



GREENBOOK

adapting settlements for the future



Ugu District Municipality

Climate Risk Profile Report based on the GreenBook

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Table of Contents

Table of Contents	ii
Figures	iii
Tables	iv
Acronyms	v
Glossary of Terms	vi
1. Introduction.....	1
1.1. Approach followed	1
1.2. Policy framework	3
1.3. District Municipal context	4
2. Baseline and future climate risk.....	7
2.1. Vulnerability and population change	7
2.1.1. Municipal vulnerability	8
2.1.2. Settlement vulnerability.....	9
2.1.3. Population growth pressure.....	12
2.2. Climate	13
2.2.1. Temperature	14
2.2.2. Rainfall	16
2.3. Climate Hazards.....	18
2.3.1. Drought.....	18
2.3.2. Heat	21
2.3.3. Wildfire	25
2.3.4. Flooding.....	27
2.3.5. Coastal flood and erosion risk.....	29
2.4. Climate impacts on key resources and sectors	32
2.4.1. Water resources and supply vulnerability	32
2.4.2. Agriculture, forestry, and fisheries	37
3. Recommendations	39
4. Bibliography.....	42

Figures

Figure 1: The interaction between the various components of risk, indicating the opportunity to reduce risk through adaptation (based on IPCC, 2014 and IPCC, 2021)	2
Figure 2: Ugu District Municipality with Local Municipalities (COGTA, 2019)	6
Figure 3: Ugu District Municipality, natural vegetation. Urban areas masked out in black, agriculture and forestry areas masked out in grey.....	7
Figure 4: Settlement vulnerability characteristics for Umdoni, Umzombe, uMuziwabantu and Ray Nkonyeni LMs	11
Figure 5: Settlement-level population growth pressure across the Ugu District Municipality....	13
Figure 6: Average annual temperature (°C) for the baseline period 1961-1990 for the Ugu District Municipality.....	15
Figure 7: Projected changes in average annual temperature (°C) from the baseline period 1961-1990 to the future period 2021-2050 for the Ugu District Municipality, assuming an RCP 8.5 emissions pathway.....	15
Figure 8: Average annual rainfall (mm) for the baseline period 1961-1990 for the Ugu District Municipality.....	17
Figure 9: Projected change in average annual rainfall (mm) from the baseline period to the period 2021-2050 for the Ugu District Municipality, assuming an RCP8.5 emission pathway.....	18
Figure 10: Projected changes in drought tendencies from the baseline period (1986-2005) to the current period (1995-2024) across the Ugu District Municipality.....	19
Figure 11: Projected changes in drought tendencies from the baseline period (1986-2005) to the future period 2015-2044 for the Ugu District Municipality	20
Figure 12: Settlement-level drought risk for the Ugu District Municipality.....	21
Figure 13: Annual number of very hot days under baseline climatic conditions across the Ugu District Municipality with daily temperature maxima exceeding 35°C	22
Figure 14: Projected change in annual number of very hot days across the Ugu District Municipality with daily temperature maxima exceeding 35°C, assuming and RCP 8.5 emissions pathway.....	22
Figure 15: Number of heatwave days under baseline climatic conditions across the Ugu District Municipality.....	23
Figure 16: Projected change in annual number of heatwave days across the Ugu District Municipality, assuming an (RCP 8.5) emissions pathway.....	24
Figure 17: Settlement-level heat risk across the Ugu District Municipality.....	24
Figure 18 The likelihood of wildfires under current climatic conditions across settlements in the Ugu District Municipality.....	26
Figure 19: The likelihood of wildfires under projected future climatic conditions across settlements in the Ugu District Municipality	26
Figure 20: The current flood hazard index across the Ugu District Municipality under current (baseline) climatic conditions.....	28
Figure 21: Projected changes into the future in extreme rainfall days across the Ugu District Municipality.....	28

Figure 22: Flood risk into a climate change future at settlement level across the Ugu District Municipality.....	29
Figure 23: Coastal climate risk indices developed by DEFF (2020)	30
Figure 24: Coastal and estuarine flood risk extent on the Ray Nkonyeni coast.....	31
Figure 25: Coastal short term erosion risk in Park Rynie, Umdoni LM.....	32
Figure 26: Main water source for settlements in the Ugu District Municipality	34
Figure 27: Groundwater recharge potential across the Ugu District Municipality under current (baseline) climatic conditions.....	35
Figure 28: Projected changes in groundwater recharge potential from baseline climatic conditions to the future across the Ugu District Municipality	36
Figure 29: Groundwater depletion risk at settlement level across the Ugu District Municipality	36

Tables

Table 1: Vulnerability indicators across the Ugu District Municipality for 1996 to 2011	9
Table 2: Settlement population growth pressure across the Ugu District Municipality.....	12
Table 3: Current water supply and vulnerability across the Ugu District Municipality	37

Acronyms

°C	Degree Celsius
AFF	Agriculture, Forestry, and Fisheries
AR5	Fifth Assessment Report
CABLE	CSIRO Atmosphere Biosphere Land Exchange model
CCAM	Conformal-cubic atmospheric model
CDRF	Climate and Disaster Resilience Fund
CMIP5	Coupled Model Intercomparison Project 5
CoGTA	Department of Cooperative Governance and Traditional Affairs
CRVA	Climate Risk and Vulnerability Assessment
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEA	Department of Environmental Affairs
DM	District Municipality
DRR	Disaster Risk Reduction
DWS	Department of Water and Sanitation
EcVI	Economic Vulnerability Index
EnVI	Environmental Vulnerability Index
GCM	General circulation model
GRiMMS	Groundwater Drought Risk Mapping and Management System
GVA	Gross Value Added
GDP	Gross Domestic Product
IDRC	International Development Research Centre
IPCC	Intergovernmental Panel on Climate Change
km	Kilometre
KZN	KwaZulu-Natal Province
l/p/d	Litres Per Person Per Day
LM	Local Municipality
MAR	Mean Annual Runoff
mm	Millimetre
NDMC	National Disaster Management Centre
PVI	Physical Vulnerability Index
RCP	Representative Concentration Pathways
SCIMAP	Sensitive Catchment Integrated Modelling and Prediction
SDF	Spatial Development Framework
SEVI	Socio-Economic Vulnerability Index
SPI	Standardised Precipitation Index
SPLUMA	Spatial Planning and Land Use Management Act, 2013 (Act No. 16 of 2013)
THI	Temperature Humidity Index
WMAs	Water Management Areas
WMO	World Meteorological Organisation
WRYM	Water Resources Yield Model
WUI	Wildland-Urban Interface

Glossary of Terms

Adaptation actions	A range of planning and design actions that can be taken by local government to adapt to the impacts of climate change, reduce exposure to hazards, and exploit opportunities for sustainable development (CSIR, 2019).
Adaptation planning	The process of using the basis of spatial planning to shape built-up and natural areas to be resilient to the impacts of climate change, to realise co-benefits for long-term sustainable development, and to address the root causes of vulnerability and exposure to risk. Adaptation planning assumes climate change as an important factor while addressing developmental concerns such as the complexity of rapidly growing urban areas, and considers the uncertainty associated with the impacts of climate change in such areas – thereby contributing to the transformational adaptation of urban spaces. Adaptation planning also provides opportunities to climate proof urban infrastructure, reduce vulnerability and exploit opportunities for sustainable development (National Treasury, 2018; Pieterse, 2020).
Adaptive capacity	“The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences” (IPCC, 2022, p. 2899).
Climate change adaptation	“In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects” (IPCC, 2022, p. 2898).
Climate change mitigation	“A human intervention to reduce emissions, or enhance the sinks, of greenhouse gases (GHGs)” (IPCC, 2022, p. 2915). The goal of climate change mitigation is to achieve a reduction of emissions that will limit global warming to between 1.5°C and 2°C above preindustrial levels (Behsudi, A, 2021).

Climate hazards	Climate hazards are a sub-set of natural hazards and a grouping of hydrological, climatological, and meteorological hazards. This includes the spatial extent and frequency of, among others, floods, fires, and extreme weather events such as extreme rainfall and extreme heat. Sometimes referred to as hydrometeorological hazards. The potential occurrence of a climate hazard may cause loss of life, injury, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (IPCC, 2022). Climate hazards can increase in intensity and frequency with climate change (Pieterse et al., 2023).
Climate risk	Risk implies the potential for adverse consequences resulting from the interaction of vulnerability, exposure, and a hazard. Relevant adverse consequences include those on “lives and livelihoods, health and well-being, economic and sociocultural assets, infrastructure and ecosystems” (IPCC, 2022, p. 144). In the IPCC’s 6th Assessment Report, it is confirmed that risks may result from “dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system” (IPCC, 2022, p. 132).
Coping capacity	“The ability of people, institutions, organizations and systems, using available skills, values, beliefs, resources and opportunities, to address, manage, and overcome adverse conditions in the short to medium term” (IPCC, 2022, p. 2904).
Disaster risk reduction	“Denotes both a policy goal or objective, as well as the strategic and instrumental measures employed for anticipating future disaster risk; reducing existing exposure, hazard or vulnerability; and improving resilience” (IPCC, 2022, p. 2906).
Exposure	Exposure implies the physical exposure of elements to a climate hazard. It is defined as the “presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected [by climate hazards]” (IPCC, 2022, p. 2908).
Mainstreaming	The process of integrating climate change adaptation strategies and measures into existing planning instruments and processes as opposed to developing dedicated adaptation policies and plans (Pieterse et al., 2021).

Resilience	<p>“The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation” (IPCC, 2022, pp. 2920–2921).</p>
Sensitivity	<p>“The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise)” (IPCC, 2022, p. 2922).</p>
Vulnerability	<p>Vulnerability is defined as the “propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including, sensitivity or susceptibility to harm and lack of capacity to cope and adapt” (IPCC, 2022, p. 2927). Vulnerability refers to the characteristics or attributes of exposed elements, i.e., elements that are exposed to potential climate-related hazards. Vulnerability is a function of sensitivity and (coping or adaptive) capacity (Pieterse et al., 2023).</p>

1. Introduction

This Climate Risk Profile report, as well as the accompanying Climate Change Adaptation Plan, were developed specifically for the Ugu District Municipality, to support its strategic climate change response agenda. Both documents are primarily informed by the GreenBook, which is an open-access online planning support system that provides quantitative scientific evidence in support of local government's pursuit in the planning and design of climate-resilient, hazard-resistant settlements. The GreenBook is an information-dense resource and planning support system offered to South African local governments to better understand their risks and vulnerabilities in relation to population growth, climate change, exposure to hazards, and vulnerability of critical resources. In addition to this, the GreenBook also provides appropriate adaptation measures that can be implemented in cities and towns, so that South African settlements are able to minimise the impact of climate hazards on communities and infrastructure, while also contributing to developmental goals (See [Green Book I Adapting settlements for the future](#)).

The purpose and strategic objectives of the Climate Risk Profile and the Adaptation Plan are to:

- Build and further the climate change response agenda,
- Inform strategy and planning in the district and its local municipalities,
- Identify and prioritise risks and vulnerabilities,
- Identify and prioritise climate interventions and responses, as well as
- Guide and enable the mainstreaming of climate change response, particularly adaptation.

The Climate Risk Profile report provides an overview of the unique climate change needs and risks of the district based on the science, evidence, and information from the GreenBook. Climate change trends, hazards, and vulnerabilities are spatially mapped for the district, its local municipalities, and settlements. Finally, the report identifies the major risks that need to be prioritised and sets out adaptation goals to further inform the adaptation plan and its implementation.

1.1. Approach followed

The approach used in the GreenBook, and the Climate Risk Profile is centred around understanding climate-related risk. Climate-related risk implies the potential for adverse consequences resulting from the interaction of vulnerability, exposure, and the occurrence of a climate hazard (see Figure 1). "Relevant adverse consequences include those on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, and services (including ecosystem services, ecosystems and species)" (Chen et al., 2021, p. 64).

The components of risk are dynamic. Climate hazards are driven by natural climate variability and anthropogenic climate change. Human activity contributes to Greenhouse Gas emissions that increase temperatures, which in turn affects changes in the occurrence of climate hazards such as drought, flooding, coastal flooding, and heat extremes. Planned as well as unplanned development and growth of our settlements drive the exposure of people as well as the built- and natural environment to climate hazards. Vulnerability includes the inherent characteristics that make systems sensitive to the effects and impacts of climate hazards. Municipal risk is driven by vulnerability and exposure to certain climate-related hazards.

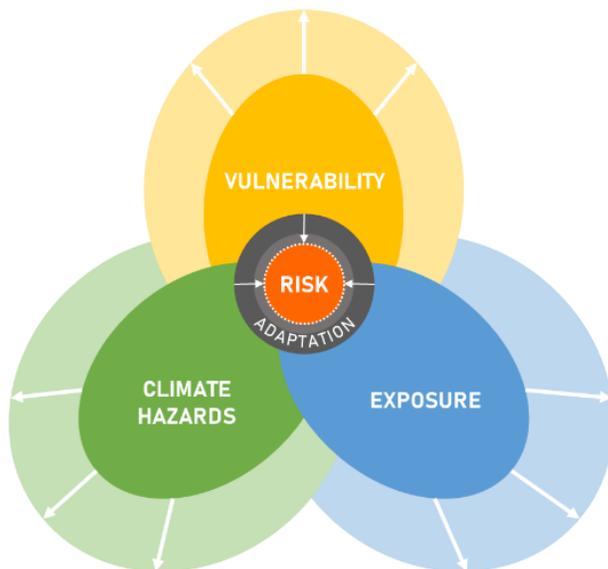


Figure 1: The interaction between the various components of risk, indicating the opportunity to reduce risk through adaptation (based on IPCC, 2014 and IPCC, 2021)

To understand climate risk across the municipal area, the exposure of settlements to certain climate hazards and their vulnerability are unpacked. In this Climate Risk Profile report multiple vulnerability indices are provided on the municipal and settlement level, as well as variables for the current and future projected climate. Climate-related hazards such as drought, heat extremes, wildfire, coastal flooding, and flooding and the impact of climate on key resources are also set out for the district and its municipalities.

All information contained in this report is based on the GreenBook, unless otherwise specified. Information and data were derived using GIS analysis and modelling techniques using secondary data and are not based on local surveys. Additional information to this report is available for local municipalities through the GreenBook Municipal Risk Profile Tool. Municipalities are encouraged to consider both the information available in this report and on the Municipal Risk Profile tool to understand their risk profile. Access the GreenBook and its various resources and tools here: <https://greenbook.co.za/>

1.2. Policy framework

There are various regulatory and legislative requirements for climate change response [planning] in South Africa at local government level. For instance, the Disaster Management Amendment Act of 2015, which aims to provide measures to reduce disaster risks through climate change adaptation and the development of early warning systems, requires each organ of state, provincial government, and municipality to identify measures for, as well as indicate plans to invest in, disaster risk reduction (DRR) and climate change adaptation. The Spatial Planning and Land Use Management Act, No. 16 of 2013 (SPLUMA) outlines five principles intended to guide spatial planning, land development and land use management at all levels of planning, including local government level. Amongst them are the principles of (1) spatial resilience, which encourages “flexibility in spatial plans, policies and land use management systems, to ensure sustainable livelihoods in communities most likely to suffer the impacts of economic and environmental shocks” – some of which may be induced by the impacts of climate change, and (2) spatial sustainability, which sets out requirements for municipal planning functions such as spatial planning and land use management to be carried out in ways that consider protecting vital ecosystem features such as agricultural land, i.e., from both anthropogenic and natural threats, including the impacts of climate change, as well as in ways that consider current and future costs of providing infrastructure and social services in certain areas (e.g., uninformed municipal investments may lead to an increase in the exposure of people and valuable assets to extreme climate hazards).

Furthermore, the National Climate Change Response White Paper – which outlines the country’s comprehensive plan to transition to a climate resilient, globally competitive, equitable and low-carbon economy and society through climate change adaptation- and mitigation, while simultaneously addressing the country’s key priorities, including job creation, poverty reduction, social equality and sustainable development, amongst others – identifies local governments as critical role players that can contribute towards effective climate change adaptation through their various functions, including “[the] planning [of] human settlements and urban development; the provision of municipal infrastructure and services; water and energy demand management; and local disaster response, amongst others.” (Republic of South Africa, 2011, p. 38). The Climate Change Bill (B9-2022) takes it further by setting out institutional arrangements for climate change response. Section 7. (1) of the Bill requires that all organs of state affected by climate and climate change align their policies, programmes, and decisions to ensure that the risks of climate change impacts and associated vulnerabilities are considered. Local government is a key player in climate change response as a facilitator and implementer to achieve effective climate response. The Bill requires that district intergovernmental forum to serve as a Municipal Forum on climate change that coordinates climate response actions and activities in its respective municipality. The Bill also sets out requirements for each district municipality to undertake a climate change needs assessment and a climate change response implementation plan. The Climate Risk Report and related Adaptation Plan, provided here, meet most of these requirements and provide the essential information needed by the district municipality to fulfil its obligations in terms of the Bill.

The National Climate Change Adaptation Strategy outlines several actions in support of climate change adaptation, that are applicable at municipal level, including the development and implementation of adaptation strategies and vulnerability reduction programmes targeting communities and individuals that are most at risk to the impacts of climate change; the development of municipal early warning systems; as well as the integration of climate change adaptation measures into municipal development plans and relevant sector plans. The National Climate Risk and Vulnerability Assessment Framework – which is aimed at all actors, including local governments – guides the development and review of climate risk and vulnerability assessments (CRVAs) to enable alignment, aggregation and comparison across all CRVAs, in an effort to inform an integrated and effective climate change adaptation response across all scales and sectors.

As for climate risks in the coastal zone, the Integrated Coastal Management Act ICMA (Act 24 of 2018) in Section 25 requires the establishment of Coastal Management Lines (a) to protect coastal public property, private property, and public safety. The establishment of Coastal Management Lines therefore needs to be based on information on coastal risks, and this report is contributing spatially explicit information towards this aim. This report also provides information to support the legally required coastal management programmes on municipal level (section 49 of ICMA).

