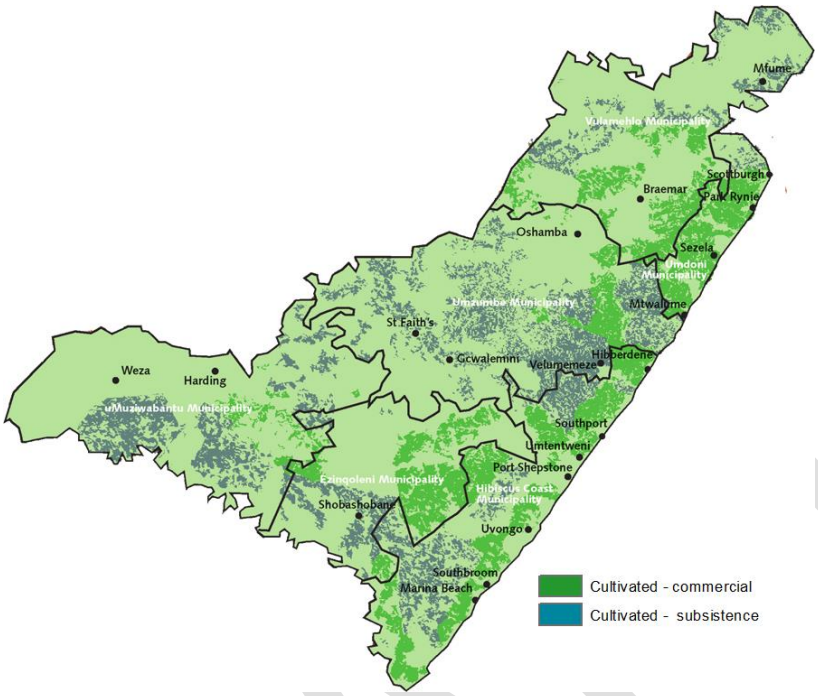


Figure 36: Commercial and substance farming[28]

Climate change impacts

Climatic vulnerability currently experienced in UGU DM will be exacerbated by the projected climate changes of increased temperatures (and associated extremes) and decreased precipitation (and increased extreme events and variability).

The district's agricultural sector will prove sensitive to projected shifts in climatic patterns, adding to existing environmental degradation and rainfall variability. Local climate change projections and related impacts are indicating that, without intervention, crop yields will be adversely affected by climate change in the UGU DM.

It is important to note that according to research, while simultaneous change in rainfall and temperature will adversely affect agricultural activities, temperature expected to have a greater bearing on the negative impacts than a reduction in rainfall alone[29]. One of the most significant findings form the Fiscal and Financial Commission's (FFC) research is variable impacts across different types of farming, with crop farming being the most vulnerable to climate change and mixed farming the least motivating diversification as a potential adaptation strategy.

There is evidence that smallholder subsistence farmers are more vulnerable to climate change than commercial farmers due to limited access to resources. This raises concern in regard to food security where many smallholders are reliant on maize production. Maize yields have been simulated to be sensitive to both climate and CO_2 fertilisation, with doubled CO_2 potentially counteracting some of the reduced productivity associated with a 2°C

[27] Turple and Visser. 2013. Chapter 4: The Impact of Climate Change on South Africa's Rural Areas. 2013/14 Submission for the division of revenue, FFC
[28] DAFF, Food Insecurity in Ugu
[29] Turple and Visser. 2013. Chapter 4: The Impact of Climate Change on South Africa's Rural Areas. 2013/14 Submission for the division of revenue, FFC.

temperature rise[30]. Changing rainfall patterns have been found to cause a likely a decline in yields[31]. Without adaptation methods the increased soil evaporation under a warmer drier climate would negatively impact smallholder maize production[32].
Increased soil evaporation will cause an increase in water stress of rain fed horticultural crops and increase the water demand of irrigated crops. Where pastures are currently irrigated these may come under pressure due to competing demands for water and increased variability in rainfall. Rain-fed pasture lands may also experience bush encroachment due to increasing levels of CO_2[33]. Livestock production will be effected by climate change both directly, through heat stress[34] and humidity[35], and indirectly, such as impact on feed production[36].

