# Alfred Nzo District Municipality

## Climate Risk Profile Report based on the GreenBook

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# Acronyms

| | |
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| °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 |
| 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

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| 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). |

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| 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). |

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| Resilience | "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). |
| Sensitivity | "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). |
| Vulnerability | 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). |

# 1. Introduction

This Climate Risk Profile report, as well as the accompanying Climate Change Adaptation Plan, were developed specifically for the Alfred Nzo 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 l 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.

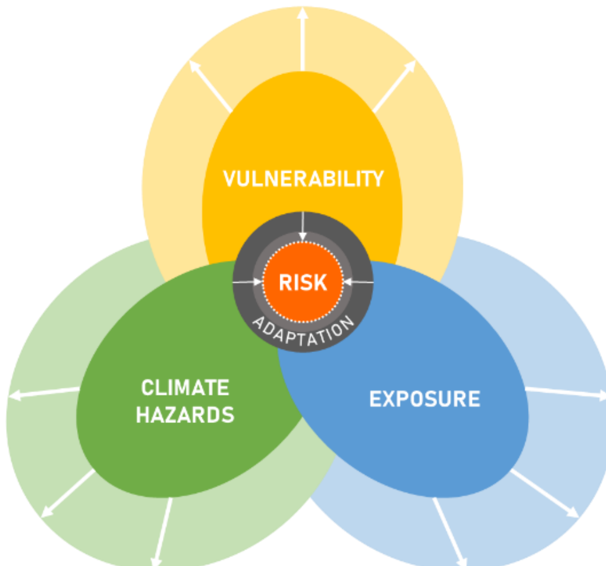


*Figure 1: The interaction between the various components of risk, indicating the opportunity to reduce risk through adaptation (based on IPCC, 2014 and IPCC, 2021)*

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 is 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.

## 1.3. District Municipal context

Alfred Nzo District Municipality is located in the northeast of the Eastern Cape Province and borders Lesotho in the north, Sisonke and Ugu district municipalities in the east and O.R. Tambo District Municipality in the south (Figure 2). The district is the smallest district in the province and its surface area is 1 1119 $km^2$, sub-divided into four local municipalities: Matatiele covering 4352 $km^2$ (39% coverage of district area), Umzimvubu 2506 $km^2$ (23% of district area), Mbizana[1] 2806 $km^2$ (25% of district area) and Ntabankulu occupying 1455 $km^2$ (13% of district area). The seat of Alfred Nzo is Mount Ayliff. The majority of the people speak isiXhosa (COGTA 2020).

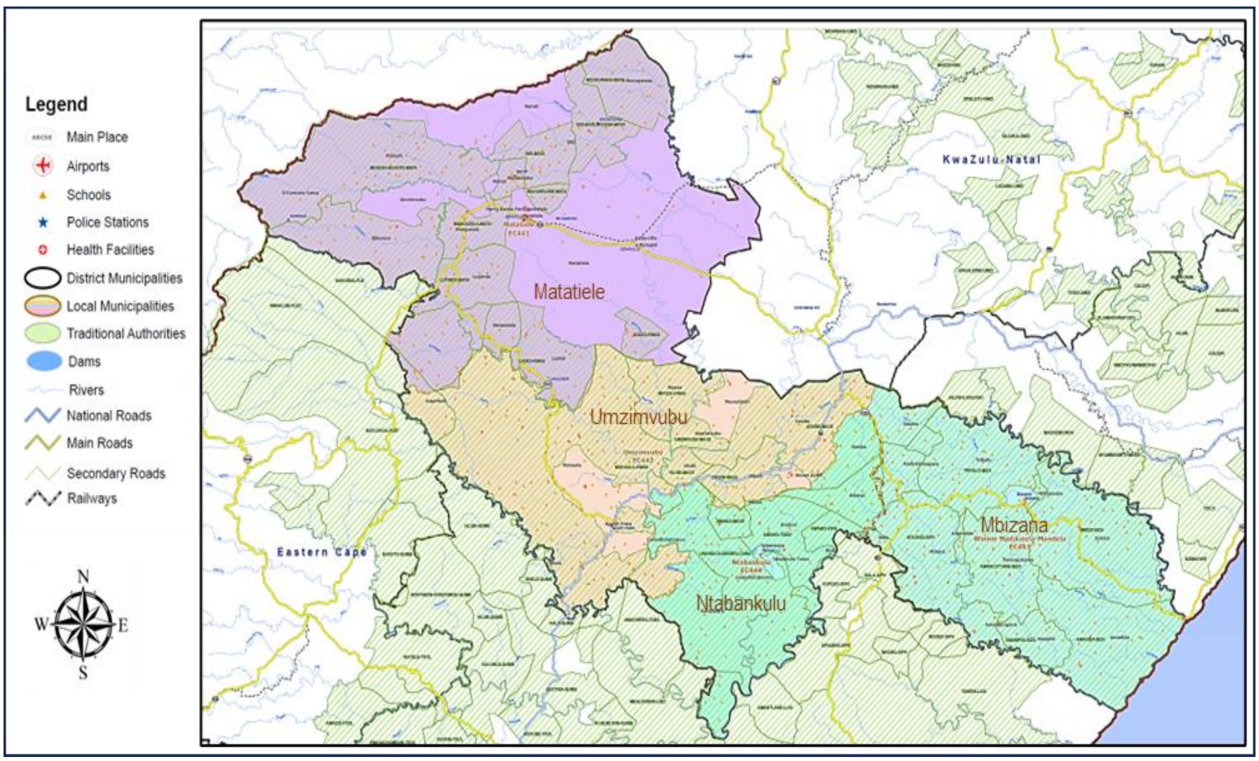


*Figure 2: Alfred Nzo District Municipality (Municipal Demarcation Board, 2022), with Local Municipalities shaded in different colours*

[1] *The municipality was renamed to Winnie Madikizela-Mandela Local Municipality effective on 1 December 2020 (source: https://municipalities.co.za/). However, given that most GIS data used in this report still use the old name Mbizana, this name will be used for consistency purposes. Future reports will use updated GIS data and the new name of this LM.*

Alfred Nzo District Municipality was historically part of the Transkei homelands. The district is largely rural in nature, with village settlements defined by the district's geographical footprint through mountain ranges and river systems. There is no clear settlement hierarchy and the area is largely characterised by high levels of low density urban sprawl. As such the district is characterized by high levels of poverty, based on both income inequality and low level of development. In response to this deprivation, the Alfred Nzo District was one of the presidential poverty nodes identified in the Integrated Sustainable Rural Development Programme (ISRDP) and has been a subject of different forms economic intervention through time (ANDM 2023) and it is also included in the presidential Eastern Seabord and Smart Cities Development Initiative. The National Department of Cooperative Governance and Traditional Affairs (CoGTA) through the Municipal Infrastructure Support Agent (MISA) has embarked on a process to develop the Eastern Seaboard which will ultimately culminate in one or more African coastal smart cities in the region of the OR Tambo, Alfred Nzo, Ugu and Harry Gwala districts across the Eastern Cape – KwaZulu Natal boundary and will include major restructuring of proposed road infrastructure, agricultural and urban development priority areas (COGTA 2023). Figure 3 provides an overview of the proposed changes, indicating that the currently largely undeveloped coastal zone of Mbizana is foreseen to be connected to the re-routed N2 Highway and to be developed into a Higher Order Settlement expanding from Port Edward. The development of a small harbour is also foreseen for this area. The settlements of Matiatiele and Bizana are to be developed as Regional Development Anchors.