1.3. District Municipal context

Ugu District is one of 11 district municipalities in KwaZulu-Natal (KZN). Its total area is 4 908 km² and its total population is 773 402 (StatsSA, 2022). Ugu embraces the four local municipalities of Umdoni, Umzumbe, uMuziwabantu and Ray Nkonyeni. In the southwest, the district borders the Eastern Cape province and in the northeast KZN's Ilembe District. "Ugu" is isiZulu for "coast", and the three LMs Umdoni, Umzumbe and Ray Nkonyeni border 112 km of the Indian Ocean. Urban development in the district is concentrated on the coast with the exception of the towns of Umzinto and Harding which are located inland (EDTEA 2021).

About 52.6% of the population are female and 47.4% male. Young children (0-14 years) make up 29.2% of the total population. The working-age population (15-64 years) accounts for 62.4%, while the elderly (65+ years) constitute 8.4%. The median age is 27 years which is below the national median age of 28 years. Between 2011 and 2022, the population growth rate in Ugu was 1.1 % p.a., which is higher than between 2001-2011 (0.3% p.a.) but below KZN's overall growth rate of 1.9 % between 2011 and 2011. The Ugu LMs Umdoni, uMuziwabantu and Ray Nkonyeni almost reach the provincial growth rates (1.8%, 1.8% and 1.6% growth respectively), but Umzumbe's growth rate is negative (-1.0%). The Umzumbe municipality, whose population is almost entirely living in traditional settlements, has the highest poverty levels, and Ray Nkonyeni municipality enduring the lowest at 19% and 11% respectively (COGTA, 2019).

The district's dependency ratio is reported at 60.1 with a sex ratio of 90 males per 100 females. Education indicators reveal that 8.8% of individuals aged 20 and above have no formal schooling,

while 9.1% have attained higher education qualifications. The district is home to 172 628 households, with an average household size of 4.5 which is greater than the national average of 3.5 people per household and the KZN average of 4.4. The dominant language (82.7%) is IsiZulu, followed by English (8.3%). About 82% of households are in rural areas and 18% in urban areas (DEA, 2018).

Formal dwellings dominate the housing landscape, representing 85.1% of the housing stock. Sanitation and waste management services are accessible, with 37.1% of formal dwellings equipped with flushing toilets connected to sewerage, and 33.1% receiving weekly refuse disposal services. Moreover, 36.2% of households have access to piped water within their dwellings, while 96.0% have electricity for lighting.

The Ray Nkonyeni Municipality is the most concentrated economic hub within the Ugu District Municipality. With 90 km of coastline, the main features of the Ray Nkonyeni economy are tourism and agriculture. The main cities and towns in the district include Harding, Hibberdene, Margate, Pennington, Port Edward, Port Shepstone, Scottburgh/Umzinto North, Ramsgate, Marburg and Southbroom, most of which are in the Ray Nkonyeni LM. The unemployment rate in Ugu was 30.4 % in 2019. With a GDP of R 38.6 billion in 2019 (up from R 20.1 billion in 2009), the Ugu District Municipality contributed 4.80% to the KwaZulu-Natal Province GDP and 0.76% to the GDP of South Africa in 2019 (COGTA, 2019).

Agricultural activity is generally confined to the coastal strip and inland to the west of Umzinto and Port Shepstone (Oribi Flats) and is dominated by sugar cane and timber, with substantial areas also under bananas and nuts and forestry plantations. The tourism sector is well-developed along the coast, but tourism infrastructure and facilities are generally out-dated (developed in the 1960s and 1970s). The only inland tourism node of note is located around the Oribi Gorge (EDTEA, 2021). Community services sector is the largest economic sector within Ugu District, accounting for R 8.07 billion or 23.4% of the total GVA in the district municipality's economy. Wholesale and retail trade, catering and accommodation (16.97%), supported by tourism and cross boarder activities emanating from the Eastern Cape province emerges as the largest contributor to district GVA followed by Government (15.84%), Finance (15.84%) and Manufacturing (15.32%) (EDTEA 2021). Agriculture contributes 10.02% to the district's GVA. The sector that contributes the least to the economy of Ugu District Municipality is the mining sector with R 170 million or 0.49% of the total GVA (COGTA 2019).

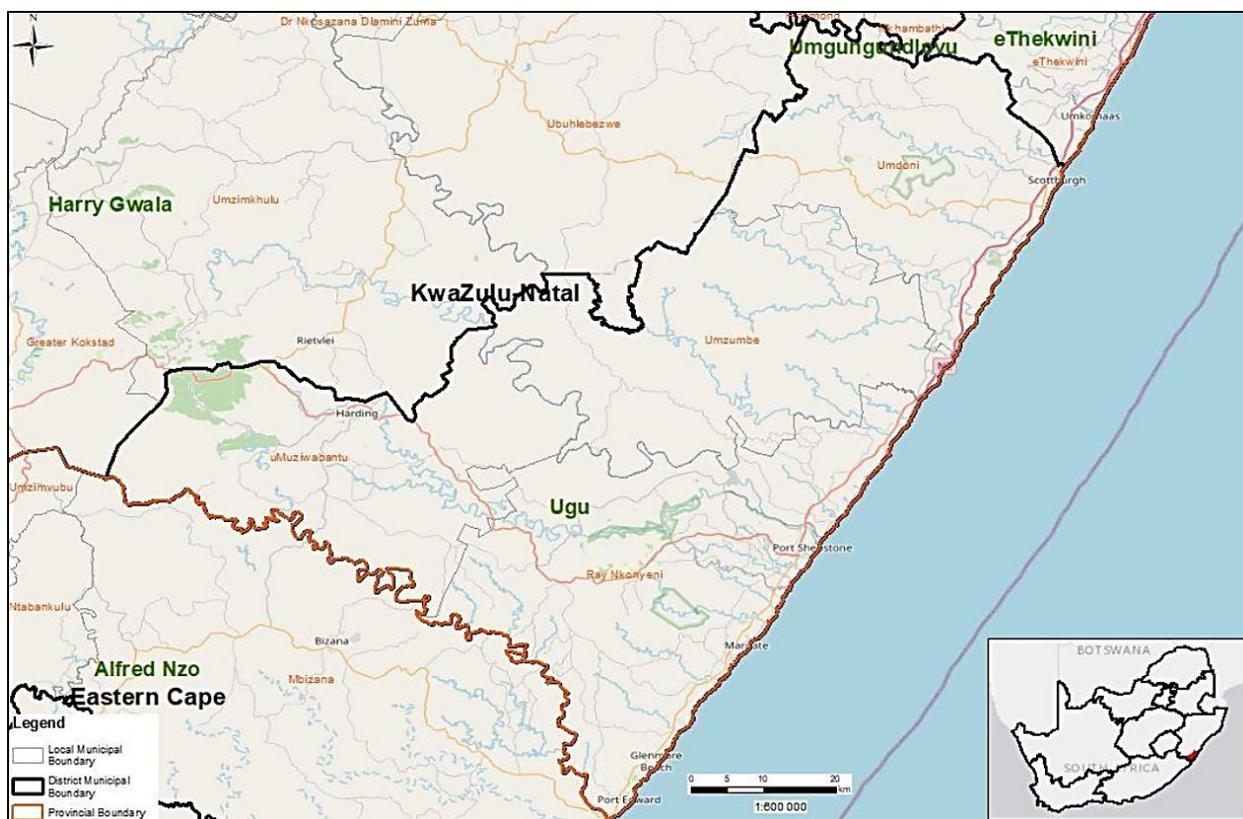


Figure 2: Ugu District Municipality with Local Municipalities (COGTA, 2019)

The natural environment of the Ugu district is very diverse, dominating by different types of grasslands in the central part of the district, with interspersed bushveld and thornveld and some remnants of Northern Coastal Forest near the coast (Figure 3). However, about 50% of the natural environment has been transformed into cultivated crops, wood plantations and settlement areas (DEA 2018; grey and black masked areas in Figure 3). Large areas in uMuziwabantu have been transformed into forest plantations, while fruit and crop agriculture dominate in the more coastal regions.

The Draft Climate Change Adaptation Summary Report for the Ugu District municipality (UrbanEarth, 2017) assesses the natural vegetation, agriculture as well as other relevant sectors in more detail. That report, which provides climate adaptation options on a more generic level, should be read in conjunction with this one.

In the following sections, baseline and future climate risk is provided on a spatially explicit level, zooming in to municipal and partly to settlement level. Together with the Summary Report provided by UrbanEarth (2017), a rich assessment of the district's situation and vulnerabilities and adaptation considerations is provided.

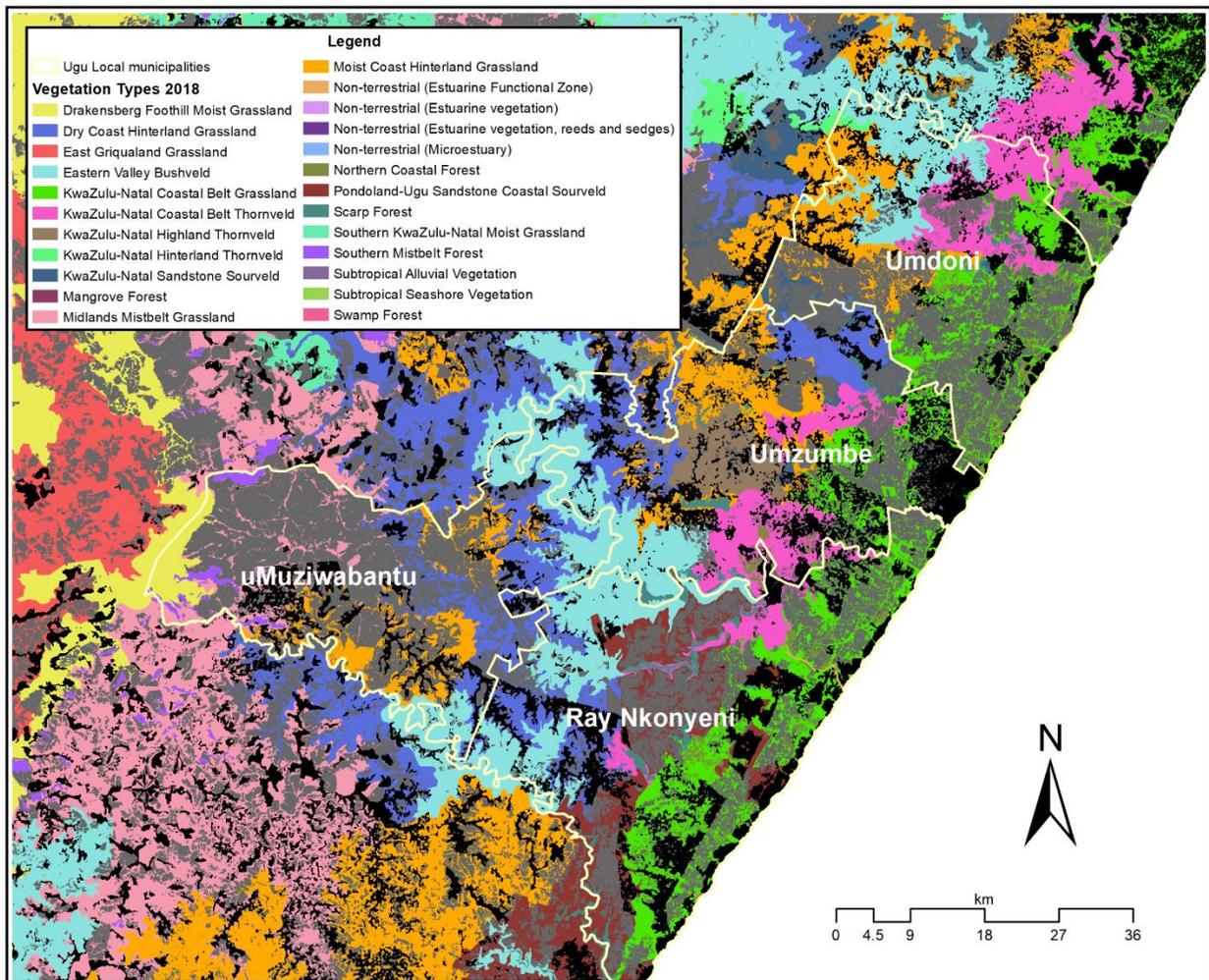


Figure 3: Ugu District Municipality, natural vegetation. Urban areas masked out in black, agriculture and forestry areas masked out in grey.

2. Baseline and future climate risk

This section starts with an overview of vulnerability and population change projections, unpacking the components of vulnerability on both the municipal and settlement level as well future population pressures. Thereafter the current and future climate is discussed in terms of temperature and rainfall across the district. Current as well as future exposure to drought, heat, wildfire, and flooding are set out. The impact of climate on key resources such as water and agriculture are also discussed for the municipalities in the district. Together this information provides an overview of current and future climate risk across the Ugu to inform responsive planning and adaptation.

2.1. Vulnerability and population change

There are many factors that influence the vulnerability of our municipalities and settlements, some of which are unpacked in the following section. The current vulnerabilities for the Ugu

District, its local municipalities, and settlements are profiled using a framework which sets out indicators that can be used to profile the multi-dimensional and context-specific inherent vulnerability of settlements and municipalities in South Africa. The framework describes and quantifies, where possible, the inherent vulnerability of people, infrastructure, services, economic activities, and natural resources by setting out context and location-specific indicators that were specifically designed to support vulnerability risk assessments of South African municipalities. Population changes drive vulnerability into the future, and therefore population growth and decline of settlements across the District are projected to 2050. Spatial population projections are integral in determining the potential exposure and vulnerability of a population to hazards.

2.1.1. Municipal vulnerability

Municipal vulnerability is unpacked in terms of four vulnerability indices, each of which are described below and in Table 1, the vulnerability scores are provided for each of the municipalities in Ugu District.

The Socio-Economic Vulnerability Index (SEVI) shows the vulnerability of households living in the municipality with regards to household composition, income composition, education, mobility, health, access to basic services, access to social government services, political instability, and safety and security of households. A high vulnerability score indicates municipalities that house a high number of vulnerable households with regards to their ability to withstand adverse shocks from the external environment.

The Economic Vulnerability Index (EcVI) speaks toward the economic resilience of the municipality, and considers economic sector diversification, the size of economy, labour force, the GDP growth/decline pressure experienced in the municipality, as well as the inequality present in the municipality. The higher the economic vulnerability the more susceptible these municipalities are to being adversely affected by external shocks.

The Physical Vulnerability Index (PVI) relates to the built environment and the connectedness of the settlements in the local municipality. It is a composite indicator that considers road infrastructure, housing types, the maintenance of the infrastructure, densities, and general accessibility. A high physical vulnerability score highlights areas of remoteness and or areas with structural vulnerabilities.

The Environmental Vulnerability Index (EnVI) highlights municipalities where there is a high conflict between preserving the natural environment and accommodating the growth pressures associated with population growth, urbanisation, and economic development. The index considers the human influence on the environment, the amount of ecological infrastructure present that needs protection, the presence of critical water resources, environmental health, and environmental governance. A high vulnerability score highlights municipalities that

experience increasing pressure relating to protecting the environment and allowing land use change due to growth pressures.

Each Local Municipality in the Ugu District is provided a score out of 10 for each of the vulnerability indices. A score higher than 5 indicates an above national average, and a score lower than 5 indicates a below national average for vulnerability. Scores are provided for both 1996 and 2011, where a lower score in 2011 compared to 1996 indicates an improvement and a higher score indicates worsening vulnerability. Trend data are only available for Socio-Economic Vulnerability and Economic Vulnerability.

Table 1 shows that Ugu's average SEVI, EcVI and PVI are higher than the national average. Specifically, the SEVI of 7.08 indicates a very high socio-economic vulnerability of the district. The look on the local municipalities shows that the largely traditional LM of Umzumbe is the most vulnerable (8.6), followed by uMuziwabantu (7.7). It is noticeable that Umzumbe's and Umdoni's socio-economic vulnerability increased from 1996 to 2011 while uMuziwabantu's and Ray Nkonyeni's socio-economic vulnerability decreased during the same time. These data are of great concern. Similarly, the economic vulnerability in Umdoni drastically increased between 1996 and 2011 from 5.3 to 6.8. Physical Vulnerability ranges between 5.7 and 6.2 in Ugu's LMs, while the Environmental Vulnerability EnVI in Umdoni, Umzumbe and Ray Nkonyeni is relatively low. Only in uMuziwabantu the environment is under pressure (EnVI 5.9), potentially through the forest plantation activities.

Table 1: Vulnerability indicators across the Ugu District Municipality for 1996 to 2011

LOCAL MUNICIPALITY	SEVI 1996	SEVI 2011	Trend	EcVI 1996	EcVI 2011	Trend	PVI	Trend	EnVI	Trend
Umdoni	5.9	6.7	↗	5.3	6.8	↗	5.70	N/A	2.6	N/A
Umzumbe	8.2	8.6	↗	6.0	5.0	↘	6.20	N/A	3.6	N/A
uMuziwabantu	7.8	7.7	↘	5.2	3.4	↘	5.80	N/A	5.9	N/A
Ray Nkonyeni	5.6	5.3	↘	5.3	5.6	↗	6.00	N/A	3.0	N/A
Ugu average	6.88	7.08		5.45	5.2		5.93		3.78	

To put the data provided in Table 1 in context, Ray Nkonyeni has the lowest SEVI of 5.3 in the district (ranked 9th least vulnerable in the province in 2011), but high EcVI (13th most vulnerable out of 44), 20th most PVI vulnerable, 5th least EnVI in province. Umzumbe has the 7th highest SEV in 2011 in KZN, average EcVI, 18th highest PVI, 9th lowest EnVI in province.

2.1.2. Settlement vulnerability

The unique set of indicators outlined below highlight the multi-dimensional vulnerabilities of the settlements within the Ugu District and its local municipalities, with regards to six composite indicators. This enables the investigation of the relative vulnerabilities of settlements within the district.

A high vulnerability score (closer to 10) indicates a scenario where an undesirable state is present e.g., low access to services, high socio-economic vulnerabilities, poor regional connectivity, environmental pressure or high economic pressures. An indicator of growth pressure, providing a temporal dimension (15-year trend), was added to show which settlements were experiencing growth pressures on top of the other dimensional vulnerabilities up until 2011.

The Socio-Economic Vulnerability Index comprises of three indicators (and eight variables) that show the vulnerability of households occupying a specific settlement with regards to their (1) household composition (household size, age dependency, female/child headed household), (2) income composition (poverty level, unemployment status, and grant dependency of the households), as well as (3) their education (literacy and level of education).