The important crop and livestock production in Ugu District Municipality include Sugar cane, Bananas, Macadamias, Vegetables, Maize, Amadumbe, Beans and timber. Regarding livestock there are Eggs, Broilers, and cattle (Beef/dairy). There are a large number of smallholder maize and livestock farmers[37].

Table: Agricultural product climate profiles and likely future stressor[38]

Product	Preferred climatic conditions	Future climate impact
Amadumbe	Requires an optimum temperature of between 13 and 30°C. Warm conditions are preferred as it cannot withstand freezing conditions. Can tolerate high rainfall areas however there should be good drainage as waterlogging will damage the crops. For optimal growth rainfall of 1 400 to 2 000 mm is required for the growing season. Planting season is November and the Amadumbe plants mature in about 8 to 10 months from planting.	Amadumbe is able to tolerate warmer weather, though when temperatures get to extreme ranges the plant may suffer. The variability in the rainfall that is projected may have a detrimental impact to the crop through insufficient or highly variable water supply.
Banana	Sub-optimal, subtropical conditions are ideal for growing bananas. The crops are highly dependent on rainfall (100mm/month) that is evenly distributed and production will be low during low rainfall periods and high during high rainfall periods. Requires warm, humid conditions that is frost free. Optimal temperature for production range between 22 and 31°C and flourish under uniform warm to hot conditions. The growth will be impeded if temperatures drop below 16°C and will eventually stop at 10°C. Harvesting period for crops is	Bananas will likely thrive in the increase temperatures projected, though erratic extreme temperature days may have a detrimental effect. The variability in the rainfall within and between years may compromise the crop. Farmers should make use of seasonal forecasts where available.

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Department of forestry and fisheries - http://www.daff.gov.za/daffweb3/Resource-Centre

Food and Agricultural Organisation and the United Nations - http://www.fao.org/

National Center for Biotechnology Information http://www.ncbi.nlm.nih.gov/

Product	Preferred climatic conditions	Future climate impact
	throughout the year (Jan-Dec). This district produces one third of the bananas consumed in South Africa. Banana production in KZN takes place between Port Edward and Port Shepstone due to its ideal climatic conditions. Ugu District supplies 10 – 15% of South Africa's total output.	
Beans	Beans are warm-season crop that are extremely sensitive to frost and hot conditions. Temperature require for optimal production range between 15 °C to 27 °C. Temperatures of below 5°C and above 35°C will yield poor quality.	Increased temperatures will have detrimental effects of the quality of Beans and there may be areas where growing them is no longer suitable. The crop will suffer through extreme days and extended heat waves.
Macadamias	Optimal temperature range between 25°C - 35°C, however if temperature are above 30°C for long periods growth will be the growth will be distorted. Full grown trees can survive under cold conditions up to 3°C, but if temperatures drop below 5°C young trees will die. Rainfall of between 800 – 1200mm per annum is sufficient for production, and can be supplemented by irrigation if needs be . Ugu is the largest macadamia producer in the KZN province owing to its optimal climatic conditions.	Macadamias will likely thrive in the increase temperatures projected, though the projected intended heat waves will have detrimental effects on the crop. The variability in the rainfall within and between years may compromise the crop. Farmers should make use of seasonal forecasts where available.
Maize	Temperatures ranges needed for maize production are wide but 18°C to 20°C is optimum. Cooler temperatures prolong the maturating of the crop but frost is damaging. Maize is able to grow in temperatures up to 45°C if sufficient water is available. Maize needs approximately 350 to 450mm during growth. This can be supplemented with irrigated water to increase yield.	The increased temperatures projected may affect the crop on the very extreme temperature days. The water requirement should be sufficient for the maturing of the crop, though it may be less reliable and if irrigation is needed, it'll add additional pressure to water resources.
Onions	Onions grow best between 18°C and 22°C. Temperatures of 25°C to 27°C will promote bulb formation. Temperatures of 8°C to 13°C will induce flowering. Onions will need significant water and irrigation is required during the growing season. Planting season is during late summer.	It is unlikely that crop will experience temperatures below 18°C often. Once bulbing has taken place, the onions are more able to tolerate warmer temperatures, yet extreme high temperatures may decrease the quality of the yield. The changing rainfall regime may not impact the crop though the resulting water stress may limit the availability of water resources of irrigation.
Sugar Cane	Requires tropical climate but also grows under subtropical conditions. The temperature for optimal growth range between 20 and 35°C. Sugar cane requires 1100 to 1500mm of rainfall during its vegetative growth period after which a dry period is needed for ripening. The ideal planting period is during autumn (mid Feb – April) and under rain fed conditions from September to November as the soil should be water soaked. The plantations are harvested after 12 – 16 months when the crops have reached a height of 2 – 4m.	Sugar cane should thrive in the increase temperatures projected, though erratic extreme temperature days may have a detrimental effect. It has already been show that sugar cane yields are sensitive to variability in rainfall. Though there is increased rainfall projected, it will be highly variable and farmers should make use of seasonal forecasts where available.