Matatiele municipality is close to the Lesotho/South Africa national border and has two urban nodes – the towns of Matatiele and Cedarville. It is currently the economically strongest LM in the Alfred Nzo District. Matatiele acts as a service node to the agrarian based economy of the area, while Cedarville serves as a secondary service centre. Umzimvubu municipality hosts the district's administrative capital in Mt Ayliff and the district's largest economic node in Mt Frere. The N2 traverses the course of the Umzimvubu municipality and can be seen as its most prominent defining trait. Ntabankulu municipality has small urban settlements at Ntabankulu town and Cacadu.

Ntabankulu's people predominantly live in traditional settlements. The LM is geographically defined by several mountain ranges. Mbizana municipality is the district's gateway to the Wild Coast and has a medium sized town at Bizana. The district has a very mountainous terrain. The landform of the district is generally rugged, with parts of it characterised by steep slopes and high elevations. The topography has implications on the district's natural, social and economic environment. The district is characterised by a high level of biodiversity, and natural resources including river systems, indigenous forests and rich soils. Socially, settlement patterns are determined by the courses of rivers, valleys and hills. The interaction between people and nature also means that the terrain either exacerbates or ameliorates human impacts on the environment (ANDM 2023).

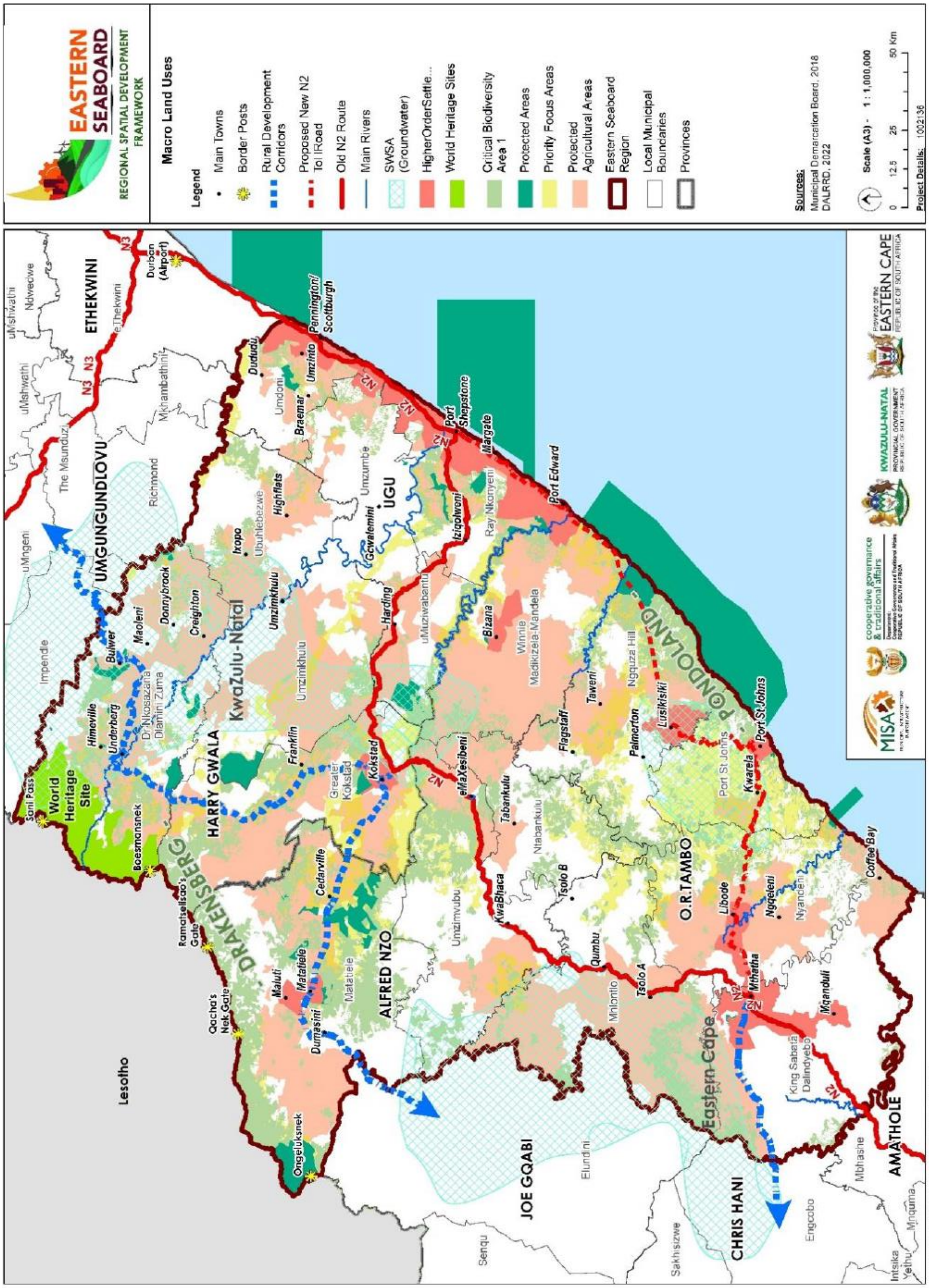


*Figure 3: Proposed macro land use in the Eastern Seaboard Spatial Development Framework (COGTA 2023).*

Economically, a mountainous terrain provides opportunities for scenic tourism and forestry activity. Challenges include high costs of doing business, given the implications of mountains and hills for the provision of infrastructure such as roads, electricity and telecommunications (ANDM 2023).

The population average annual growth rate between 2009 and 2019 was 0.9% (COGTA 2020). Based on the 2022 Census (StatsSA, 2022) Alfred Nzo District in the Eastern Cape has a total population of 936 462. Matatiele LM's population is 255 562, Umzimvubu LM's population is 214 477, Ntabankulu LM's population is 146 423 and Mbizana's population is 350 000. Within this population, young children (0-14 years) make up 35.8% of the total population. The working-age population (15-64 years) accounts for 57.6%, while the elderly (65+ years) constitute 6.6%. The district's dependency ratio is reported at 73.7 with a sex ratio of 88.4. Education indicators reveal that 8.2% of individuals aged 20 and above have no formal schooling, while 7.4% have attained higher education qualifications. With regards to housing, the district hosts 198 300 households, with an average household size of 4.7. Formal dwellings dominate the housing landscape, representing 70.7% of the housing stock. Sanitation and waste management services are accessible, with 22.7% of formal dwellings equipped with flushing toilets connected to sewerage, and 21.8% receiving weekly refuse disposal services. Only 22.1% of households have access to piped water within their dwellings given the challenge to establish water infrastructure for the widely dispersed dwellings, and 90.3% have electricity for lighting.

The Community Services sector is the strongest in the district, followed by Trade and Finance (COGTA 2020). In 2018, the unemployment rate in Alfred Nzo District Municipality was 39.73%, which is 12.7%, higher than that of Eastern Cape. The Alfred Nzo District Municipality had a total GDP of R15.3 billion in 2018 and in terms of total contribution towards Eastern Cape Province ranked seventh (out of 8) relative to other districts in the province. In terms of its share, it was in 2018 (4.1%) slightly smaller compared to what it was in 2008 (4.4%). For the period 2008 to 2018, the average annual growth rate of -0.1% of Alfred Nzo was the lowest relative to its peers in terms of growth.

# 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 Alfred Nzo District 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 Alfred Nzo 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 the Alfred Nzo 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 Alfred Nzo 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 (SEVI) and Economic Vulnerability (EcVI).

Table 1 shows that between 1996 and 2011 the socio-economic vulnerability for all four LMs in the Alfred Nzo district increased (worsened) drastically above the national average of 5.0. In 2011, Ntabankulu had the highest SEVI in the province and the country. Matatiele, Umzimvulu and Mbizana had the 189th, 192nd and 203rd highest SEVI out of a total of 213 LMs in the country, respectively, making the Alfred Nzo district one of the most vulnerable districts countrywide. Interestingly, over the same period, the economic vulnerability of all LMs decreased drastically and is now, with values between 3.0 and 4.6, significantly lower than the national average, with Ntabankulu being the least vulnerable (EcVI 3.0, 3rd least vulnerable in the province). The physical vulnerability of all four LMs is relatively high, with Mbizana being 2nd most vulnerable in the country and most vulnerable in the province. Ntabankulu's PVI of 6.0 ranks it 14th least vulnerable out of 33 LMs in province.