The Economic Vulnerability Index comprises of five variables grouped into three indicators that highlight the economic vulnerability of each settlement with regards to (1) its size (GDP per capita and GDP production rates), (2) the active labour force (taking note of unemployed and discouraged work seekers), and (3) the GDP growth rate for the past 15 years.

The Environmental Vulnerability Index considers the footprint composition of the settlement taking the ration of built-up versus open spaces into account.

The Growth-Pressure Vulnerability Index shows the relative (1996-2011 growth rates) and anticipated pressure on settlements.

The Regional Economic Connectivity Vulnerability Index looks at the regional infrastructure of each settlement (measured through a remoteness/accessibility index), as well as the role of the town in terms of its regional economy.

The Service Access Vulnerability Index comprises of 10 variables grouped into four indicators, that show the level of services offered and rendered within a settlement and includes the settlement's (1) access to basic services (electricity, water, sanitation, and refuse removal), (2) settlement's access to social and government services (health access, emergency service access, access to schools, and early childhood development), (3) access to higher order education facilities, and (4) access to adequate housing.

Figure 4 below provides an overview of the settlement vulnerability characteristics for settlements in the Umdoni, Umzumbe, uMuziwabantu and Ray Nkonyeni LMs in the Ugu DM.

Umdoni Local Municipality

Umdoni is the LM in the district with the highest number of settlements, most of which located in the coastal belt. Figure 4 shows that each settlement has a very characteristic vulnerability profile with challenges being experienced in different sections. In Umdoni, 69.98 % of the population are living in traditional settlements; these are characterised by extreme growth

pressure, economic, socio-economic and regional connectivity vulnerability. Scottsburgh's overall vulnerability is the lowest, indicating a high degree of development and economic activities and moderate population growth. However, these aspects cause a relatively high environmental vulnerability of 7.844. In contrast Umzinto's greatest challenge is service access. Amangamazi is facing extreme growth pressure, causing high environmental and economic vulnerability. High growth pressure and economic vulnerability are also experienced in Esperanza and Umtwalume. Bazley Beach and Pennington are the least vulnerable settlements, with the lowest growth rates.

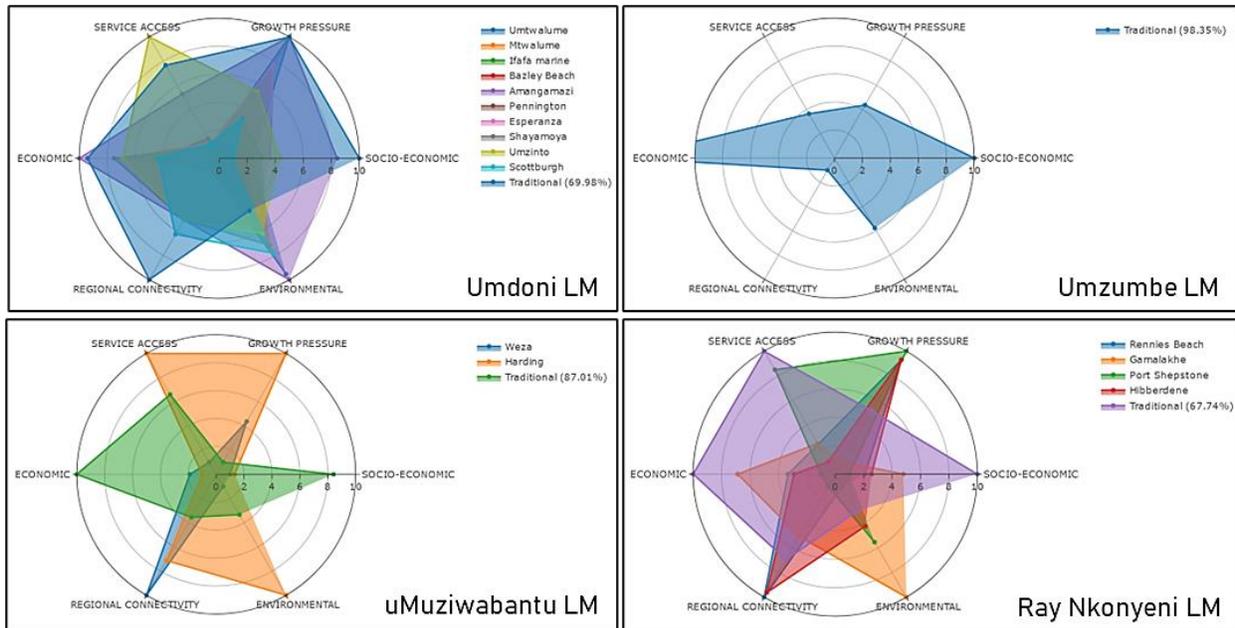


Figure 4: Settlement vulnerability characteristics for Umdoni, Umzumbe, uMuziwabantu and Ray Nkonyeni LMs

Umzumbe Local Municipality

Umzumbe's settlements are 98.35% traditional. These experience very high (10) Socio-economic and extreme economic vulnerability. The relatively low growth pressure is explained by a decreasing population.

uMuziwabantu Local Municipality

In uMuziwabantu, 87.01% of the population live in traditional settlements, the remaining 13% reside in the formal settlements of Harding and Weza, at the core of the forest plantation region. Harding is the most vulnerable settlement in this LM, with very high (10) service access, growth pressure and environmental vulnerability. Weza struggles most with regional connectivity. The traditional settlement area is facing very low (1) growth pressure but very high economic and socio-economic vulnerability.

Ray Nkonyeni Local Municipality

In Ray Nkonyeni, 67.74% of the population was living in traditional areas in 2011. Here extreme vulnerability was experienced in terms of socio-economic vulnerability, economic vulnerability, and service access. The very high growth pressure in Port Shepstone, Hibberdene and Rennies Beach indicates a high migration towards these coastal towns, while very low growth pressure in Gamalakhe indicates stagnation of population or out-migration. Further, Rennies Beach and Hibberdene have very high regional connectivity vulnerability and Port Shepstone high service access vulnerability (8.49).

2.1.3. Population growth pressure

The core modelling components of the settlement growth model are the demographic model and the population potential gravity model. The demographic model produces the long-term projected population values at the national, provincial, and municipal scale using the Spectrum and Cohort-Component models. The spatially-coarse demographic projections were fed into the population potential gravity model, a gravity model that uses a population potential surface to downscale the national population projections, resulting in 1x1 km resolution projected population grids for 2030 and 2050. The availability of a gridded population datasets for past, current and future populations enable the assessment of expected changes in the spatial concentration, distribution, and movement of people.

Using the innovative settlement footprint data layer created by the CSIR, which delineates built-up areas, settlement-scale population projections were aggregated up from the 1 x 1 km grids of South African projected population for a 2030 and 2050 medium and high growth scenario. These two population growth scenarios (medium and high) are differentiated based on assumptions of their in- and out-migration assumptions. The medium growth scenario (Table 2) assumes that the peak of population influx from more distant and neighbouring African countries into South Africa has already taken place. The high growth scenario assumes that the peak of migrant influx is yet to happen.

Table 2: Settlement population growth pressure across the Ugu District Municipality

Population per municipality	2011	Medium Growth Scenario		% Growth 2011-2050	Growth pressure until 2050
		2030	2050		
Umdoni	130 361	162 962	188 930	45	High to no change
Umzumbe	153 318	132 173	97 509	-36	Decrease
uMuziwabantu	96 488	133 612	166 669	73	Low
Ray Nkonyeni	308 560	428 908	552 072	79	High
Ugu DM Total	688 727	857 655	1 005 180	46	

According to these projections, the district's population is expected to increase by 46% by 2050, relative to 2011. Most of this growth will take place in the uMuziwabantu and Ray Nkonyeni LMs.

Figure 4 depicts the growth pressures arising from this growth on the settlements across the district. Growth pressure is not only a function of the actual increase in population but also dependent on the capacity of the municipalities and settlements to absorb this influx.

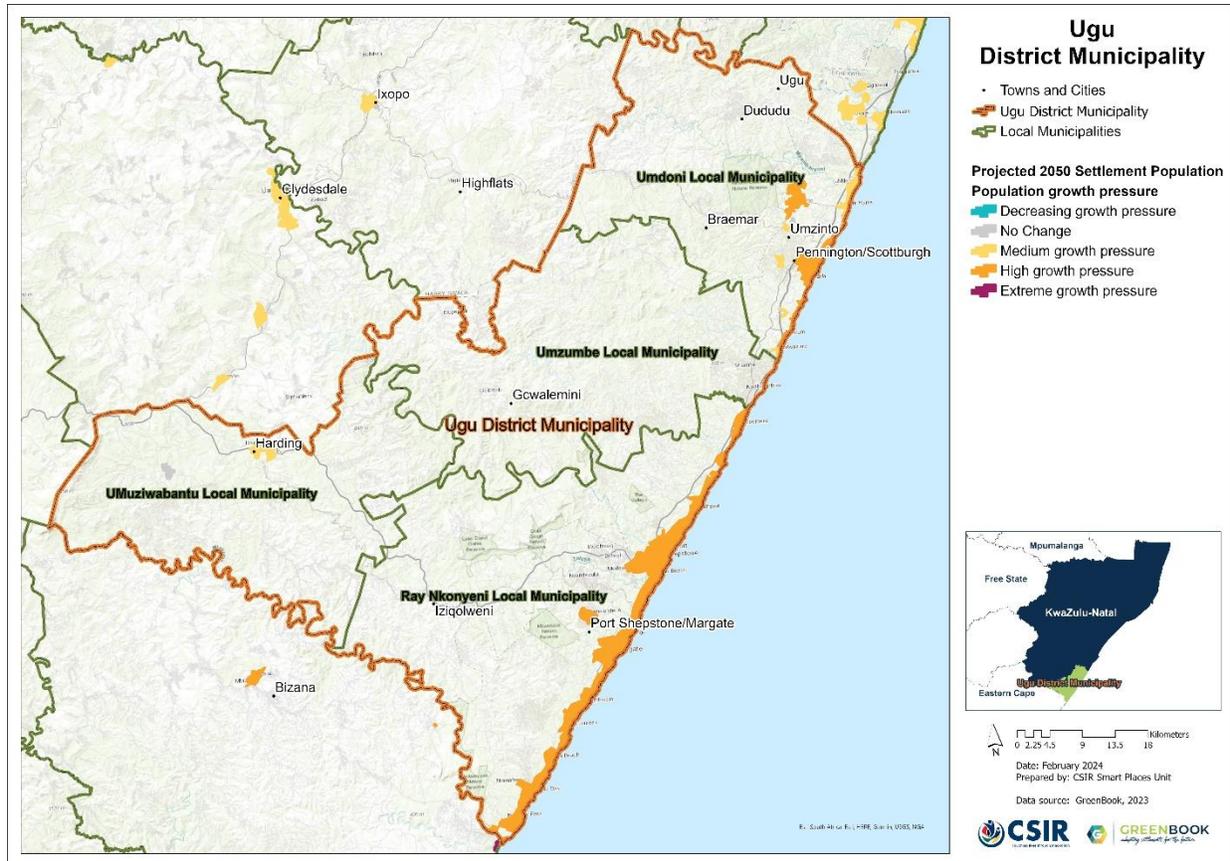


Figure 5: Settlement-level population growth pressure across the Ugu District Municipality

2.2. Climate

An ensemble of very high-resolution climate model simulations of present-day climate and projections of future climate change over South Africa has been performed as part of the GreenBook. The regional climate model used is the Conformal-Cubic Atmospheric Model (CCAM), a variable-resolution Global Climate Model (GCM) developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). CCAM runs coupled to a dynamic land-surface model CABLE (CSIRO Atmosphere Biosphere Land Exchange model). GCM simulations of the Coupled Model Inter-Comparison Project 5 (CMIP5) and the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), obtained for the emission scenarios described by Representative Concentration Pathways 4.5 and 8.5 (RCP 4.5 and RCP 8.5) were first downscaled to 50 km resolution globally. The simulations span the period 1960–2100. RCP 4.5 is a high mitigation scenario (assuming a reduction in CO₂ emissions into the future), whilst RCP 8.5 is a low mitigation scenario (assuming “business as usual” emissions).

After completion of the 50 km resolution simulations described above, CCAM was integrated in stretched-grid mode over South Africa, at a resolution of 8 x 8 km (approximately 0.08° degrees in latitude and longitude). The model integrations performed at a resolution of 8 km over South Africa offer a number of advantages over the 50 km resolution simulations:

- a) Convective rainfall is partially resolved in the 8 km simulations, implying that the model is less dependent on statistics to simulate this intricate aspect of the atmospheric dynamics and physics.
- b) Important topographic features such the southern and eastern escarpments are much better resolved in the 8 km resolution simulations, implying that the topographic forcing of temperatures, wind patterns and convective rainfall can be simulated more realistically.

For more information on the climate simulations, see the GreenBook [Climate Change Story Map](#) and the [full technical report](#).

For each of the climate variables discussed below:

- a) The simulated baseline (also termed “current” climatological) state over South Africa calculated for the period 1961–1990 is shown (note that the median of the 6 downscaled GCMs are shown in this case).
- b) The projected changes in the variable are subsequently shown, for the time-slab 2021–2050 relative to the baseline period 1961–1990.
- c) An RCP 8.5 scenario (low mitigation) is shown.

2.2.1. Temperature

The model was used to simulate average annual average temperatures (°C) for the baseline (current) period of 1961–1990, and the projected change for period 2021–2050 under a RCP8.5 mitigation scenario. Currently, i.e. as measured between 1961 and 1990, Ugu district experienced mean annual temperatures between 14°C in the western, most inland parts of uMuziwabantu and 22°C on the coast, with most of the district having average annual temperatures between 18–20°C (Figure 6). It is expected that these temperatures will increase by 2.0–2.5°C in the inland and about 2.0°C in the coastal area (Figure 7).

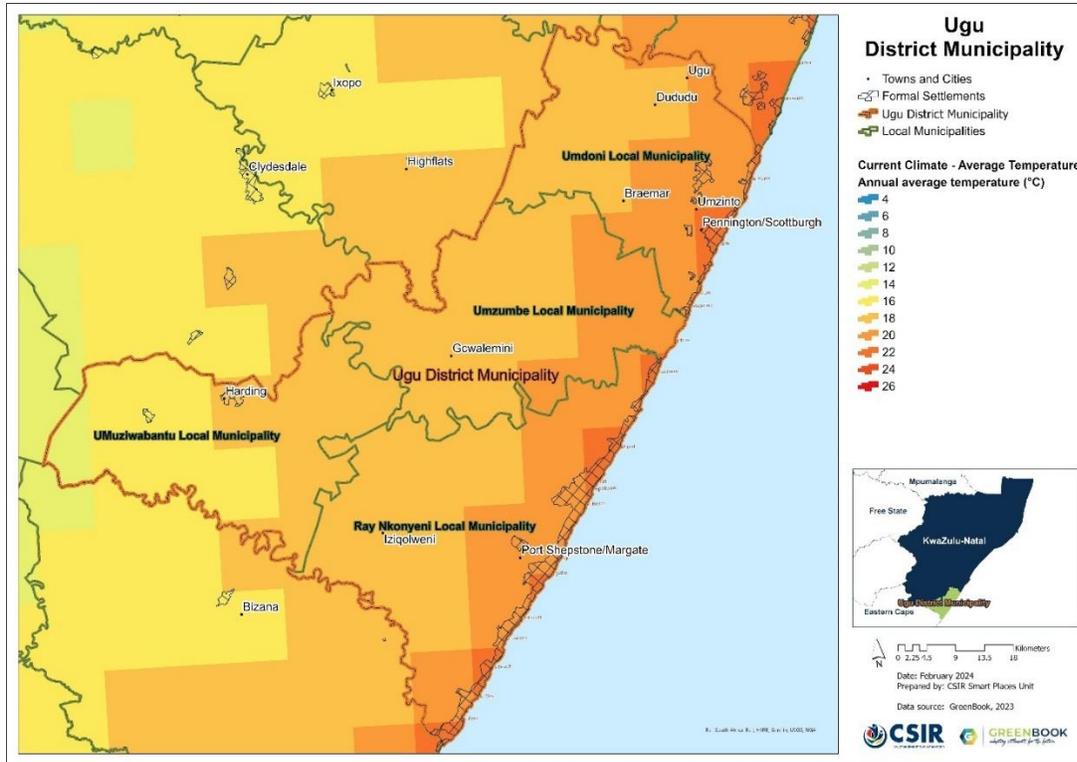


Figure 6: Average annual temperature (°C) for the baseline period 1961-1990 for the Ugu District Municipality

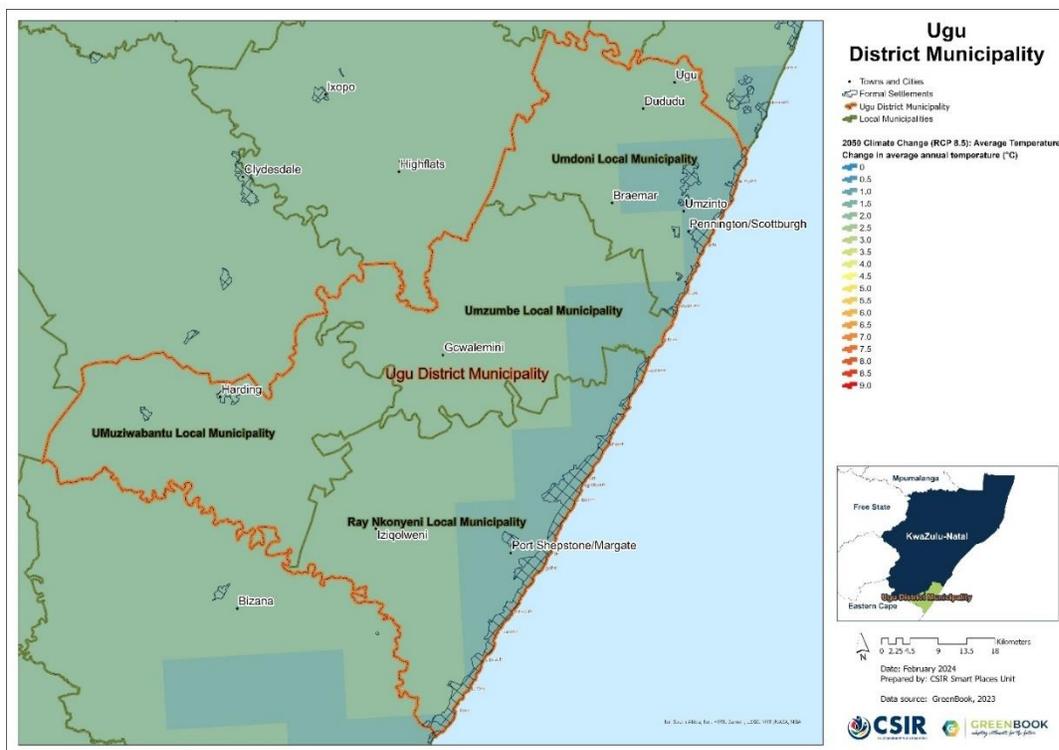


Figure 7: Projected changes in average annual temperature (°C) from the baseline period 1961-1990 to the future period 2021-2050 for the Ugu District Municipality, assuming an RCP 8.5 emissions pathway

2.2.2. Rainfall

The multiple GCMs were used to simulate average annual rainfall (depicted in mm) for the baseline (current) period of 1961–1990, and the projected change from the baseline to the period 2021–2050 under an RCP8.5 emissions scenario. Model projections of precipitation manifest uncertainty due to several factors, including model sensitivity to spatial resolution at which processes are resolved. At 8 X 8km horizontal resolution, for example, some processes (such as convective systems) that contribute to rainfall are not adequately resolved by the climate models. The precipitation projections therefore could reflect uncertainty in some locations since fine-scale processes that contribute to precipitation and its extremes are not captured. When the modelling ensemble approach used in the online GreenBook is considered, and the 10th, 50th and 90th percentiles, per grid point, agree on the directional change relative to the reference period, the signal is considered well developed and conclusive. In the case where the respective model percentiles show conflicting signs, the model ensemble manifest uncertainty and therefore reflect low confidence on which future model realisation/outcome is more likely. It is therefore critical to consider the ensemble distribution uncertainty when devising long-term adaptation strategies.