Product	Preferred climatic conditions	Future climate impact
Tomatoes	Average daily mean of between 20°C and 24°C provides optimum quality. Quality determinates below 12°C and above 35°C. Excess rain can result in the occurrence and spread of foliar diseases. Irrigation is recommended. Planning generally occurs late winter in warmer regions.	It is unlikely that crop quality will suffer from temperatures below 12°C. Yet the expected higher temperatures will decrease the quality of the yield. The changing rainfall regime may not impact the crop though the resulting water stress may limit the availability of water resources of irrigation.
Cattle (Beef/Dairy)	Beef cows thrive at an ambient temperature range of about 15°C to 25°C. The water needs of cows is reliant on the temperature. Above 35°C the water requirement is triple that of 15°C to 25°C.	Though cattle are very resilient, the increased temperatures will likely increase heat stress of the cattle and also increase the amount of water they consume.
Broilers	The recommended temperatures for poultry varies with age. Week 1 - 30°C, week 2 - 26°C, week 3 - 22°C, week 4 - 20°C The ideal relative humidity for poultry is approximately 60%	Increased future temperatures will often exceed these thresholds and animal heat stress may occur.
Eggs	Chickens lay eggs best at temperature of 11°C to 26°C. Below 11°C many chicken types do not lay eggs. Above 28°C production and quality of eggs decrease. Relative humidity of more than 75% will decrease egg production.	Increased future temperatures will often exceed 25°C and therefore production and egg quality will deteriorate unless air conditioners are used. High humidity may occur due to enhanced evaporation on hot days though heat stress is more likely to decrease production.
Timber	UMuziwabantu LM has the largest concentration of forestry activity within the Ugu DM. The Ugu district produces an estimated 195 000 tons of pine per annum as well as 1755 million tons of gum and wattle that is used by a major pulp mill. ideal regions for commercial plantations is in subtropical parts of South Africa that are above 400 m altitude where the rainfall is in the range 850-1200 mm and the mean annual temperature above 16ºC .	Timber should cope well in the future. Increased CO2 in the atmosphere will enhance growth of large trunked trees. The increase in temperature will have minimal effect on the tree, though the increased potential of forest fires will damage stocks.