*Table 1: Vulnerability indicators across the Alfred Nzo District Municipality for 1996 t0 2011*

| LOCAL MUNICIPALITY | SEVI 1996 | SEVI 2011 | Trend | EcVI 1996 | EcVI 2011 | Trend | PVI | Trend | EnVI | Trend |
|---|---|---|---|---|---|---|---|---|---|---|
| Matatiele | 7.5 | 8.0 | ↗ | 4.4 | 3.6 | ↘ | 7.2 | N/A | 5.3 | N/A |
| Umzimvubu | 7.5 | 8.3 | ↗ | 5.1 | 4.6 | ↘ | 7.1 | N/A | 5.6 | N/A |
| Ntabankulu | 9.5 | 10.0 | ↗ | 6.0 | 3.0 | ↘ | 6.0 | N/A | 3.7 | N/A |
| Mbizana | 8.7 | 8.8 | ↗ | 5.2 | 3.4 | ↘ | 8.7 | N/A | 4.5 | N/A |

The environmental vulnerability of all four LMs is about average in the national comparison, with Ntabankulu being the least vulnerable (EnVI 3.7), ranking 22nd out of 33 in the province and 88th out of 213 in the country, and Umzimvubu (EnVI 5.6) ranking 28th in province, 172nd in country.

### 2.1.2. Settlement vulnerability

The unique set of indicators outlined below highlight the multi-dimensional vulnerabilities of the settlements within the Alfred Nzo 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 indictors, 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 a graphical overview of the abovementioned six vulnerability indicators for all settlements in the four LMs in the Alfred Nzo district. The figure also indicates that in all four LMs most of the population is living in traditional settlement areas, ranging from 85.34% in Matatiele to 96.77% in Mbizana. The number of formal settlements, and people residing there is with one to 3 per LM very low.

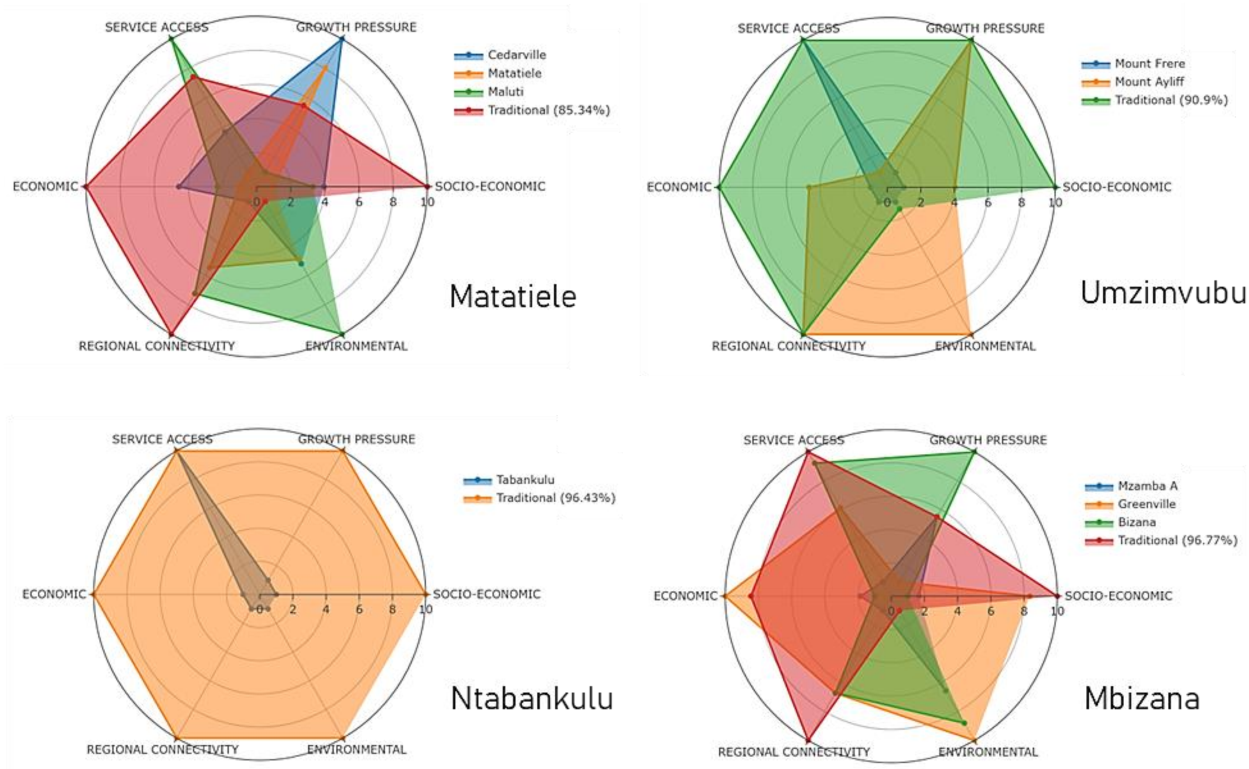


*Figure 4: Settlement vulnerability for settlements within Alfred Nzo LMs*

Each vulnerability indicator has a range between 0 (least vulnerable) to 10 (most vulnerable), as ranked within the respective LM (i.e. not on a national scale). The settlement profiles show that the traditional settlement areas in Ntabankulu are very vulnerable in each of the six indices, followed by the traditional areas in Umzimvubi, Matatiele and Mbizana. The formal settlements of Tabankulu and Mount Frere feature very low vulnerabilities altogether, apart from Service Access, where both settlements are very vulnerable. Growth pressure maxima in the settlements of Cedarville, Matatiele, Mount Ayliff and Bizana might indicate a migration trend from traditional areas.

### 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 dataset for past, current and future populations, enables 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 1x1 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 Table 3 assumes that the peak of migrant influx is yet to happen.

Under a medium growth scenario, the total population within the district will increase by 47% by 2050, compared to the 2011 baseline. The highest growth rate of 97% is expected for the Mbizana LM with most of the growth expected for Bizana settlement (compare Figure 4), followed by Matatiele with 37% growth. Umzimvubu's population is expected to slightly decrease (-7% growth).

*Table 2: Settlement population growth pressure across the Alfred Nzo District Municipality (medium growth scenario)*

| Population per municipality | | Medium Growth Scenario | | % Growth | Growth pressure |
|---|---|---|---|---|---|
| | 2011 | 2030 | 2050 | 2011-2050 | Until 2050 |
| Matatiele | 203 652 | 250 879 | 278 851 | 37 | medium to high |
| Umzimvubu | 191 722 | 211 253 | 204 294 | -7 | medium |
| Ntabankulu | 123 638 | 138 990 | 138 512 | 12 | medium |
| Mbizana | 281 265 | 414 964 | 555 478 | 97 | high to extreme |
| Alfred Nzo DM Total | 800 277 | 1 016 086 | 1 177 135 | 47 | |

*Table 3: Settlement population growth pressure across the Alfred Nzo District Municipality (high growth scenario)*

| Population per municipality | | High Growth Scenario | | % Growth |
|---|---|---|---|---|
| | 2011 | 2030 | 2050 | 2011-2050 |
| Matatiele | 203 652 | 263 048 | 306 895 | 51 |
| Umzimvubu | 191 722 | 221 535 | 224 941 | 17 |
| Ntabankulu | 123 638 | 145 741 | 152 481 | 23 |
| Mbizana | 281 265 | 435 134 | 611 564 | 117 |
| Alfred Nzo DM Total | 800 277 | 1 065 458 | 1 295 881 | 62 |

Under a high growth scenario, Alfred Nzo's population is expected to grow by 62% until 2050, relative to the 2011 baseline. Under this scenario, Mbizana's population will more than double (117% growth), followed by Matatiele (51% growth), Ntabankulu (23% growth) and Umzimvubu with a growth of 17%.