Ugu district currently experiences average annual rainfall amounts ranging from about 1500mm in some inland areas to 2440 mm in the southern coastal parts. Most of the district's inland has average annual rainfall amounts between 1600–2000 mm, and the coastal zone between 2000–2400 mm (Figure 8). For 2050, it is projected that the district will receive more rainfall (Figure 9). The most eastern and northern areas of the district are expected to see an increase of 130–200 mm per year, and the other areas between 200–300 mm per year under a low mitigation - high emissions scenario. Furthermore, Engelbrecht (2019) states that the region can expect higher rainfall variability, increased likely intensity and more frequent extreme events.

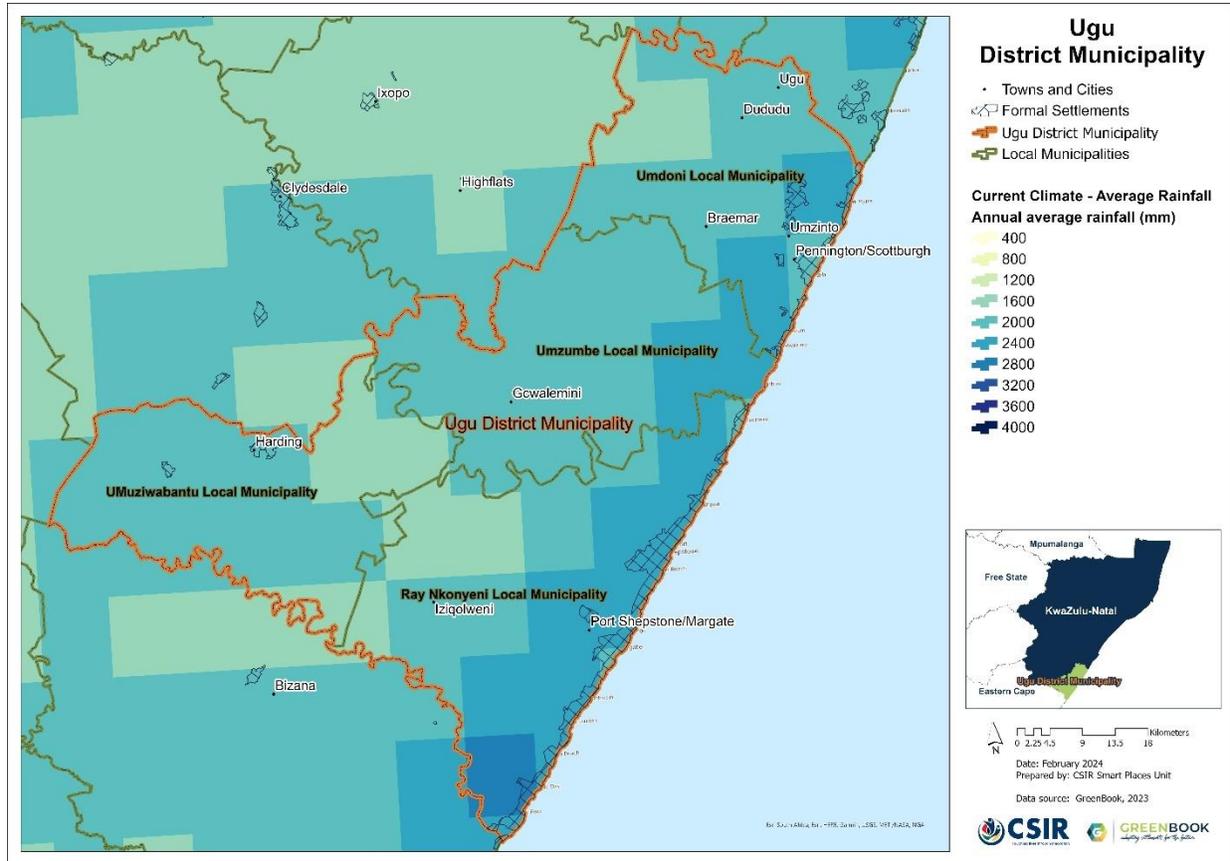


Figure 8: Average annual rainfall (mm) for the baseline period 1961-1990 for the Ugu District Municipality

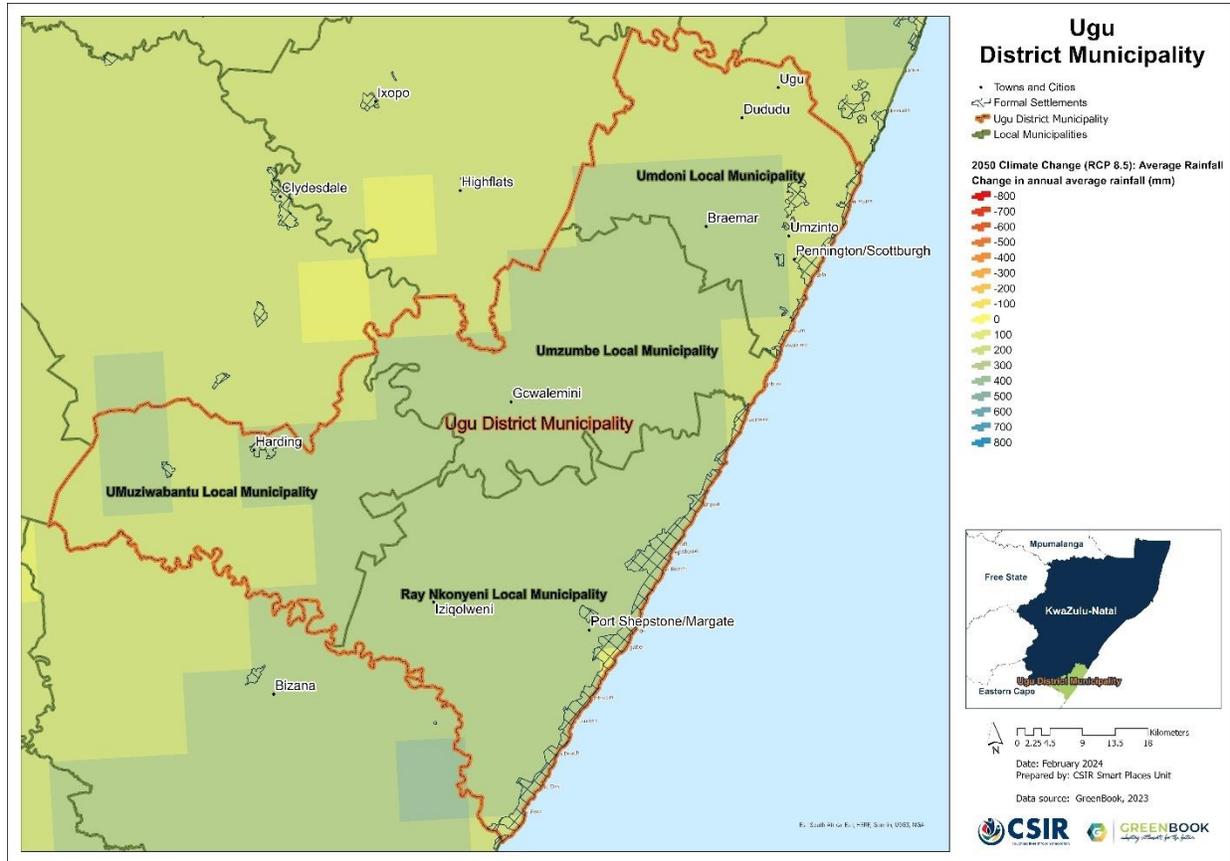


Figure 9: Projected change in average annual rainfall (mm) from the baseline period to the period 2021-2050 for the Ugu District Municipality, assuming an RCP8.5 emission pathway

2.3. Climate Hazards

This section showcases information with regards to the Ugu District Municipality's exposure to climate-related hazards.

2.3.1. Drought

The southern African region (particularly many parts of South Africa) is projected to become generally drier under enhanced anthropogenic forcing, with an associated increase in dry spells and droughts. To characterise the extent, severity, duration, and time evolution of drought over South Africa, the GreenBook uses primarily the Standardised Precipitation Index (SPI), which is recommended by the World Meteorological Organisation (WMO) and is also acknowledged as a universal meteorological drought index by the Lincoln Declaration on Drought. The SPI, with a two-parameter gamma distribution fit with maximum likelihood estimates of the shape and scale parameters, was applied on monthly rainfall accumulations for a 3-, 6-, 12-, 24- and 36-months base period. The SPI severity index is interpreted in the context of negative values indicating droughts and positive values indicating floods. These values range from exceptionally drier (<-2.0) or wetter (>2.0) to near-normal (region bounded within -0.5 and 0.5).

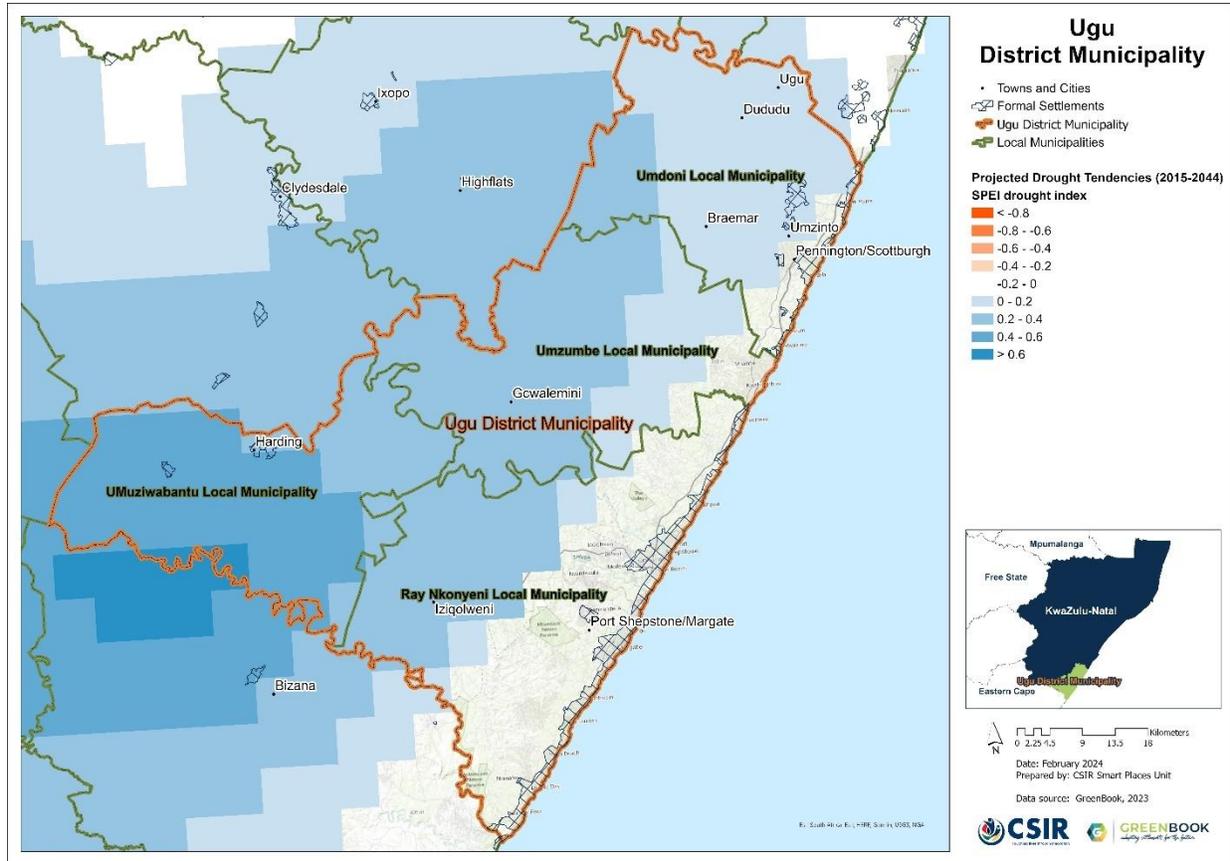


Figure 11: Projected changes in drought tendencies from the baseline period (1986–2005) to the future period 2015–2044 for the Ugu District Municipality

Figure 11 depicts the projected change in drought tendencies (i.e., the number of cases exceeding near-normal per decade) for the period 2015–2044 relative to the 1986–2005 baseline period, under the low mitigation “business as usual” emissions scenario (RCP 8.5). A negative value is indicative of an increase in drought tendencies per 10 years (more frequent than baseline) into the future and a positive value indicative of a decrease. Figure 12 depicts the settlements that are at risk of increases in drought tendencies. Figure 11 shows that for Ugu the occurrence of droughts is to decrease even more. Figure 12 therefore concludes that for all settlements in the district the likelihood of increase in droughts is very low.

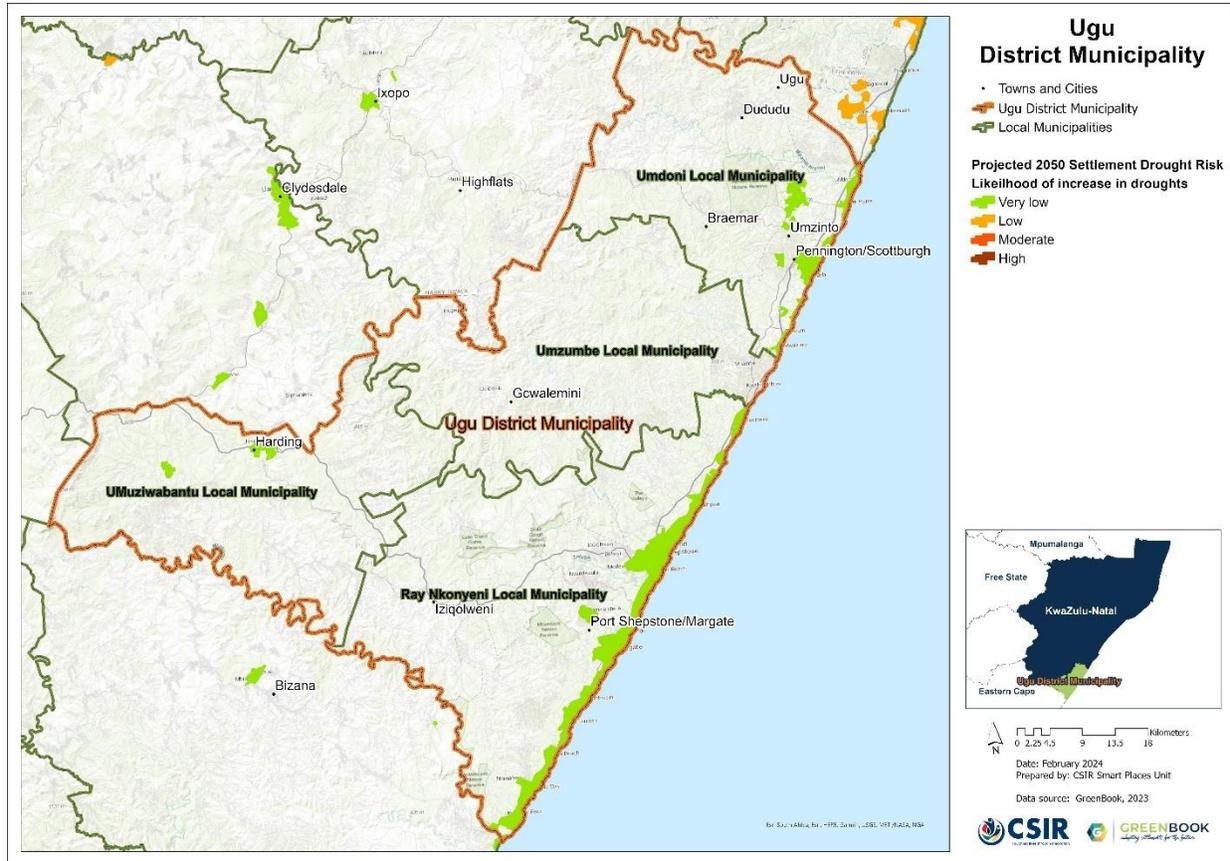


Figure 12: Settlement-level drought risk for the Ugu District Municipality

2.3.2. Heat

With the changing climate, it is expected that the impacts of heat will only increase in the future. The heat-absorbing qualities of built-up urban areas make them, and the people living inside them, especially vulnerable to increasingly high temperatures. The combination of the increasing number of very hot days and heatwave days over certain parts of South Africa is likely to significantly increase the risk of extreme heat in several settlements.