4.5.2.7 Tourism impacts

Tourism is included in 'wholesale and retail trade, catering and accommodation' which makes up 17% of the Ugu Municipality District economy (2011)[39].broken down as follows Forests (R260 million), Beaches (R42 million) and Near-shore environments and reefs (R537 million) [40]:

Tourism Seasonality:

The Ugu Municipality District experiences a generally warm, sunny climate all year which means that the weather is almost always suitable for the above-mentioned tourist activities. In the past, the main tourism seasons were during the April, July and December school holidays. However, the December school holidays have become the only main tourism season[41]. The 2016 school holidays are as follows

[39] Invest in KwaZulu-Natal, South Coast (Brochure), http://www.scda.org.za/scda-brochure/
[40] Estimates of the recreational and productive values of natural assets. From *KZN PSEDS: Profiling District Economic Drivers.* www.scda.org.za/?wpdmact=process&did=OS5ob3RsaW5
[41] Ugu South Coast Development Agency, http://www.scda.org.za/tourism/

21 March – 4 April

27 June – 15 July

3 October – 7 October

8 December – January 2017

The tourism decline could be attributed to inadequate infrastructure maintenance and development. Coastal tourism infrastructure is regarded 'out of date' and in need of upgrading[42].

Climate Sensitivity:

All outdoor activities will be sensitive to the changing climate. However some activities may benefit from these changes.

Table 14: *The main tourism activities include*[43]

Activity type	activity	Climate impact
Maritime Activities	Scuba Diving Blue Flag beaches and beach activities Deep sea and rock fishing (Sardine Run)	Increased temperature will likely increase activity desirability and may also extend the duration for which it is opportune. Water sports are less sensitive to extreme temperatures. Increase in rainfall intensity may make activities less popular. Sea-level rise may damage coastal areas and reduce beach areas.
Sport and Adventure Tourism	Oribi Gorge Forest activities: mounting biking, hiking Golf Courses (Africa's Golf Coast)	Increased temperature may increase activity desirability and may also extend the duration for which it is opportune. Though extreme temperature and heat waves may have a detrimental effect. Increase in rainfall intensity may make activities less popular.
Cultural and Heritage Sites	Isandludlu/Tragedy Hill: where Shaka's warriors killed a group of Mpondos Execution Rock: where enemies where executed by Zulus	Increased temperature may increase activity desirability and may also extend the duration for which it is opportune. Though extreme temperature and heat waves may have a

[42] Ugu District Growth and Development Strategy: Final Report (December 2012), http://devplan.kzncogta.gov.za/idp_reviewed_2014_15/IDPS/DC21/Adopted/2012-12-03%20Ugu%20Growth%20and%20Development%20Strategy%20(Final%20Report).pdf

[43] Ugu Municipality District IDP, Annual Review 2015/16, pg 12, http://ugu.gov.za/Documents/IDP/Ugu-District-Municipality-IDP-2015-16.pdf

	Kniesel's Castle: 19th Century Dwelling declared a heritage site	detrimental effect. Increase in rainfall intensity may make activities less popular.
Agritourism	Touring Farming areas. Fruit picking and panicking	Climate sensitivity of the farming industry may reduce the appeal of Agritourism.
Ecotourism	Umtamvuna Nature Reserve Uvongo Nature Reserve	Warmer days should increase the desire to do ecotourism activities, however, climate impacts to reserves through vegetation patterns no longer meeting the suitability criteria should reduce the desire for ecotourism.
General tourism	Increased variability in climate could have an impact on the ability to be able to take part in the tourism activities all year round. Outdoor activities will be limited to the warmer seasons. Extreme weather events can damage already poorly maintained tourism infrastructure and have a negative impact on the nature reserves. Sewerage spills – caused by flood damage to sanitation infrastructure – has resulted in the loss of Blue Flag status for several beaches[44]. Sea level rise constrains the amount and type of tourism infrastructure development that can happen on the coast and can have an impact on the maritime tourism activities.	

[44]Ugu District Growth and Development Strategy: Final Report (December 2012).