Table 2 also indicates the pressure that the projected growth will put on the local municipalities and Figure 4 depicts the growth pressures that the settlements across the district are likely to experience. Growth pressure is a function of the expected population growth and the capability of the municipality and settlement to absorb this influx. High growth and low absorption capacity results in high growth pressure. The most extreme growth pressure is expected for the settlement of Mzamba A, located at the northernmost part of Mbizana's coast, bordering the Ugu District in KwaZulu-Natal.

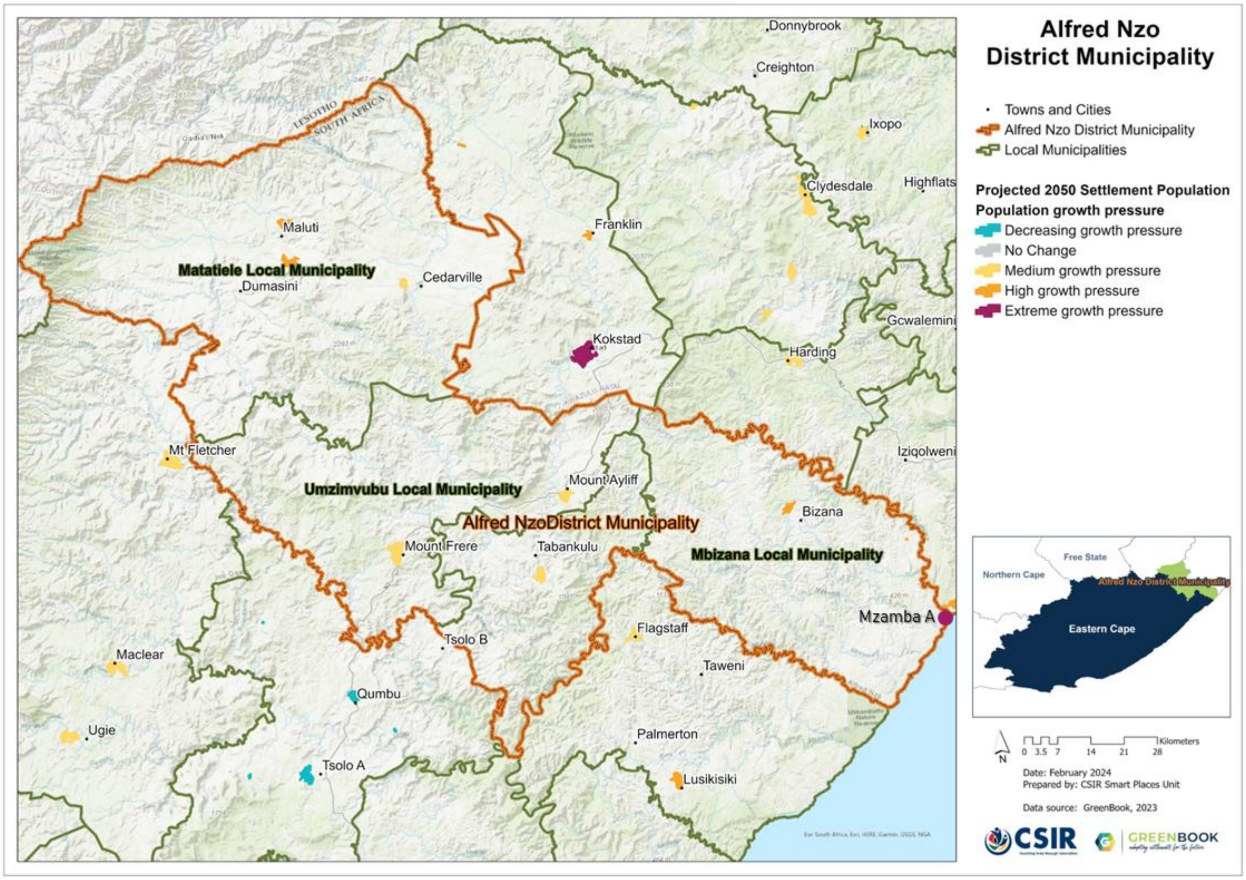


*Figure 5: Settlement-level population growth pressure across the Alfred Nzo District Municipality*

## 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 $CO_2$ 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 8x8 km (approximately 0.08° degrees in latitude and longitude). The model integrations performed at a resolution of 8 km over South Africa offer several 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. During this period, the Alfred Nzo District, located on a gradient from coastal areas to mountainous inlands, had an annual average temperature range from 22°C on the coast to 12°C in parts of Matatiele (Figure 6). Assuming a climate "worst case" scenario RCP8.5, it is expected that average annual temperatures will increase by 2°C for most of the district, apart from the coastal area where the moderating impact of the ocean will lead to slightly lower increases in the range of 1.5°C (Figure 7).

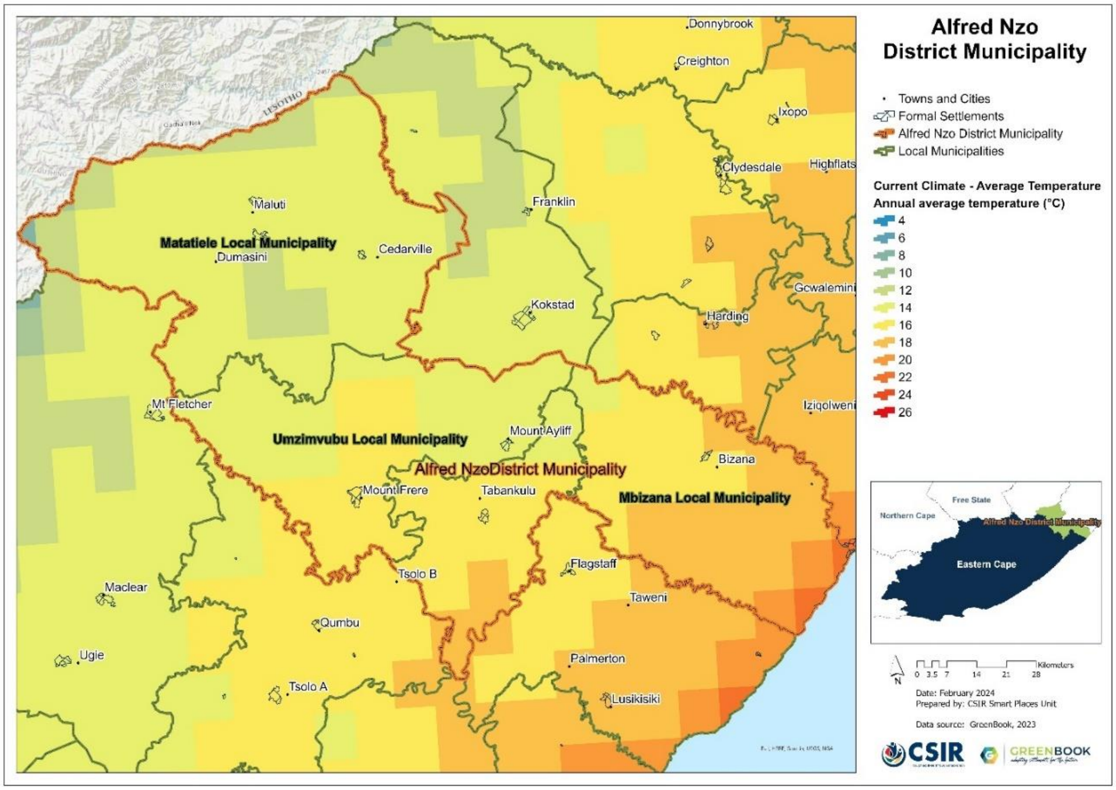


*Figure 6: Average annual temperature (°C) for the baseline period 1961-1990 for the Alfred Nzo District Municipality*