The GCMs were used to simulate bias-corrected, annual average number of very hot days, defined as days when the maximum temperature exceeds 35°C per GCM grid point for the baseline (current) period of 1961–1990 (Figure 13), and for the projected changes for period 2021–2050 (Figure 14). Both figures show that the current and projected number of very hot days in Ugu are very low. For 2050, an increase of up to 1.28 days is expected under a medium RCP4.5 scenario and an increase of up to 3 days is expected under a worst case RCP8.5 scenario.

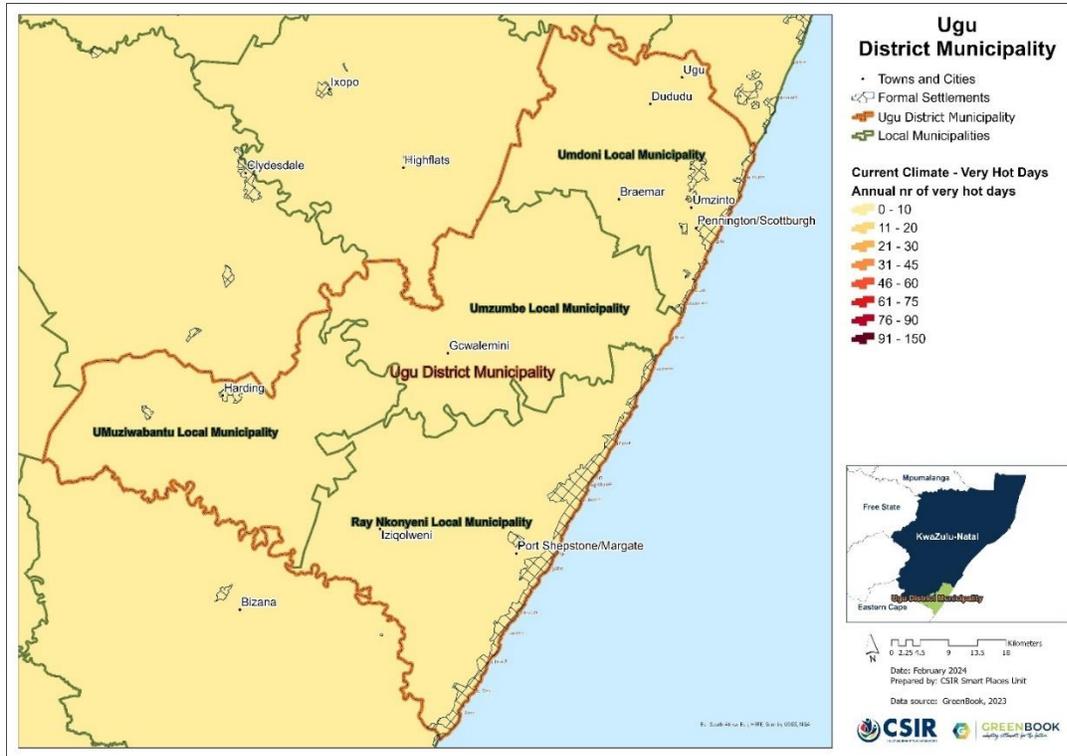


Figure 13: Annual number of very hot days under baseline climatic conditions across the Ugu District Municipality with daily temperature maxima exceeding 35°C

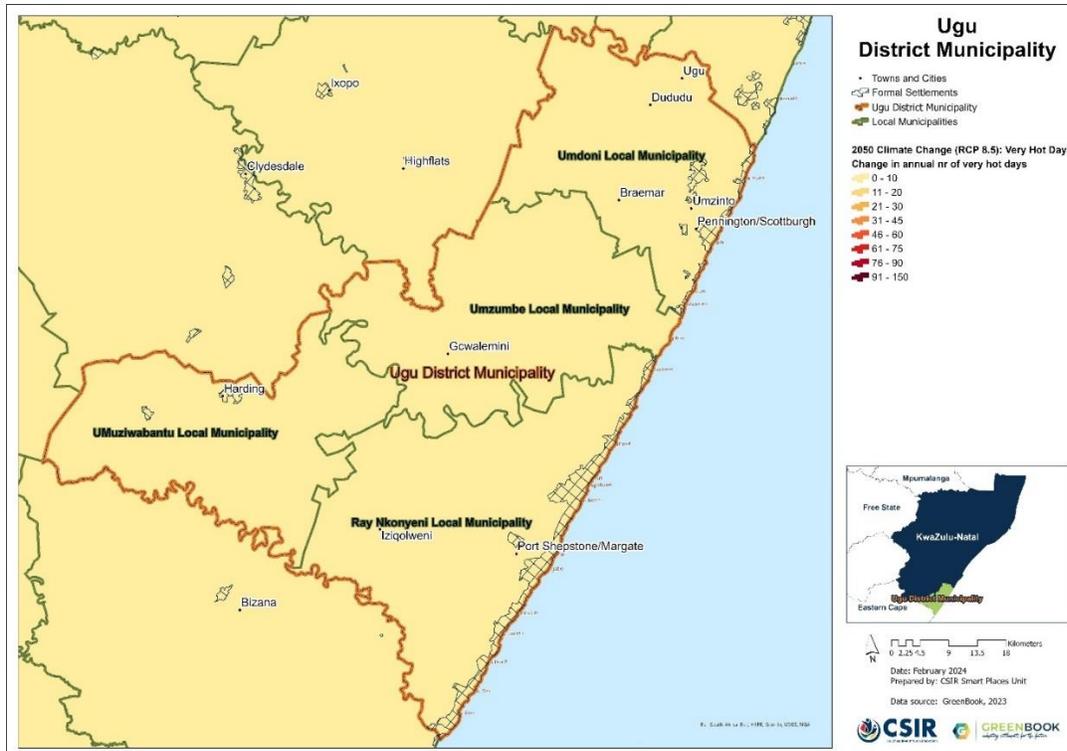


Figure 14: Projected change in annual number of very hot days across the Ugu District Municipality with daily temperature maxima exceeding 35°C, assuming and RCP 8.5 emissions pathway

The annual heatwave days map under baseline conditions (Figure 15) depicts the number of days (per 8x8 km grid point) where the maximum temperature exceeds the average maximum temperature of the warmest month of the year at that location by at least 5°C for a period of at least three consecutive days. The projected change in the number of days belonging to a heatwave for the period 2021–2050 (Figure 16), assuming a “business as usual” (RCP 8.5) emissions pathway is also shown. Figure 15 shows that under current conditions, Ugu is experiencing 0-1 heatwave days in the coastal zone, up to 2 heatwave days in the central part and up to 3 heatwave days in the eastern part of uMuziwabantu. Figure 16 shows that a very low increase of heatwave days (<4 days) is expected by 2050 under worst case scenario RCP8.5. This means that altogether the heat risk in the district is very low. Figure 17 confirms this result on settlement level.

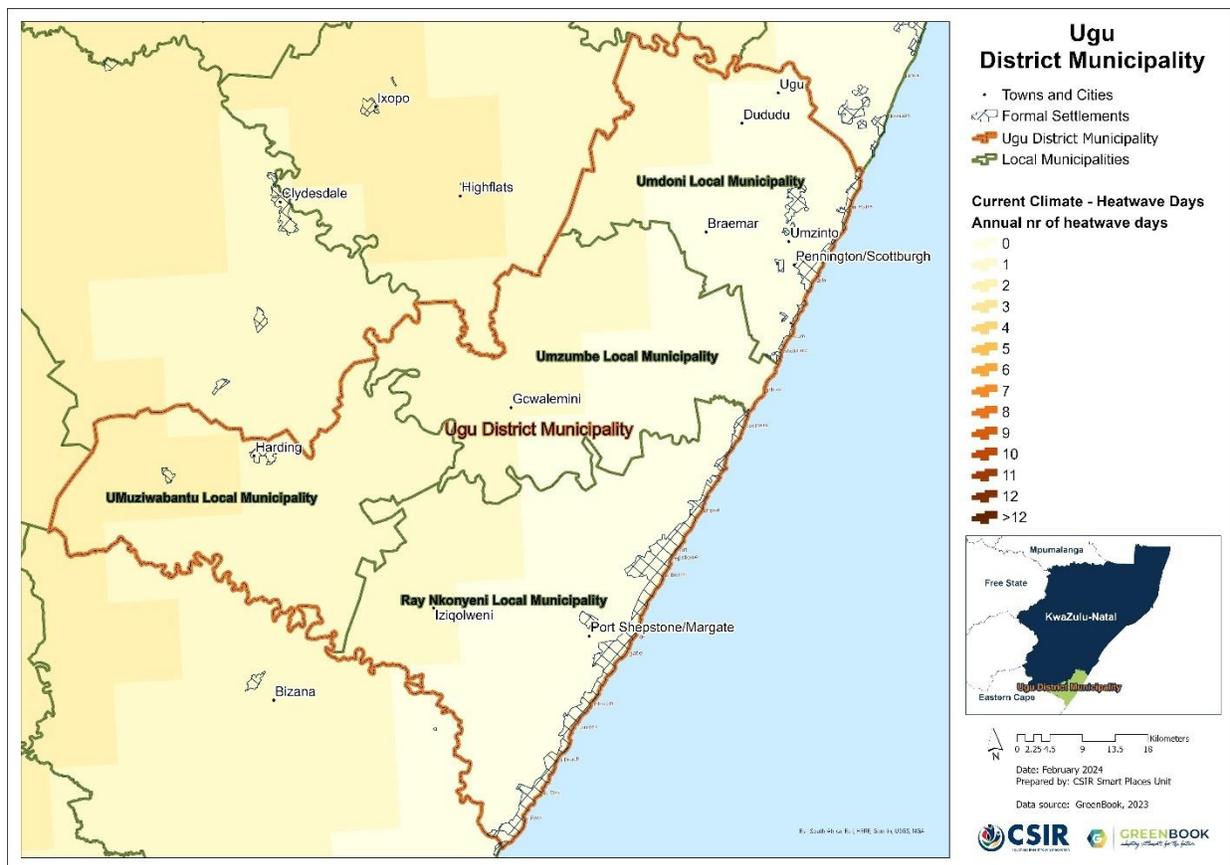


Figure 15: Number of heatwave days under baseline climatic conditions across the Ugu District Municipality

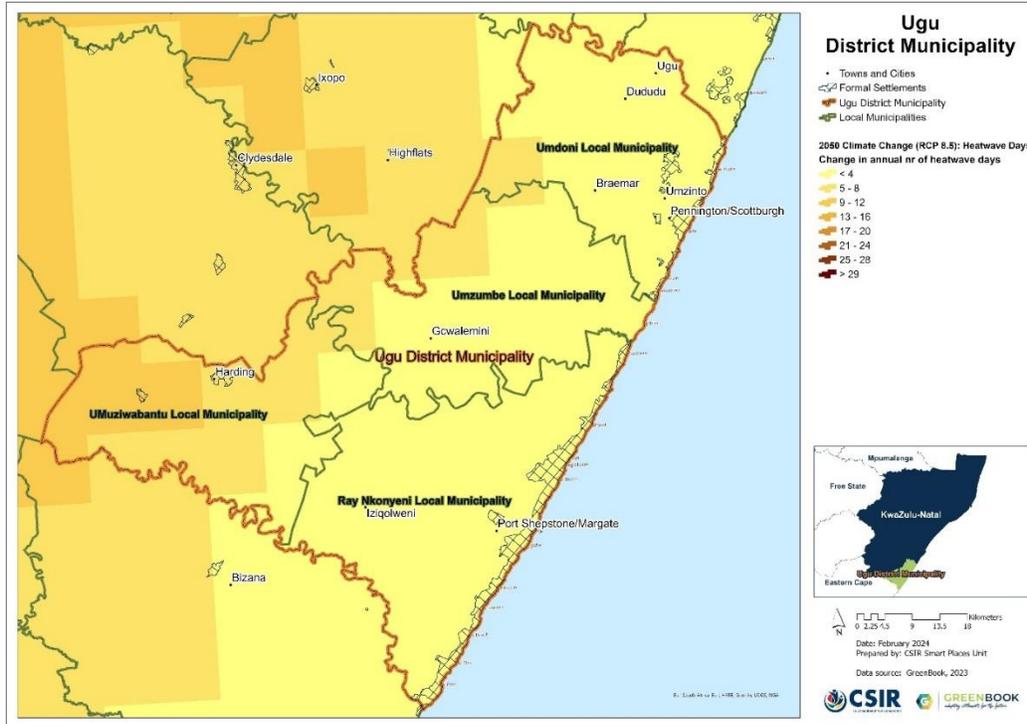


Figure 16: Projected change in annual number of heatwave days across the Ugu District Municipality, assuming an (RCP 8.5) emissions pathway

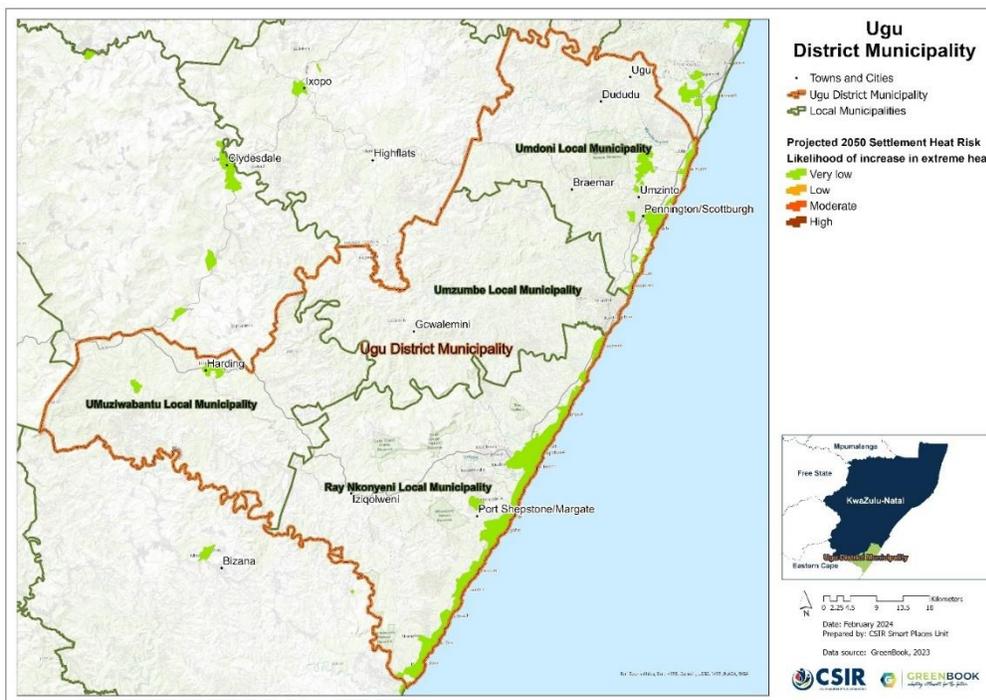


Figure 17: Settlement-level heat risk across the Ugu District Municipality

2.3.3. Wildfire

Wildfires occur regularly in South Africa and often cause significant damage. The main reasons for recurring wildfires are that we have climates with dry seasons, natural vegetation that produces sufficient fuel, and people who light fires when they should not. Much of the natural vegetation requires fires to maintain the ecosystems and keep them in good condition. At the same time fires are a threat to human lives, livelihoods, and infrastructure. More and more people, assets and infrastructure are placed on the boundary or interface between developed land and fire-prone vegetation – what we call the wildland-urban interface (WUI) – where they are exposed to wildfires. The combination of climate and vegetation characteristics that favour fires, and growing human exposure, results in significant wildfire risk across the country, especially in the southern and eastern parts.

Fire risk is determined by combining the typical fire hazard for a fire-ecotype (i.e., likelihood, fire severity) and the social and economic consequences (i.e., the potential for economic and social losses). The typical fire hazard was used to develop a plausible fire scenario for each fire-ecotype, i.e., what a typical wildfire would be like. The fire scenarios were then combined with the vulnerability to estimate the economic and social consequences. A scale was used where the likelihood was rated from 'rare' to 'almost certain' and the consequences were rated from 'insignificant' to 'catastrophic' to determine a level of fire risk which ranged from 'low' to 'high'. The risks were then summarised for all the settlements within a local authority. Changes in the fire risk in future were accommodated by adjusting either the fire scenarios or the likelihood, or both.

Figure 18 depicts the likelihood and the risk of wildfires occurring in the wildland-urban interface (the boundary or interface between developed land and fire-prone vegetation) of the settlements in the district. The inland areas of the municipality are likely to be vulnerable to veldfires due to the presence of extensive grasslands and savanna biomes, and dry winter conditions. Currently the wildfire likelihood is high in Harding and Weza (due to vicinity to forest plantations), and in Umzinto, Ifafa Glebe and Ifafa Marina in Umdoni. Gamalakhe, west of Port Shepstone has a moderate (possible) fire risk. All settlements in the coastal belt currently have a very low wildfire risk.

Further, the projected number of fire danger days for an 8 x 8 km grid-point under an RCP 8.5 "business as usual" emissions scenario was calculated. A fire danger day is described as a day when the McArthur fire-danger index (McArthur 1967) exceeds a value of 24. The index relates to the chances of a fire starting, its rate of spread, its intensity, and its difficulty of suppression, according to various combinations of air temperature, relative humidity, wind speed and both the long and short-term drought effects. Future settlement risk of wildfires is informed by the projected change in the number of fire danger days. Figure 19 depicts the settlements that could be at risk of increases in wildfires by the year 2050. This figure shows that in 2025, most coastal settlements in Ray Nkonyeni could face a slight increase in wildfire risk from currently "very low" to "low".