5 Climate Change Response Strategy

5.1 Vision

Vision to be discussed and finalised with the PSC. Some examples follows

- "Transition to a climate resilient and low-carbon society"
- "A low carbon and climate resilient District committed to sustainable and sustained economic and community development"
- "Ugu District, coping for today, adapting for tomorrow and building a sustainable future

5.2 Strategic Objectives

5.3 Ugu District Municipality: Climate Change Approach

5.4 Adaptation Approach

5.4.1 Strategic adaptation objectives

5.4.2 Action planning

5.4.3 Adaptation decision Matrix

5.4.3.1 Specific Sea level rise adaptation

5.5 Mitigation

5.6 Sectoral Climate Change Response Recommendations

5.7 Information Management and Communication

5.8 Financing Climate Change Response

6 Implementation Framework

7 Conclusion

8 Appendixes

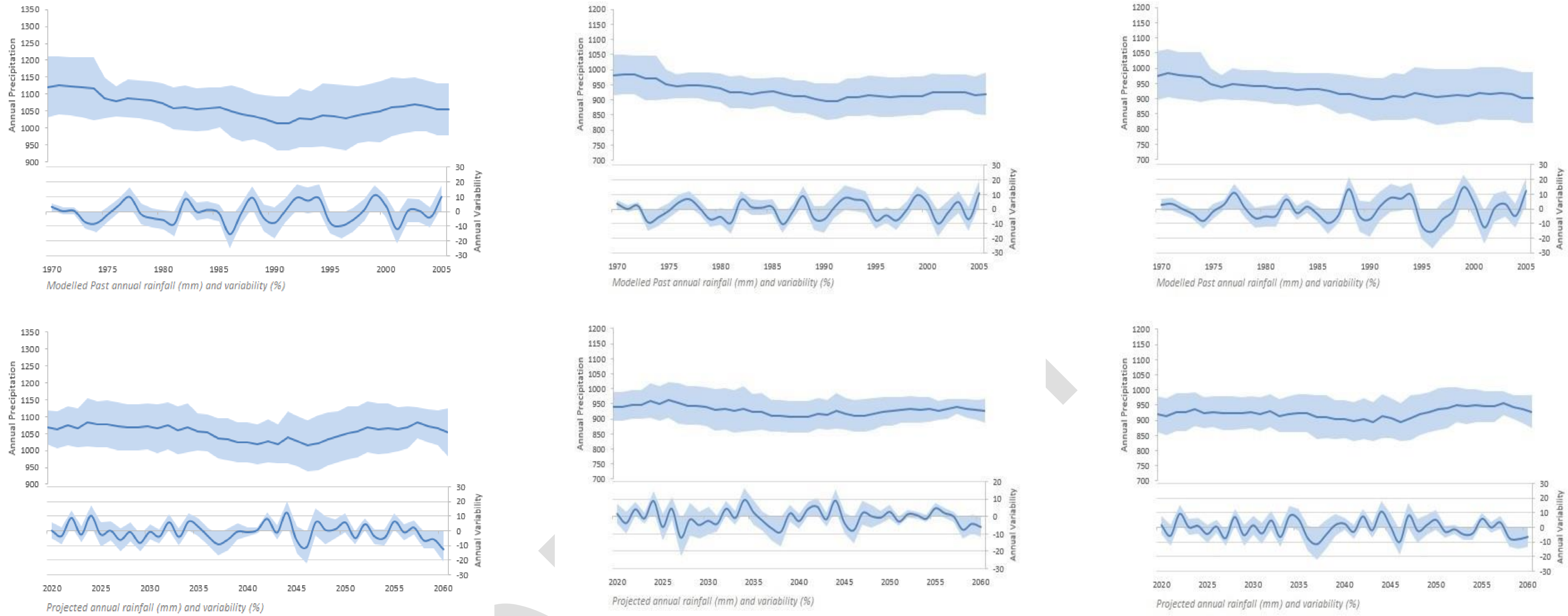

Figure 37: Annual average precipitation volumes and yearly variability potential for Coastal (left set), Inland South (centre set) and Inland North (right set) climate zones, Modelled past (top set), RCP4.5 Projected future (bottom set)