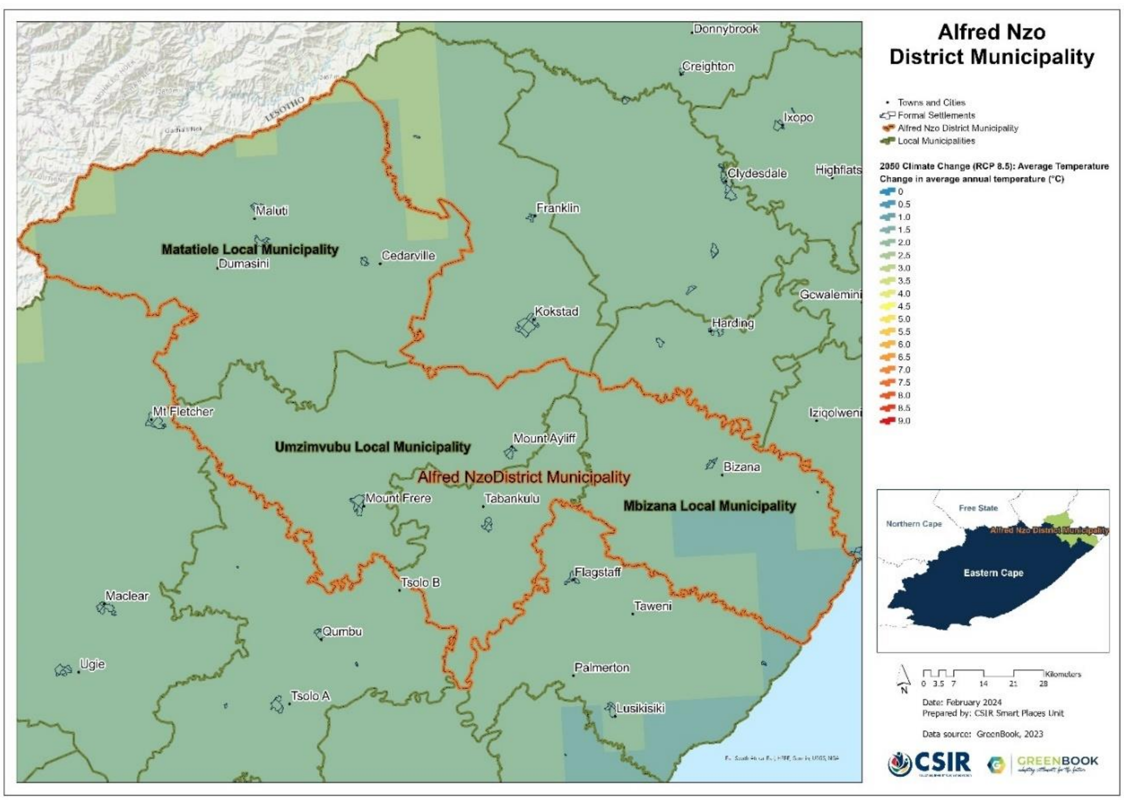


*Figure 7: Projected changes in average annual temperature (°C) from the baseline period 1961-1990 to the future period 2021-2050 for the Alfred Nzo District Municipality, assuming an RCP 8.5 emissions pathway*

### 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. Figure 8 depicts the average annual rainfall amount for the Alfred Nzo District under the current baseline conditions. According to these data, the inland areas of the district receive between 1600-2000mm of rain p.a. Towards the coast annual rainfall of up to 2800mm can be received. Figure 9 shows the projected change in average annual rainfall (mm) from the baseline period to the period 2021-2050 for the Alfred Nzo District Municipality, assuming an RCP8.5 emission pathway. The data show a slight increase in annual rain between 100-200mm for Matatiele, Umzimvubu and Ntabankulu, and a moderate increase of 200-400mm for Mbizana, especially in the coastal areas. An increase in annual average rainfall does not necessarily imply flood risk, which is more closely related to extreme rainfall events. These are analysed in more detail in section 2.3.4 below.

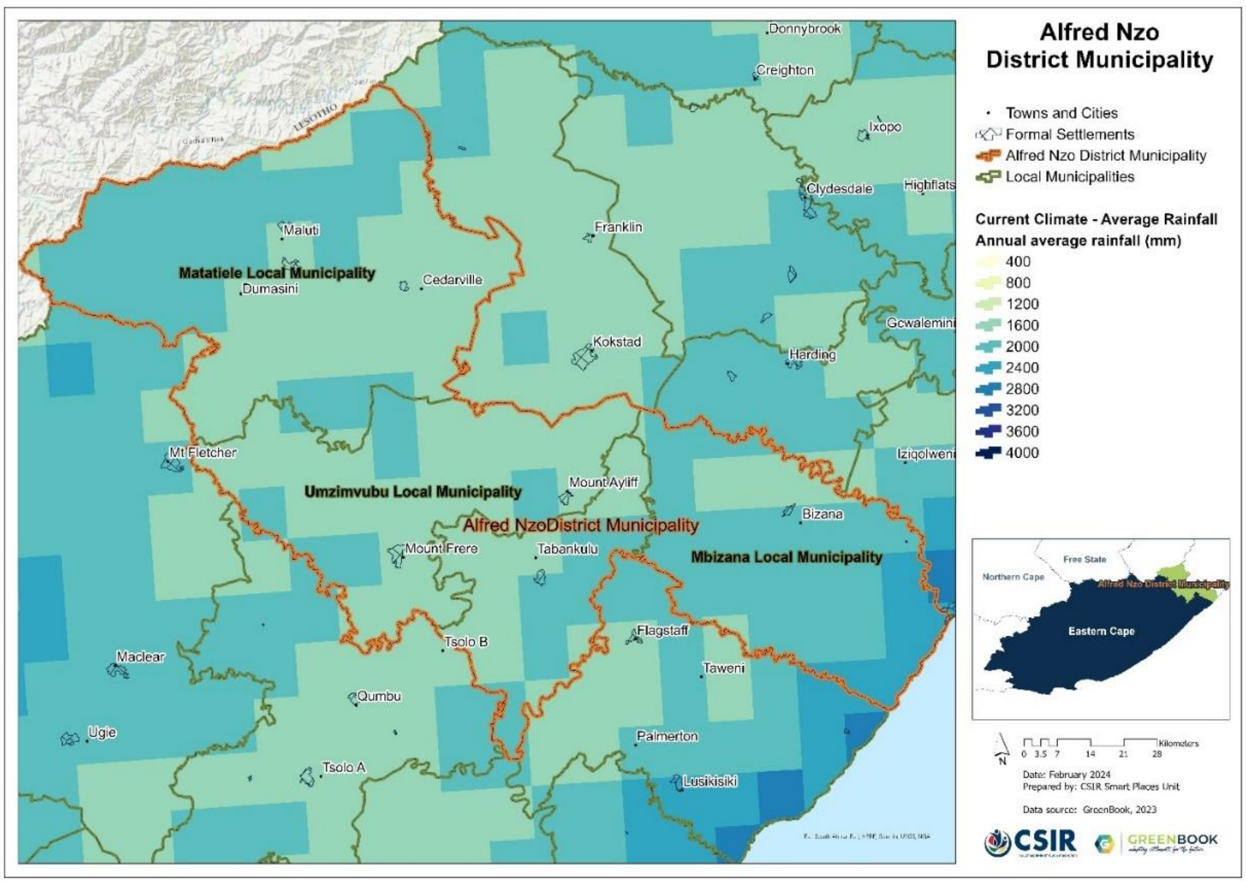


*Figure 8: Average annual rainfall (mm) for the baseline period 1961-1990 for the Alfred Nzo District Municipality*