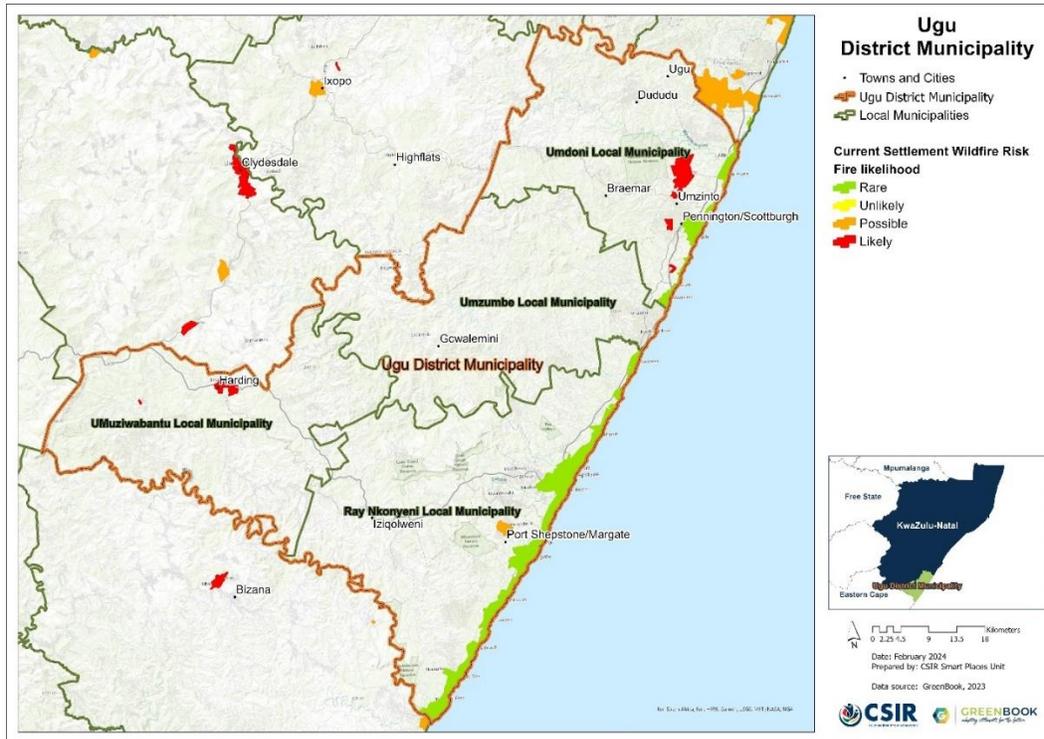


Figure 18 The likelihood of wildfires under current climatic conditions across settlements in the Ugu District Municipality

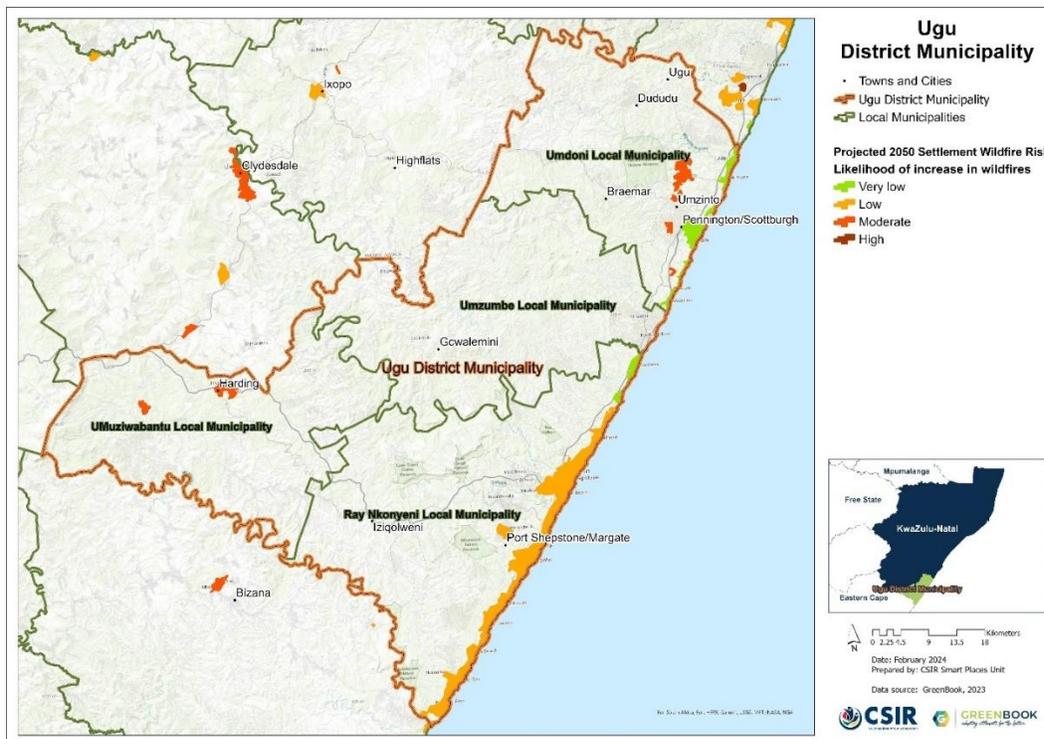


Figure 19: The likelihood of wildfires under projected future climatic conditions across settlements in the Ugu District Municipality

2.3.4. Flooding

The flood hazard assessment for inland floods combines information on the climate, observed floods, and the characteristics of water catchments that make them more or less likely to produce a flood. The climate statistics were sourced from the South African Atlas of Climatology and Agrohydrology, and a study of river flows during floods in South Africa (Schulze, 2008). The catchment characteristics that are important are those that regulate the volume and rate of the water flowing down and out of the catchment. The SCIMAP model was used to analyse the hydrological responsiveness and connectivity of the catchments and to calculate a Flood Hazard Index. Changes in the land cover, such as urbanisation, vegetation and land degradation, or poorly managed cultivation, reduce the catchment's capacity to store or retain water. More dynamic changes in land cover could not be considered in this analysis, such as for example, recent informal settlements that may increase exposure and risk. Additional local and contextual information should be considered to further enrich the information provided here.

Since the magnitude and intensity of rainfall are the main drivers of floods, and rainfall intensity is likely to increase into the future, it is projected that flood events are likely to increase into the future. Estimates of the extreme daily rainfall into the future were obtained from high-resolution regional projections of future climate change over South Africa. The settlements that are at risk of an increase in floods were identified using a risk matrix, which considered the flood hazard index and the projected change in extreme rainfall days from 1961-1990 to the 2050s.

Large areas of the municipality are likely to be vulnerable to flooding due to the high density of rivers within municipality and the encroachment of agriculture and development onto floodplains and wetlands (DEA, 2018).

Figure 20 depicts the flood hazard index of the individual Quinary catchments present or intersecting with the Ugu District. The flood hazard index is based on the catchment characteristics and design rainfall, averaged at the Quinary catchment level. Green indicates a low flooding hazard, while red indicates a high flood hazard. Figure 20 show that currently most of Ugu Districts area is facing a medium flood likelihood on a quinary catchment level. The western-most Mtamvuna catchment in uMuziwabantu is facing high to very high flood risk, the Mzumbe catchment intersecting Ugu's central region is facing a low flood risk.

Figure 21 depicts the projected change into the future in extreme rainfall days for an 8 x 8 km grid. This was calculated by assessing the degree of change when projected future rainfall extremes (e.g., 95th percentile of daily rainfall) are compared with those under the current rainfall extremes. A value of more than 1 indicates an increase in extreme daily rainfalls. Figure 21 shows that most of uMuziwabantu is likely to see a significant increase in flood risk, likely related to the increase in average annual rainfall. The wider Port Shepstone area might see a slight decrease of flood risk, while most of the remaining area in Ugu might see a moderate increase in inland flood risk.

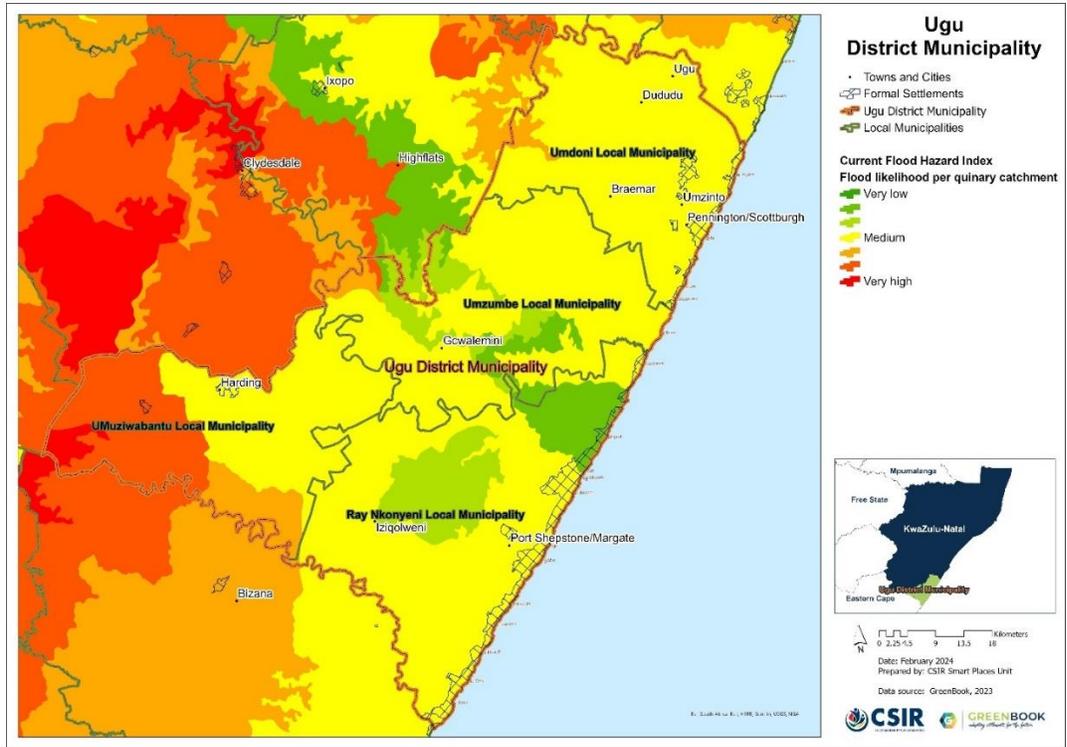


Figure 20: The current flood hazard index across the Ugu District Municipality under current (baseline) climatic conditions

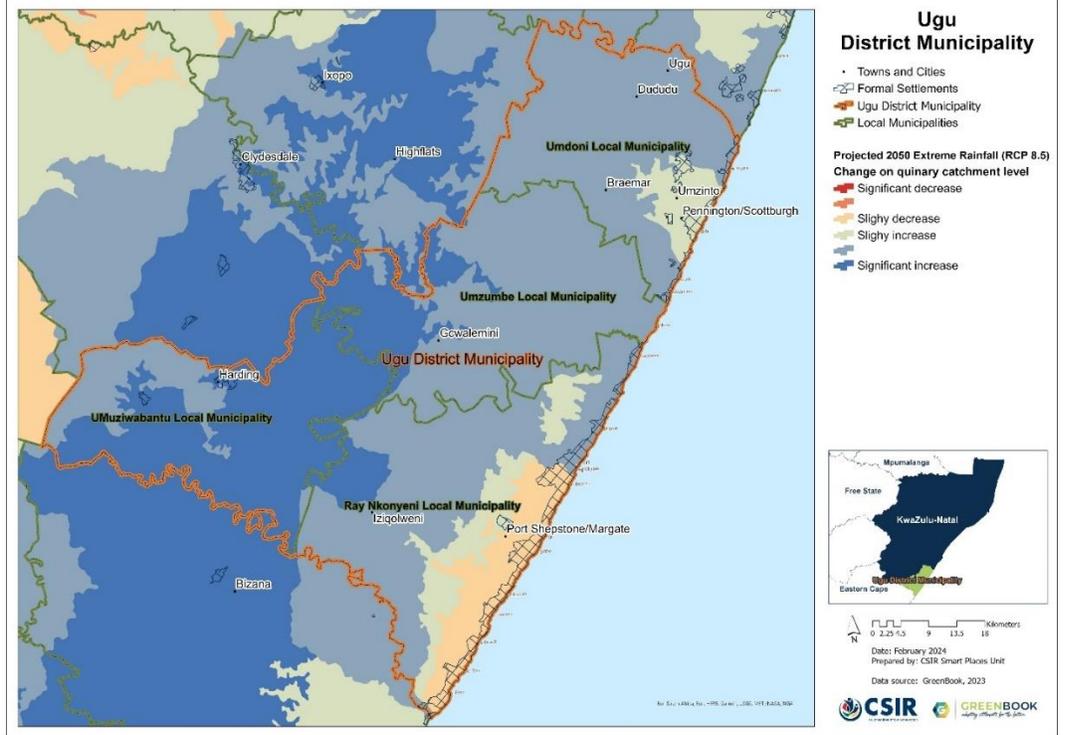


Figure 21: Projected changes into the future in extreme rainfall days across the Ugu District Municipality

Figure 22 depicts the settlements that are at increased risk of flooding under an RCP 8.5 low mitigation (worst case of greenhouse gas emissions) scenario. Weza and Harding are very likely to see an increase in flood risk, the coastal settlements in Umdoni and Gamalakhe will see a low increase in flood risk and the coastal settlements in Ray Nkonyeni will see a very low increase in flood risk.

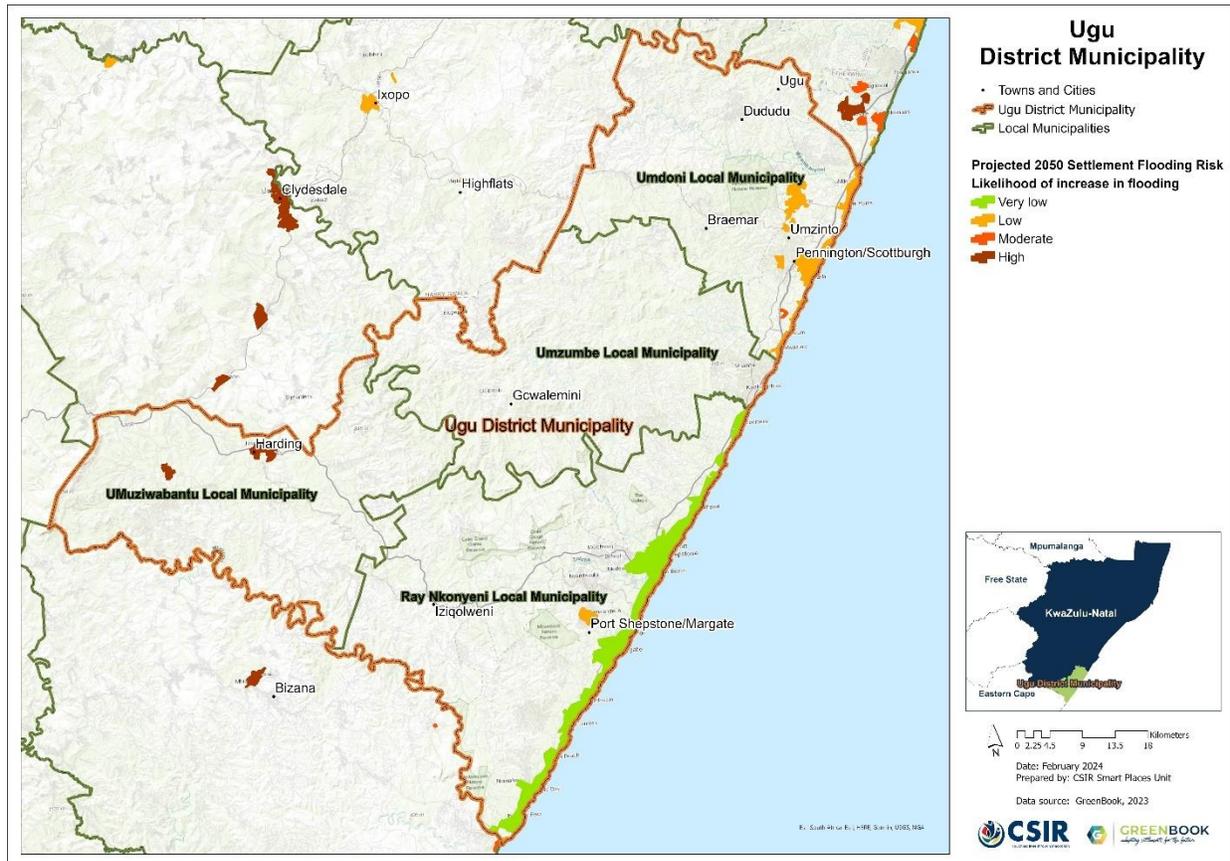


Figure 22: Flood risk into a climate change future at settlement level across the Ugu District Municipality.

2.3.5. Coastal flood and erosion risk

Coastal flood and erosion risk is determined by a variety of input factors, such as coastal topography, geology, land cover, presence of engineered protective structures (seawalls, breakwaters) as well as exposure to wave impact and sea level rise (SLR). In the National Coastal Climate Change Vulnerability Assessment (DEFF 2020), five coastal risk assessments were conducted, namely risk of coastal flooding as a result of storm impact, i.e. storm surge and wave run-up, and SLR, coastal short-term erosion caused by storms, coastal long-term erosion as a result of SLR. Further, estuarine flood and erosion was modelled as caused by inland storm events, i.e. due to rainfall. The open coast risk indices are more mature than the estuary risk indices, as their development was based on previous work. The estuarine indices however were a “first-ever” approach in South Africa and therefore more conceptual (Figure 23). The resulting five coastal climate change vulnerability dataset and the technical report can be accessed

through DFFE's Coastal Viewer (<https://mapservice.environment.gov.za/Coastal%20Viewer/>) can be downloaded [here](#).

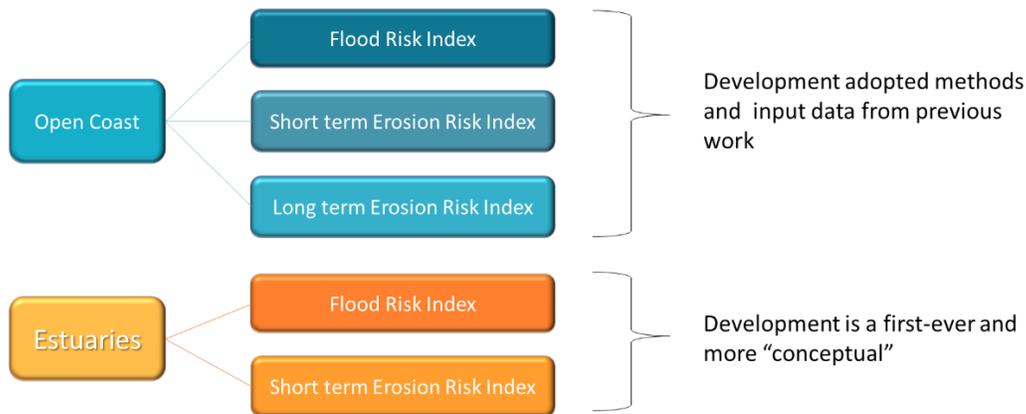


Figure 23: Coastal climate risk indices developed by DEFF (2020)

Given the relatively steep coastal topography in Ugu, the areas at highest risk of flooding and erosion are the numerous estuaries in the district. Here, storm surges, wave run-up and future SLR are contributing to flood risk from the ocean side, while river discharge from increasing rainfall amounts in the catchment contributes to flood risk from the inland. However, the 2023 storms in KZN have shown that coastal developments can also be severely affected by rainfall related flooding in combination with stormwater management issues. Those events are not considered in this coastal flood risk assessment.