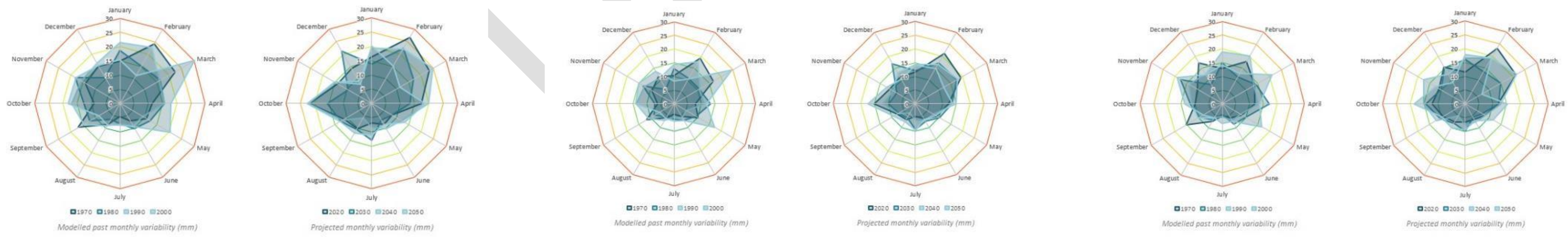

Figure 38: Monthly variability potential (mm volume) for Coastal (left set), Inland South (centre set) and Inland North (right set) climate zones, Modelled past (left of each set), RCP4.5 Projected future (right of each set)

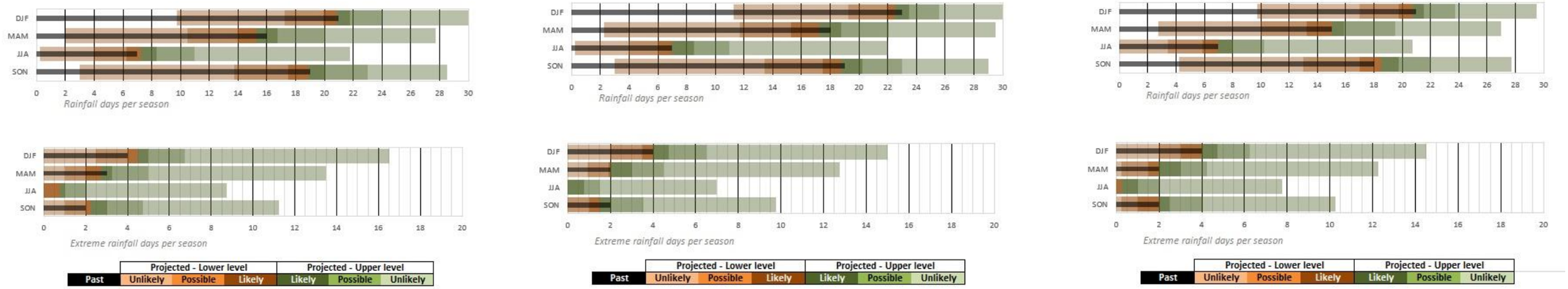

Figure 39: Number of rain days (top set) and extreme rainfall days (bottom set) per season for Coastal (left set), Inland South (centre set) and Inland North (right set) climate zones, Modelled past (thin black bars), RCP4.5 Projected future (thick brown and green bars)