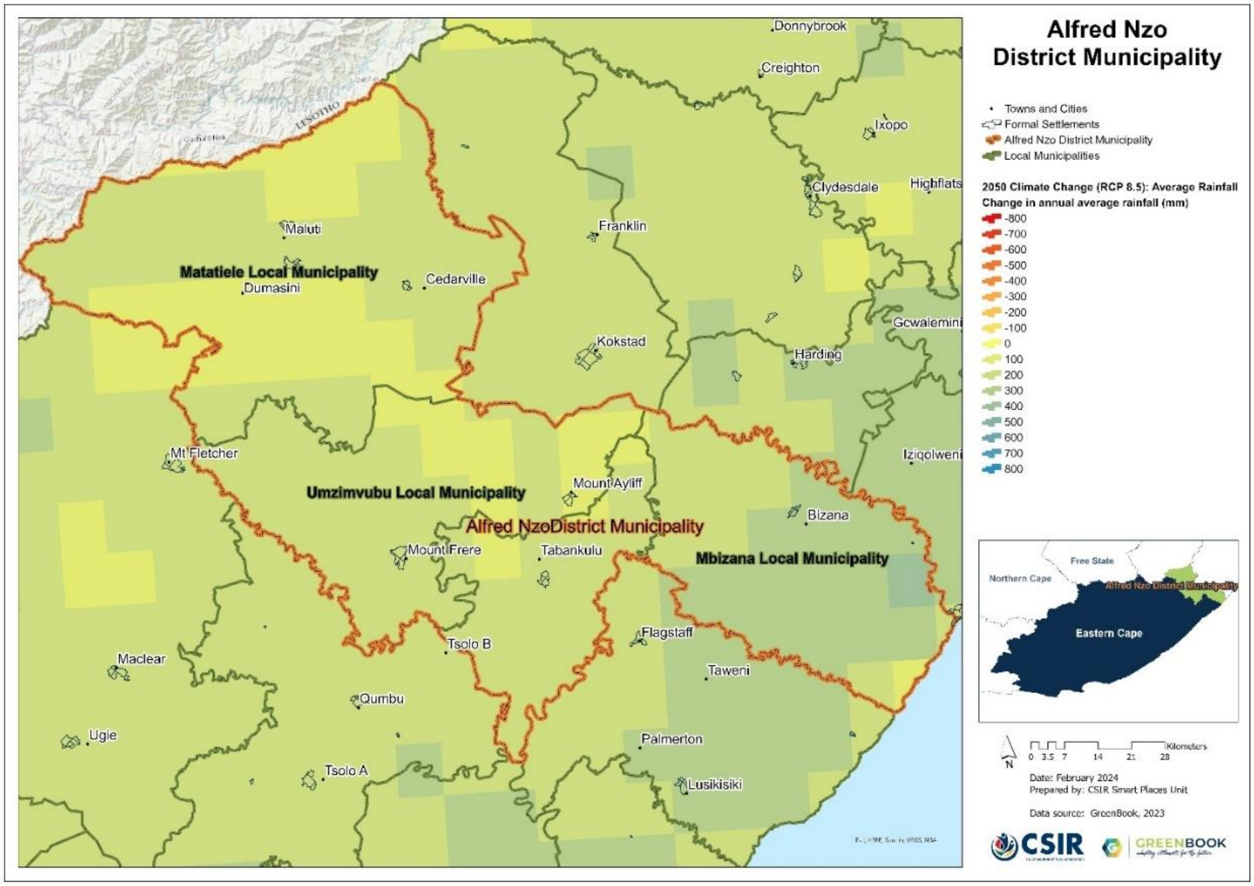


*Figure 9: Projected change in average annual rainfall (mm) from the baseline period to the period 2021-2050 for the Alfred Nzo District Municipality, assuming an RCP8.5 emission pathway*

## 2.3. Climate Hazards

This section showcases information with regards to Alfred Nzo 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 10 depicts the current drought tendencies (i.e., the number of cases exceeding near-normal per decade) for the period 1995-2024, relative to the 1986-2005 baseline period, under an RCP 8.5 "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 the observed baseline) with a positive value indicative of a decrease in drought tendencies. The figure shows that for most of the Alfred Nzo the drought tendency increased slightly during the last decades (SPEI index between 0 and -0.2) or even slightly decreased in the Tabankulu-Kokstad area (SPEI index between 0 and 0.2). 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. The figure shows that the trend towards less drought and more wet spells is expected to increase significantly in the near future, especially for the inland areas of the district (Figure 11). Consequently, the future risk of droughts is very low for all settlements in the district (Figure 12).

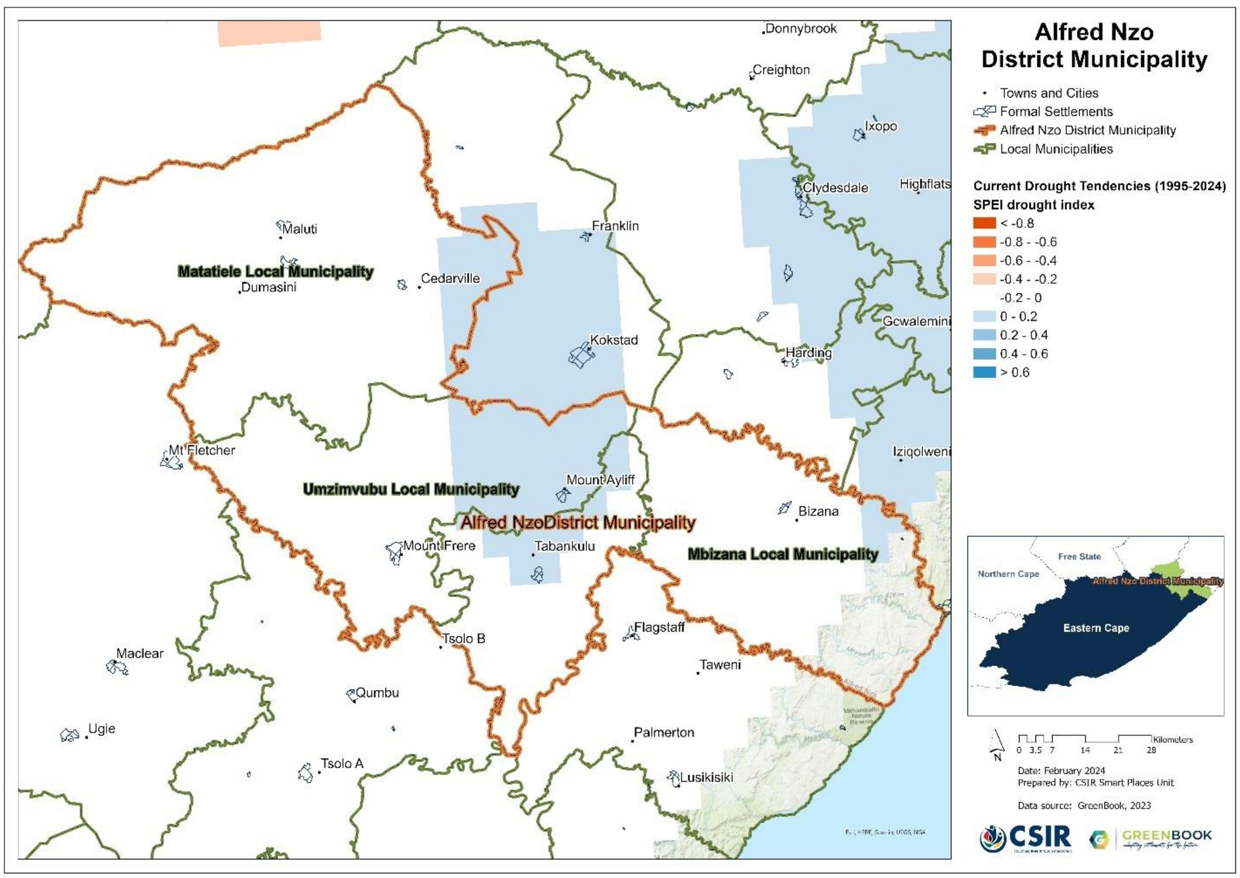


*Figure 10: Current drought tendencies from the baseline period (1986–2005) to the current period (1995-2024) across the Alfred Nzo District Municipality*