Coastal flood risk modelling approach is divided into two parts, first, hydrodynamic modelling determined the water-level height on the coastline, based on statistically determined offshore wave conditions for the 1:10, 1:30, 1:50 and 1:100 years storm events, in combination with a medium-future sea-level rise of 0.35 m and a long-term sea-level rise scenario of 1.0 m. The expected wave run-up heights for those scenarios were then extrapolated inland, using the enhanced BathTubModel in ArcGIS (Williams & Lück-Vogel, 2020). Figure 24 shows an example of the resulting risk lines for a section of the Ray Nkonyeni LM coast. Areas classified as “very low” risk are, according to the models, only affected by 1:100 years storm runup in combination with 1.0m sea level rise (SLR), “low risk” areas will be affected by 1:50 years storms with 1.0 m SLR, “medium” risk areas by 1:30 years storms and 1.0 m SLR, “high risk” areas by 1:30 years storms with 0.35 cm SLR and “very high risk” areas by 1:10 years storms at 0.35 m SLR.

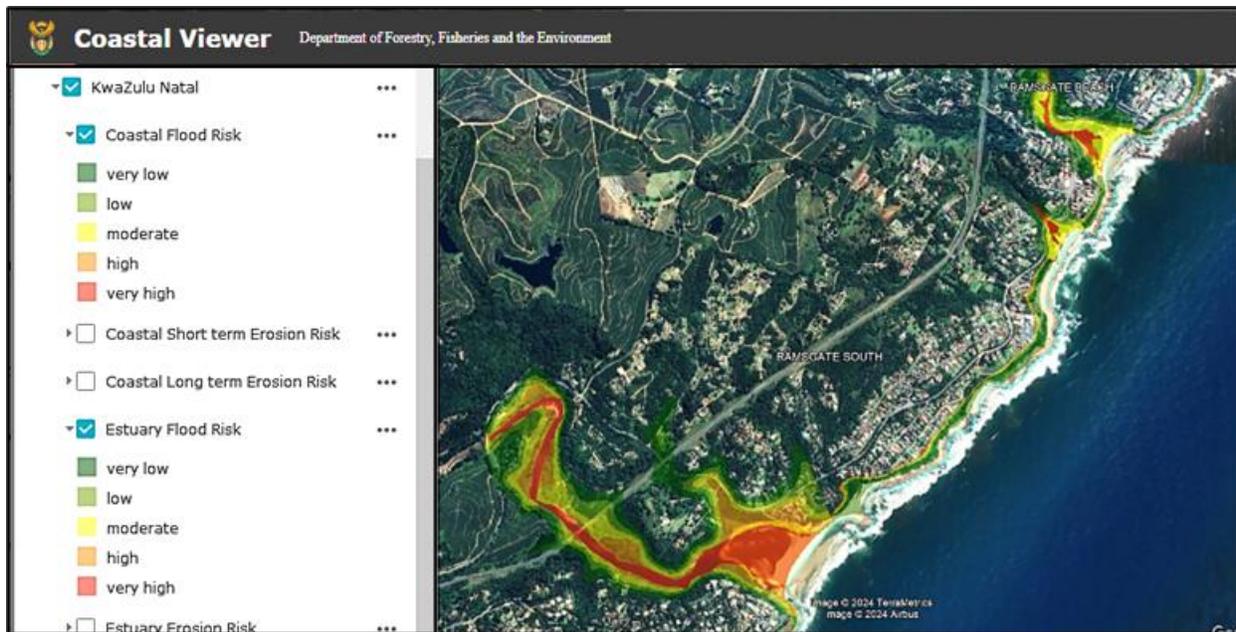


Figure 24: Coastal and estuarine flood risk extent on the Ray Nkonyeni coast

Coastal erosion was modelled in two different approaches. Coastal long-term recession due to SLR was modelled separately from coastal erosion due to storm impact. Both resulting risk line datasets can be accessed through DFFE's Coastal Viewer (<https://mapservice.environment.gov.za/Coastal%20Viewer/>) and can be downloaded [here](#). The modelling of storm-related coastal short-term erosion extents followed a three-step approach as described in DEFF (2020). First, hydrodynamic modelling determined the water level height and wave energy on the coastline, based on statistically determined offshore wave conditions for 1:1, 1:10, 1:30, 1:50 and 1:100 years storm events. Engineering-based equations were used to determine the expected "erosion distance" i.e., the amount the coastline would move "inland", based on the erodibility of the local geology. This geologically possible erosion distance was then modulated with protective factors such as respective coastal vegetation, dune height and presence of seawalls and breakwaters. Soft engineered erosion protection structures were not considered. The resulting modulated erosion distance was then extrapolated inland in a GIS approach. Figure 25 shows an example of the erosion risk lines for Park Rynie, south of Scottsburgh. Erosion risk class "very low" refers to a 1:100 years storm impact, "low" refers to a 1:50 years storm, "moderate" to a 1:30 years storm, "high" to a 1:10 years storm, and "very high" to a 1:1 years storm. This figure indicates that erosion risk might threaten coastal infrastructure locally, like the railway line in this example.

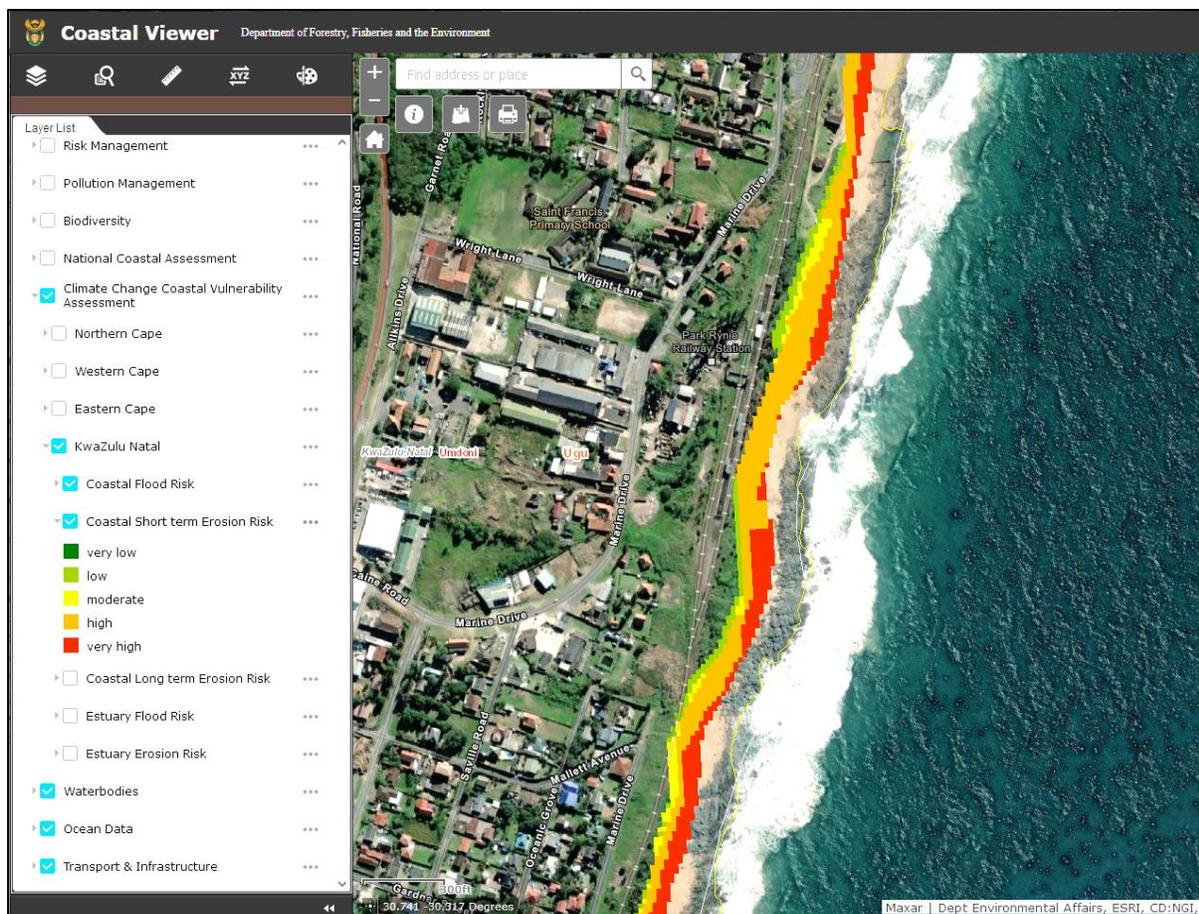


Figure 25: Coastal short term erosion risk in Park Rynie, Umdoni LM

Section 2.3.4 above stated that flood risk for the coastal settlements generally is “moderate” to “low” (Figure 20) and “low” to “very low” on a settlement level (Figure 22). While this might be true for the respective settlements in their entirety, the localised flood risk in the low-lying estuarine areas can be very high.

2.4. Climate impacts on key resources and sectors

To understand the impact that climate change might have on major resources, this section explores the impact that climate change is likely to have on the resources and economic sectors of the Ugu District Municipality.

2.4.1. Water resources and supply vulnerability

South Africa is a water-scarce country with an average rainfall of approximately 450 mm per year, with significant annual and seasonal variability. Rainfall also varies from over 1900 mm in the east of the country and in the mountainous areas, to almost zero in the west and northwest of the country. Conversion of rainfall to runoff is also low with an average mean annual runoff (MAR) of only 40 mm, one seventh of the global average of 260 mm per year. Runoff is even more highly variable than precipitation, both in space and time. Furthermore, demand for water

is not evenly distributed, with most of the major water demand centres located far from the available water resources. This has resulted in a need to store water and to transfer water around the country to meet current and future demands.

Water availability is directly impacted by the climate and climate change. It is not just changes in precipitation that need to be considered, but also increasing temperatures that will lead to increased evaporation which could further reduce runoff and increase water losses from dams. Increasing temperatures will also impact on water demand, particularly for irrigation, but also from urban and industrial users. This could also contribute to reduced water security if existing systems are not able to meet these increasing demands. Increasing air temperatures will also increase water temperatures and hence increase pollution and water quality risks.

To obtain a high-level first order assessment of the relative climate change risks for water supply to different towns and cities across South Africa, a general risk equation was developed to determine the current and future surface water supply vulnerability that combines both climate change and development risks (i.e., due to an increase in population and demand). The current vulnerability of individual towns was calculated based on the estimated current demand and supply as recorded across the country by the Department of Water and Sanitation's (DWS) All Towns study of 2011 (Cole, 2017). The future vulnerability was calculated by adjusting the water demand for each town proportional to the increase in population growth for both a high and medium growth scenario. The level of exposure was determined as a factor of the potential for increasing evaporation to result in increasing demands, and for changes in precipitation to impact directly on the sustainable yield from groundwater, and the potential for impacts on surface water supply. These were then multiplied by the proportion of supply from surface and groundwater for each town. Exposure to climate change risk for surface water supply was calculated in two ways. The first was by assuming surface supply was directly related to changes in streamflow in the catchment in which the local municipality was located (E1) and alternatively (E2) taking into account the potential benefits offered by being connected to a regional water supply system by using the result from a national study of climate change impacts on regional water supply derived from a high level national configuration of the water resources yield model (WRYM) that calculated the overall impacts on urban, industrial and agriculture water supply to each of the original 19 (now 9) Water Management Areas (WMAs) in South Africa.

In South Africa, groundwater plays a key strategic role in supporting economic development and sustaining water security in several rural and urban settlements that are either entirely or partially dependent on groundwater supply. Groundwater is, however, a natural resource, the availability and distribution of which are highly influenced by climate variability and change. An analysis of the impact of climate change on potential groundwater recharge was conducted for the period 2031 to 2050. The Villholth GRiMMS (Groundwater Drought Risk Mapping and Management System) formulation (Vilholth et al., 2013), which implemented a composite mapping analysis technique to produce an explicit groundwater recharge drought risk map, was adapted to formulate a series of potential groundwater recharge maps for the far-future across

South Africa. Finally, the future period 2031 to 2050 was compared with the historical period 1961 to 1990.

Figure 26 indicates Ugu's settlements main water supply, be it groundwater, surface water or a combination of both sources. Settlements that rely on groundwater, either entirely or partially, are deemed to be groundwater dependent. In the Ugu District, all towns are surface water dependent.

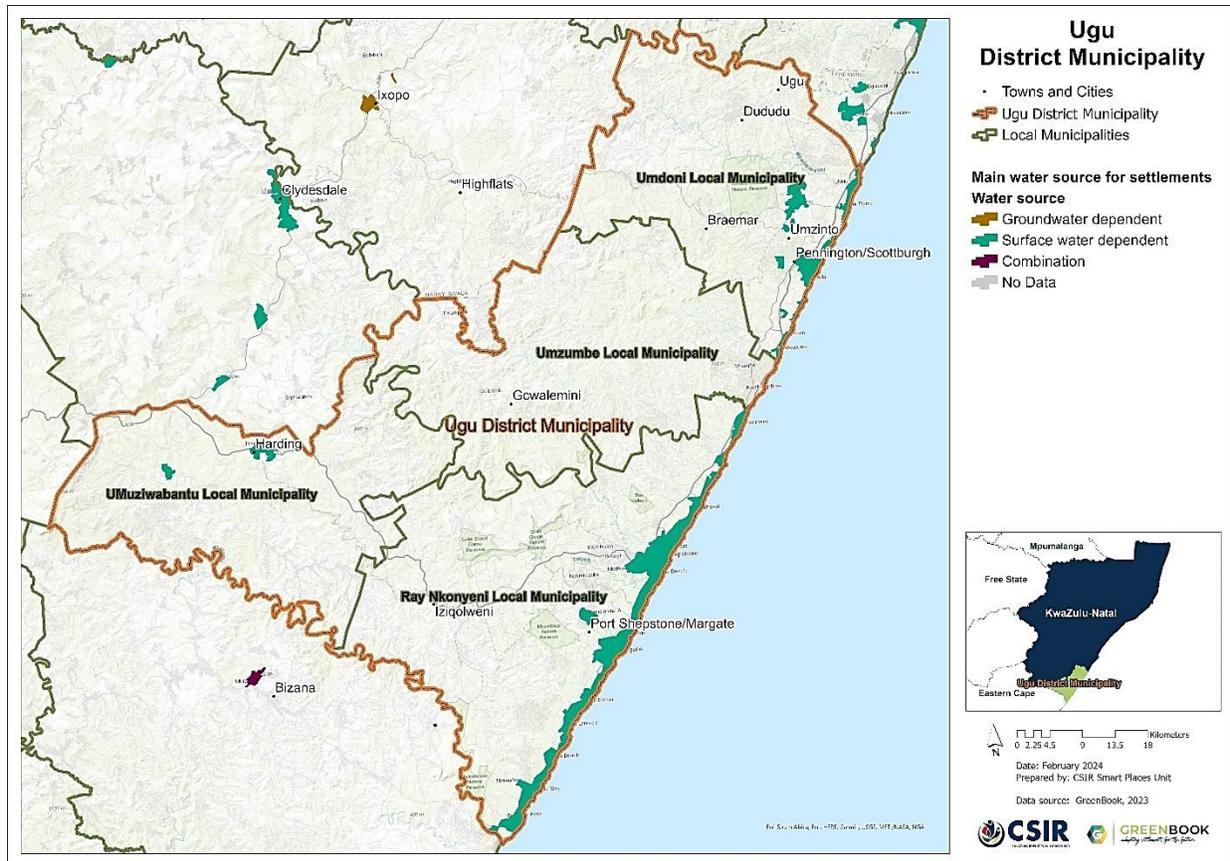


Figure 26: Main water source for settlements in the Ugu District Municipality

Figure 27 indicates the occurrence and distribution of groundwater resources across the District Municipality, showing distinctive recharge potential zones. Most of Ugu District, in accordance with the very high annual rainfall received, has a very high groundwater recharge potential of >4.26, with some localised areas with a slightly lower recharge potential between 2.69-4.26.

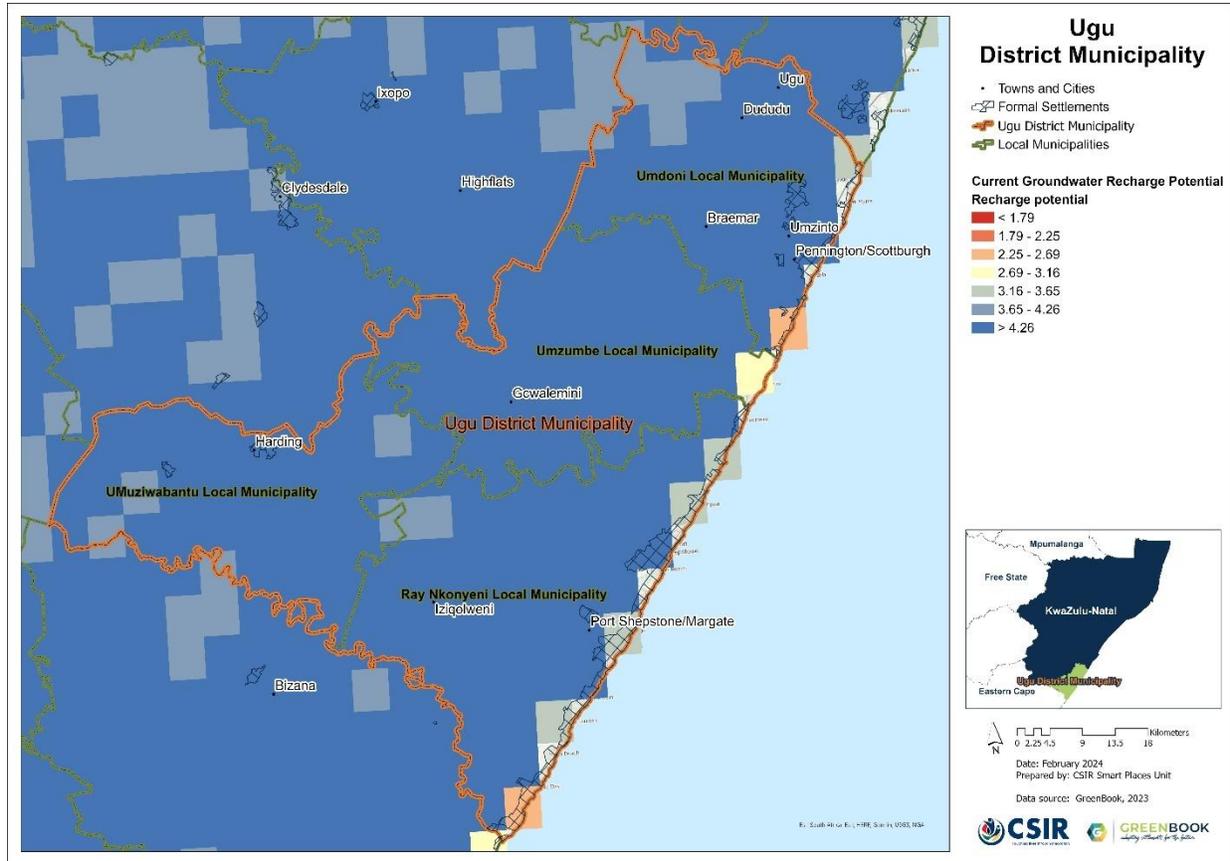


Figure 27: Groundwater recharge potential across the Ugu District Municipality under current (baseline) climatic conditions

Figure 28 indicates the projected change in groundwater potential. According to these data, Ugu District will see a small-scale pattern of areas with no change, some increase, and some areas with high increase in groundwater recharge potential.