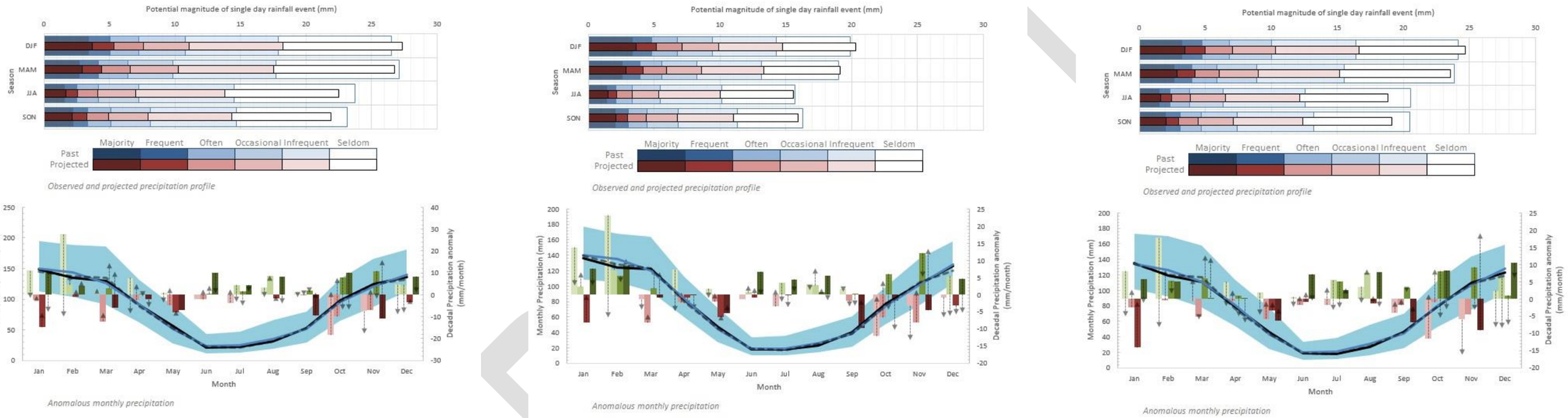

Figure 40: Rainfall Profile (top set), past and projected future monthly precipitation volumes (bottom set : blue lines and envelope) and RCP4.5 projected monthly anomaly from monthly mean per decade 2020, 2030, 2040, 2050 (bottom set : green and red bars, black arrows represent RCP8.5) for each climate zone, Coastal (left set), Inland South (centre set) and Inland North (right set)

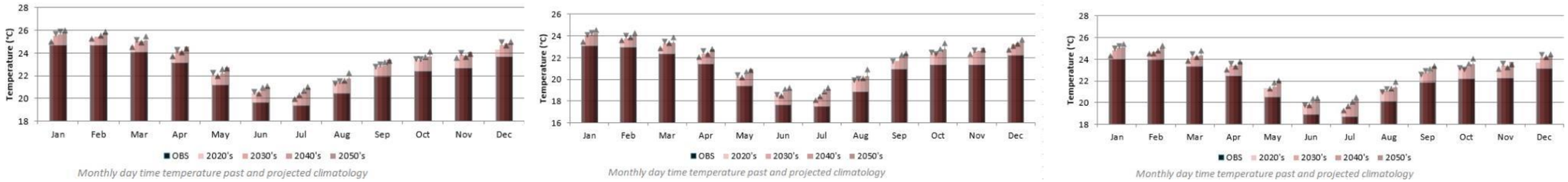

Figure 41: Anomalous projected temperature changes for 2020's, 2030's, 2040's, 2050's (lighter red bars), from the past temperatures (dark bars) for RCP4.5, arrows show further change under RCP8.5 for each climate zone, Coastal (left), Inland South (centre) and Inland North (right)

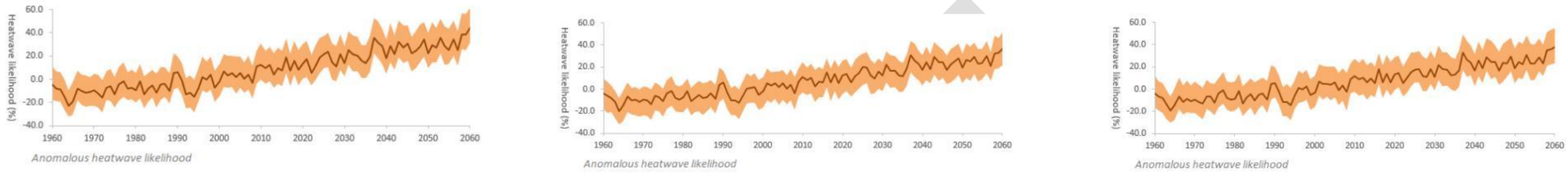

Figure 42: Anomalous change over time (from 1990-2000) of heatwave likelihood from RCP4.5 for each climate zone, Coastal (left), Inland South (centre) and Inland North (right)

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