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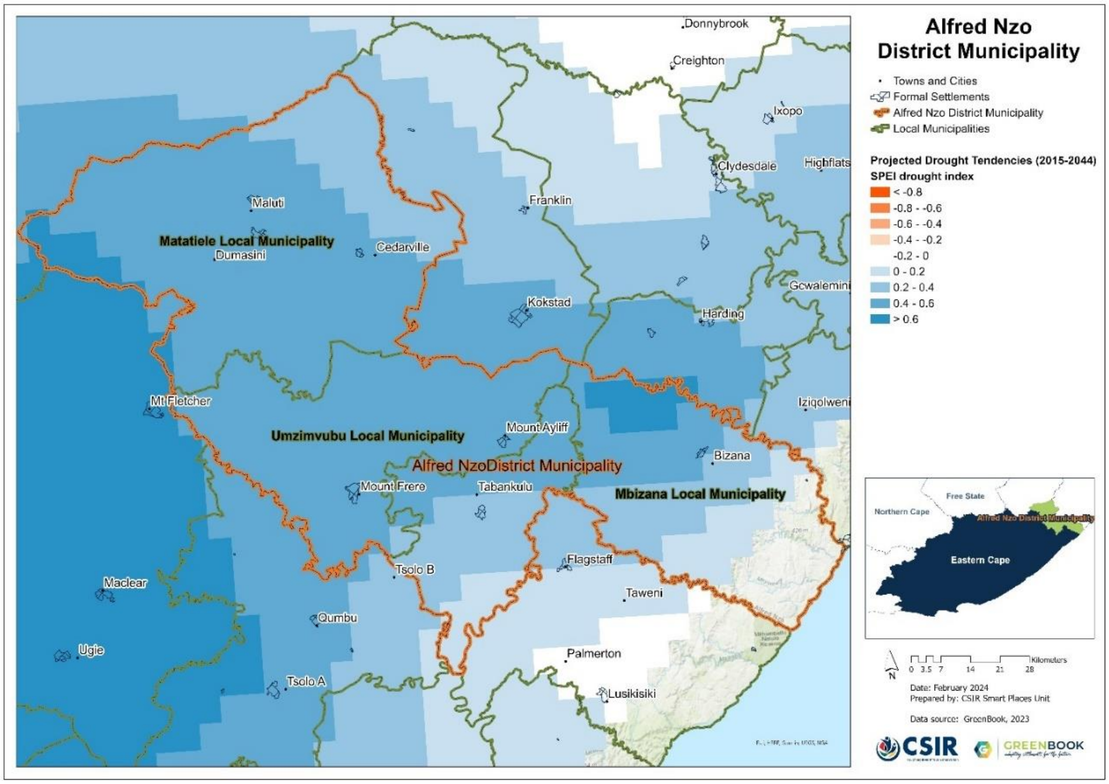


*Figure 11: Projected changes in drought tendencies from the baseline period (1986–2005) to the future period 2015-2044 for the Alfred Nzo District Municipality*

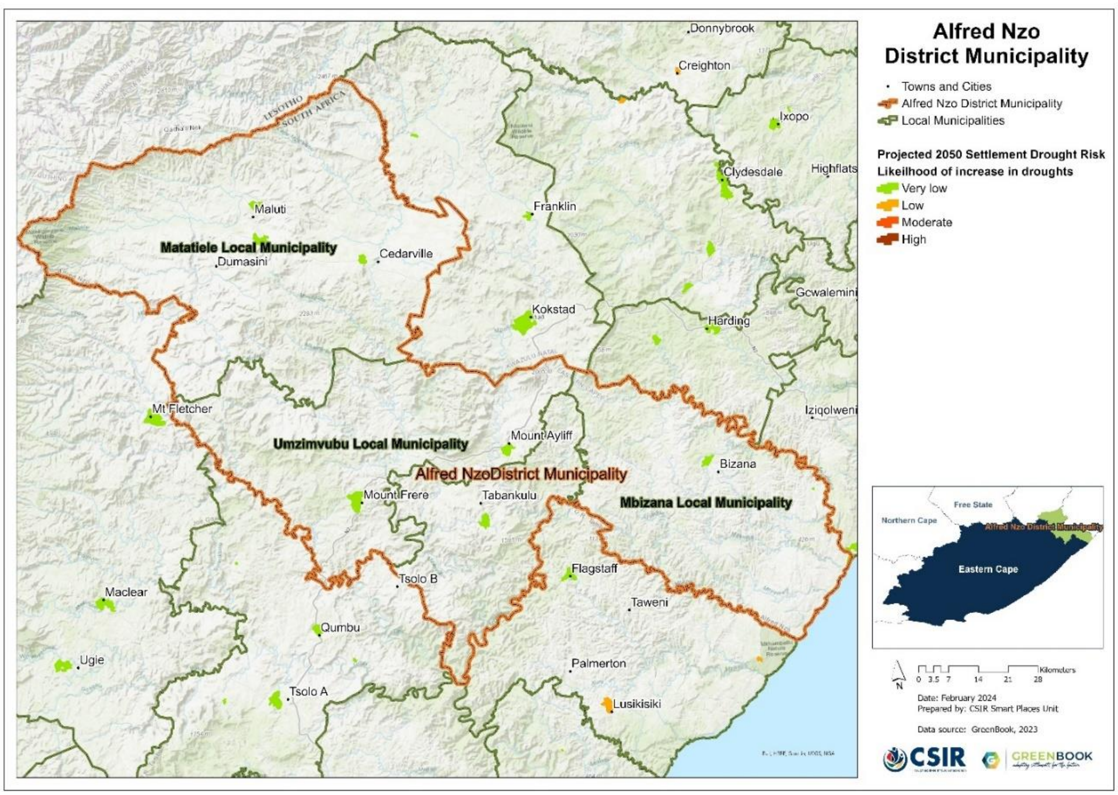


*Figure 12: Settlement-level drought risk for the Alfred Nzo District Municipality*

### 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). The Figures show that currently the district is experiencing between zero and 10 very hot days per year and that this number is not expected to increase until 2050.