Figure 29 indicates which settlements that may be at risk of groundwater depletion based on decreasing groundwater aquifer recharge potential and significant increases in population growth pressure into the future. However, given the very high annual rainfall and the use of surface water as main water supply, “no risk” of groundwater depletion was modelled for Ugu’s settlement.

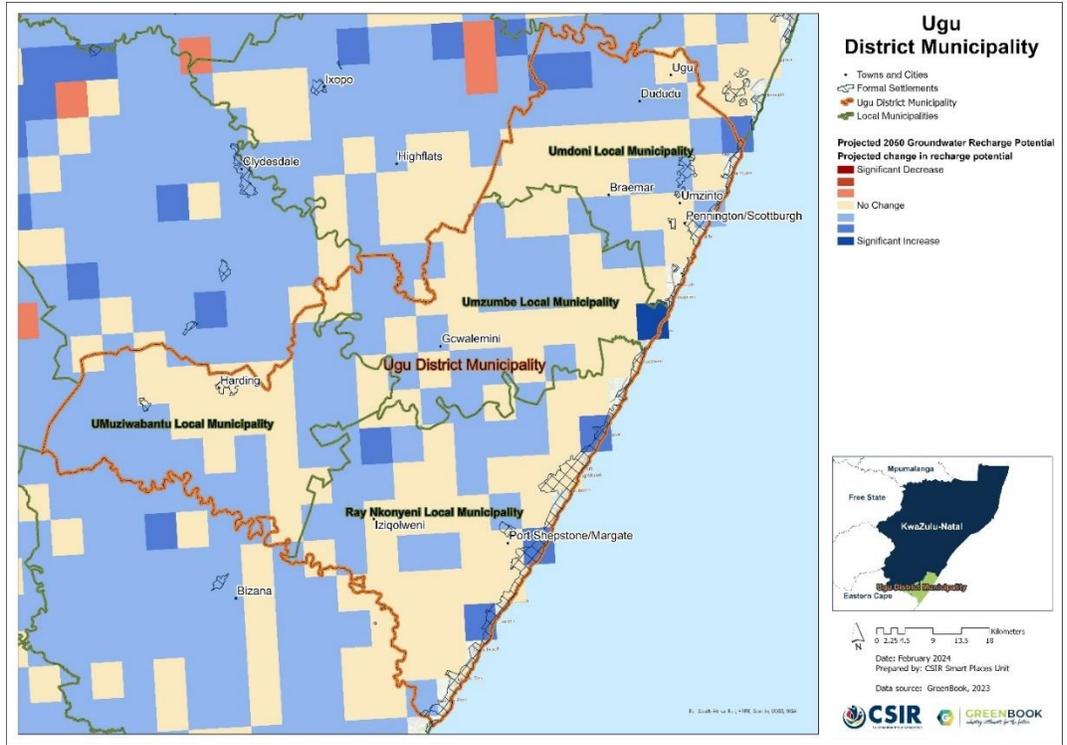


Figure 28: Projected changes in groundwater recharge potential from baseline climatic conditions to the future across the Ugu District Municipality

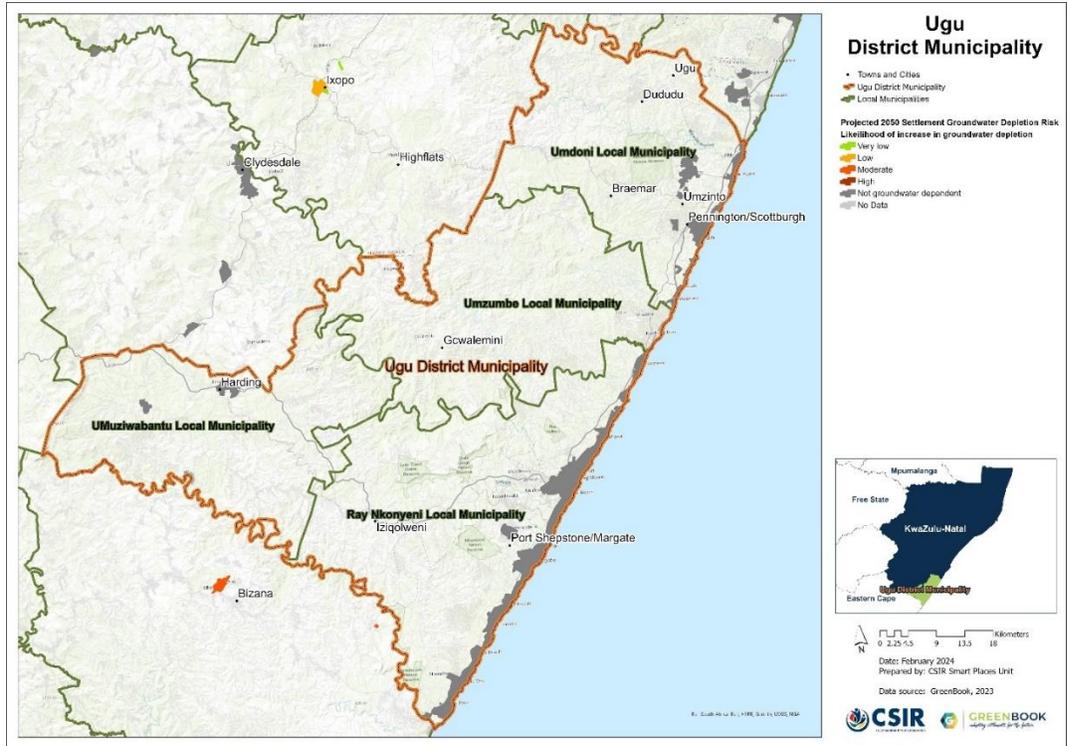


Figure 29: Groundwater depletion risk at settlement level across the Ugu District Municipality

Table 3 provides an overview of current water supply vulnerability (i.e., demand versus supply) for the Local Municipalities in the Ugu District based on the data compiled for the Department of Water and Sanitation's (DWS) All Town's Study (Cole, 2017). A water supply vulnerability score above 1 indicates that demand is more than supply, while a score below 1 indicates that supply is meeting demand.

Table 3: Current water supply and vulnerability across the Ugu District Municipality

Local Municipality	Groundwater dependence	Water Demand per Capita (l/p/d)	Water Supply per Capita (l/p/d)	Current Water Supply Vulnerability
Umdoni	0.0 %	127.57	156.15	0.82
Umzumbe	6.6 %	84.52	71.48	1.18
uMuziwabantu	0.0 %	136.01	107.33	1.27
Ray Nkonyeni	0.0 %	154.85	102.11	1.52

According to these data, currently only Umdoni's water supply is meeting the demand. The under-supply in the other LMs is likely related to the low total number of households with access to piped water within their dwellings (36.2%) in the district. The district is aware of the shortage of water supply, as indicated by the first strategic priority of the Climate Change Response Strategy for the Ugu District Municipality: "to provide access to sustainable quality drinking water and sanitation services" (Ugu, 2017).

Current and future water supply vulnerability estimations are based on: 1) a local water supply perspective incorporating changes to population growth coupled with exposure to climate risk and 2) a regional water supply perspective, based on impacts of regional water supply assuming supply is part of the integrated regional and national bulk water supply network. The water supply vulnerability estimations do not consider the current state of water supply and reticulation infrastructure. The current context and conditions within each of the Local Municipalities need to be considered when interpreting the information provided in this report. See the GreenBook Municipal Risk Profile Tool for more information on surface water, change in precipitation, runoff, and evaporation.

2.4.2. Agriculture, forestry, and fisheries

Agriculture and food production is arguably the sector most vulnerable to climate impacts in South Africa. Many settlements in South Africa owe their existence to the primary sector of the country. Agriculture, forestry, and fisheries (AFF) form the bulk of the primary sector and act as catalysts for the economic development of secondary and tertiary sectors. Where these sectors are the primary economic activity in an area, they contribute to the local economy, employment, food security, and livelihoods. They also indirectly benefit from services such as health care, education, and basic infrastructure. In such regions, social and economic stability are linked with the profitability of the agricultural sector.

Climate change, through increased temperature and changing rainfall patterns, can have fundamental impacts on agriculture if the climatic thresholds of the commodities being farmed are breached. However, the nature and extent of these impacts depends on the type of commodity being farmed and the relative geographic location of the farmer with regard to the industries served, and also on the resources available to the farmer. The same climate impact can have different impacts on different commodities and farms. Overall, climate change could make it more difficult to grow crops, raise animals, and catch fish in the same ways and same places as has been done in the past.

The methodological approach to understanding the impact of climate and climate change on AFF, consisted of four components. Firstly, the most important areas in terms of Gross Value Added (GVA) and employment for the AFF sector relative to the other sectors of the South African economy were determined. Secondly, an analysis of climate change scenarios was done using historical climate variables, as well as multi-model projections of future climates to help identify specific climate-related risk factors for agriculture within specific regions. Thirdly, crop suitability modelling was done to indicate how the area suitable for crop production under the present climate conditions might shift or expand under the scenarios of future climate change, in addition to using the Temperature Humidity Index (THI) to assess heat stress in livestock. Finally, the climate change analysis was used in conjunction with the crop modelling outputs to assess the potential impacts of climate change over a specific area, or for a specific crop, to give more detail on how predicted climate changes translate into location/crop specific impacts. This was developed at a local municipal level and guided by the outcome of the agricultural industry sector screening and climate scenario analysis.

Below, the main agricultural commodities for each local municipality within the district is discussed in terms of what the impact of climate change might be on those commodities under an RCP 8.5 low-mitigation “business as usual” greenhouse gas emissions scenario.

Umdoni

Main commodities: Sugarcane, Milk and Cream, Forestry. AFF contributes 10.84% to Umdoni GVA production. AFF contributes 16.77% to Umdoni total employment. The total AFF GVA production of Umdoni Municipality contributes 0.56% to the national AFF GVA, ranking them as the 53rd biggest contributor.

Umzumbe

Main commodities: Beef cattle, Sugarcane, Forestry. AFF contributes 8.57% to Umzumbe GVA production. AFF contributes 10.78% to Umzumbe total employment. The total AFF GVA production of Umzumbe Municipality contributes 0.19% to the national AFF GVA, ranking them as the 143rd biggest contributor.

uMuziwabantu

Main commodities: Forestry, Beef cattle, Sugar cane. AFF contributes 16.74% to uMuziwabantu GVA production. AFF contributes 18.57% to uMuziwabantu total employment. The total AFF GVA production of uMuziwabantu Municipality contributes 0.4% to the national AFF GVA, ranking them as the 80th biggest contributor.

Ray Nkonyeni

Main commodities: Sugarcane, Forestry, subtropical fruit. AFF contributes 8.19% to Ray Nkonyeni GVA production. AFF contributes 12.39% to Ray Nkonyeni total employment. The total AFF GVA production of Ray Nkonyeni Municipality contributes 1.43% to the national AFF GVA, ranking them as the 12th biggest contributor.

The AFF sector contributes about 10% to Ugu's GVA. Sections 2.2 and 2.3 have shown that Ugu is likely to face only a low increase in average temperatures and an increase in rainfall. Hence, the expected number of very hot days, heatwave days and droughts are remaining about the same. This means that agricultural activities will not be at high risk to these climate factors in the future. However, the increase in rainfall, which might expect a greater variability (Engelbrecht 2019) and thus lead to more extreme events, might threaten agricultural and other infrastructure and livelihoods, specifically in low-lying areas such as estuaries and on steep slopes. Extreme events are also the biggest challenge for the Wholesale and retail trade, catering and accommodation sector, which is, after governance, the second most important sector in Ugu.

3. Recommendations

The greatest climate risk faced by the Ugu district will be an increase in overall rainfall, an increased variability in rainfall leading to more extreme rainfall events, and the resulting risk of flooding. While Figure 21 suggests that specifically the catchments in the western, inland areas of the district will see a significant increase in extreme rainfall, it has to be considered that these catchments ultimately drain into the coastal estuaries. This means that extreme rainfall events in the inland can increase the flood risk in the estuaries, putting infrastructure and livelihoods located there at risk.

Figure 4 and 5 in Section 2 showed that in many of Ugu's settlements the growth pressure is high. This means that the municipalities must plan for the influx of people in terms of service provision, but also in terms of space to settle. Settlements with high growth pressure frequently also see a high environmental vulnerability. Therefore, in response to these climate risks and impacts and the most challenging settlement vulnerabilities, the following adaptation goals are recommended:

1. Climate-wise planning of future settlements and urban development: The awareness of the expected influx of people enables the District and its LMs to proactively plan for the growing population. Climate risks as described above, should be considered for future

urban development. Specifically, the delineation of potential hotspots for flooding, i.e. areas where extreme rainfalls are expected as well as low-lying areas and estuaries should be excluded from spatial development (amend SDP accordingly) or architectural design standards and practices to flood-proof development in risk zones should be adopted, to ensure that Ugu's urban/settlement fabric is resilient to the anticipated climate conditions and extreme events (e.g., climate proofing infrastructure and buildings). These standards could include the condition to put, e.g. electrical main switches on higher levels in the buildings, include storm water drainage pipes and protect fresh and sewerage pipes from flood impact. On a town planning level, special attention should be put on the design of stormwater drainage systems to accommodate higher stormwater volumes than currently anticipated. Partnering with insurance companies can be considered to develop disincentives for development in flood risk areas.

2. Climate-wise rural development and agriculture: The natural dense vegetation in the province has excellent flood prevention properties in that it slows down surface water flow and enables soil infiltration. However, about 50% of Ugu's land surface has lost its natural vegetation cover to AFF and urban development. While the crops cultivated in Ugu might not be negatively affected by future climate conditions directly, agricultural production practises can have tremendous impact on flood risk in the catchment, even large distances away. Rural flood risk frequently also leads to soil erosion. It has been proven that cultivated land can be more prone to surface run-off (contributing to flooding). Therefore, agricultural practices should be considered which enhance the soil's absorption of rainfall. These could be, ploughing parallel to topographic contours, avoid tilling during high rainfall seasons (to prevent soil erosion), keep sufficient distance from water courses, leave riverine vegetation intact, leave cordons of natural vegetation between crop fields, among others. For small-scale farming, the generation of level terraces for cultivation will prevent run-off, as well as leaving some vegetation matter (stubbles) standing after harvest to slow down surface water flow during fallow periods.
3. Ensure water security for human consumption under a changing climate: Given the projected population growth for many settlements in the district, and the already prevailing under-provision of drinking water, it is expected that provision of water will become an even greater challenge in the future. Some of the actions that the district could take include prioritising infrastructure maintenance; investing in efficient water supply infrastructure to meet future demand; promoting water conservation practices by implementing strategies such as public awareness campaigns, leak detection and repairs, water metering and billing; as well as exploring measures to secure alternative water sources such as rainwater (harvesting), groundwater (recharge and extraction) and wastewater (reuse).

4. To increase the adaptive capacity of people to climate change and extreme events: To reduce the vulnerability of people to climate-related hazards and extreme events, it is essential to increase their capacity to adapt to such impacts and events. One particular challenge in this regard for the Ugu district is that the vast majority is living in traditional settlements, and the high rate of population growth bears the probability that in-migrating people are not familiar with, e.g. historic flood events occurred in certain areas as indicator for existing flood risk. The district could increase the adaptive capacity of the rural population through targeted information campaigns and sign boards on areas to avoid for settling. Further, easy-to-implement architectural measures for flood proofing housing in traditional areas should be developed and made public. Another measure to reduce risk would be early warning systems developed between the district (or even province) and local community leaders, where, for instance, SAWS or the respective disaster management centre issues weather warnings to community leaders which use a snowball system to inform and evacuate people from risk areas.

5. To protect biodiversity and improve sustainable use of natural resources: As noted earlier, the district's natural environment is under severe pressure due to rapid urbanisation, agricultural expansion and land-use change. This therefore makes the district's natural environment and resources, as well as biodiversity, very vulnerable to extreme climate-related events. It is thus necessary to protect and restore these natural environments in order to maintain their key functions. The protection and restoration of natural ecosystems, like high-priority biomes, wetlands, river ecosystems and riparian areas, are integral to maintaining biodiversity, supporting water resource management, and providing natural buffers against climate-related hazards like wildfires and floods. Some of the actions that the district could take to realise this goal include establishing or expanding protected areas, enforcing regulations against harmful practices in such areas, and promoting the sustainable use of natural resources.

These goals should be pursued with the understanding that the District's climate risks are likely to increase due to climate change. Hence, any actions taken need to remain adaptable to the evolving risks over time. Furthermore, while these recommended goals are not exhaustive, they can be enhanced by strategies tailored to the specific needs of the district. The key to success lies in integrating these goals and the principles behind them into all aspects of municipal decision-making and operations, as well as in actively engaging communities in these initiatives.

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