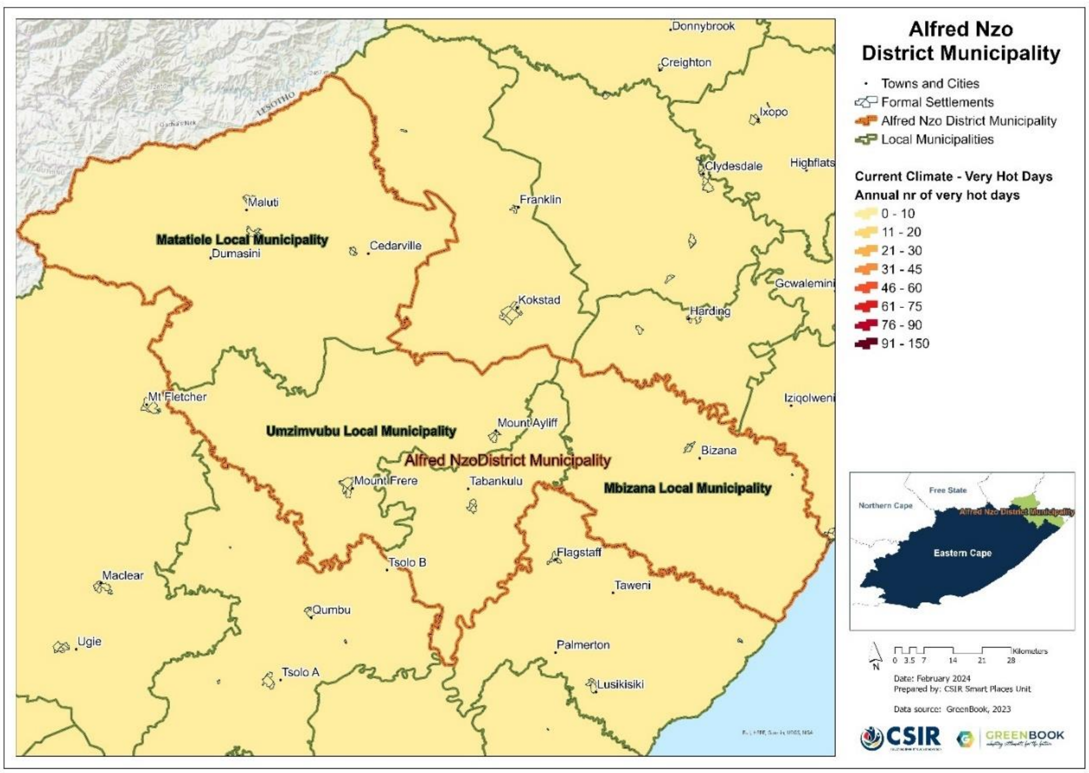


*Figure 13: Annual number of very hot days under baseline climatic conditions across the Alfred Nzo District Municipality with daily temperature maxima exceeding 35°C*

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 the Alfred Nzo District is currently experiencing a gradient from zero to one heatwave days on the coast to 4-5 heatwave days in Matatiele.

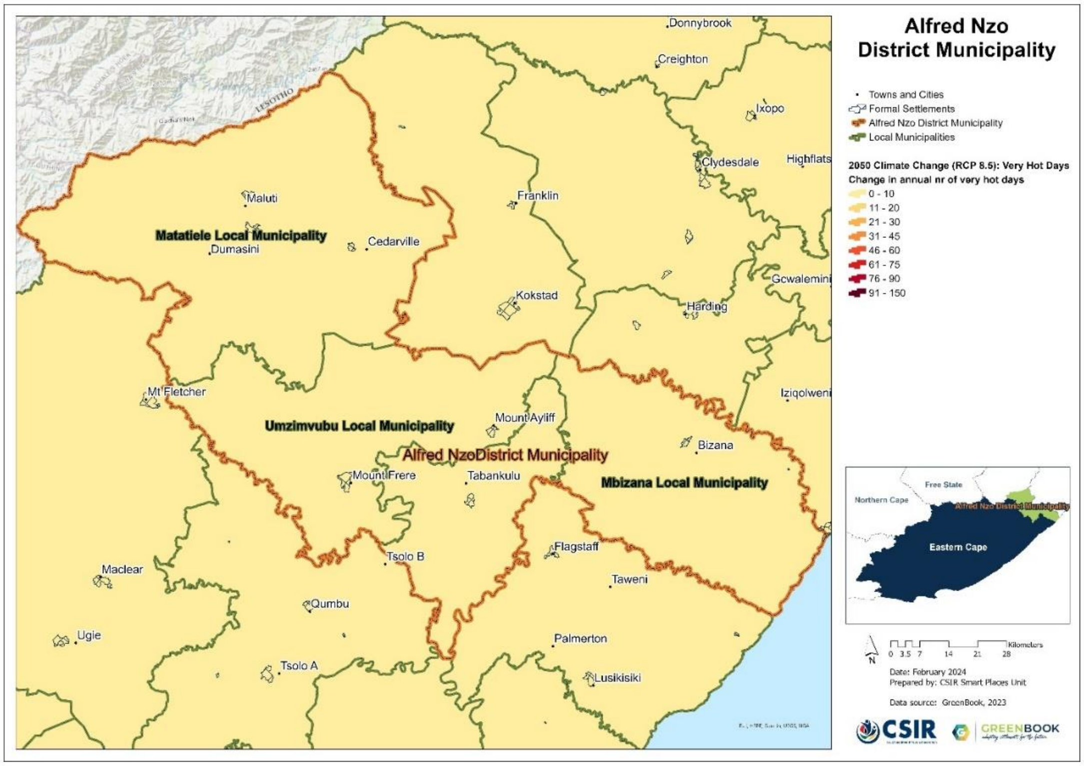


*Figure 14: Projected change in annual number of very hot days across the Alfred Nzo District Municipality with daily temperature maxima exceeding 35°C, assuming and RCP 8.5 emissions pathway*

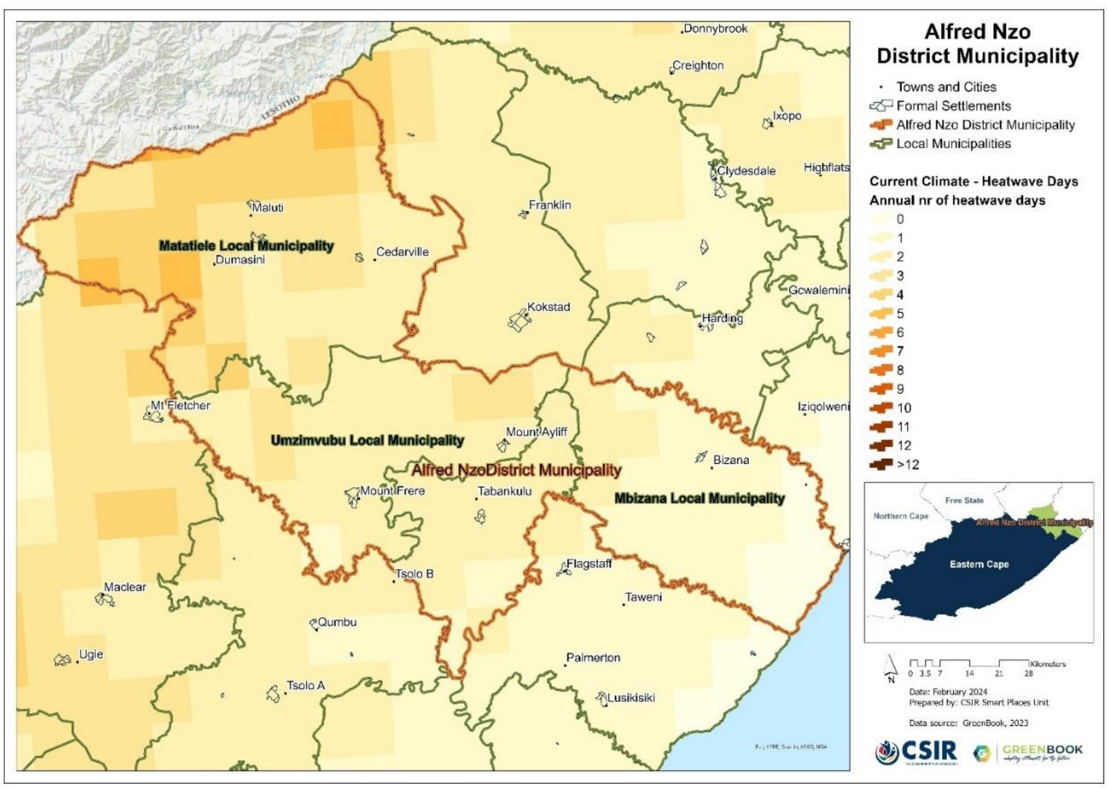


*Figure 15: Number of heatwave days under baseline climatic conditions across the Alfred Nzo District Municipality*

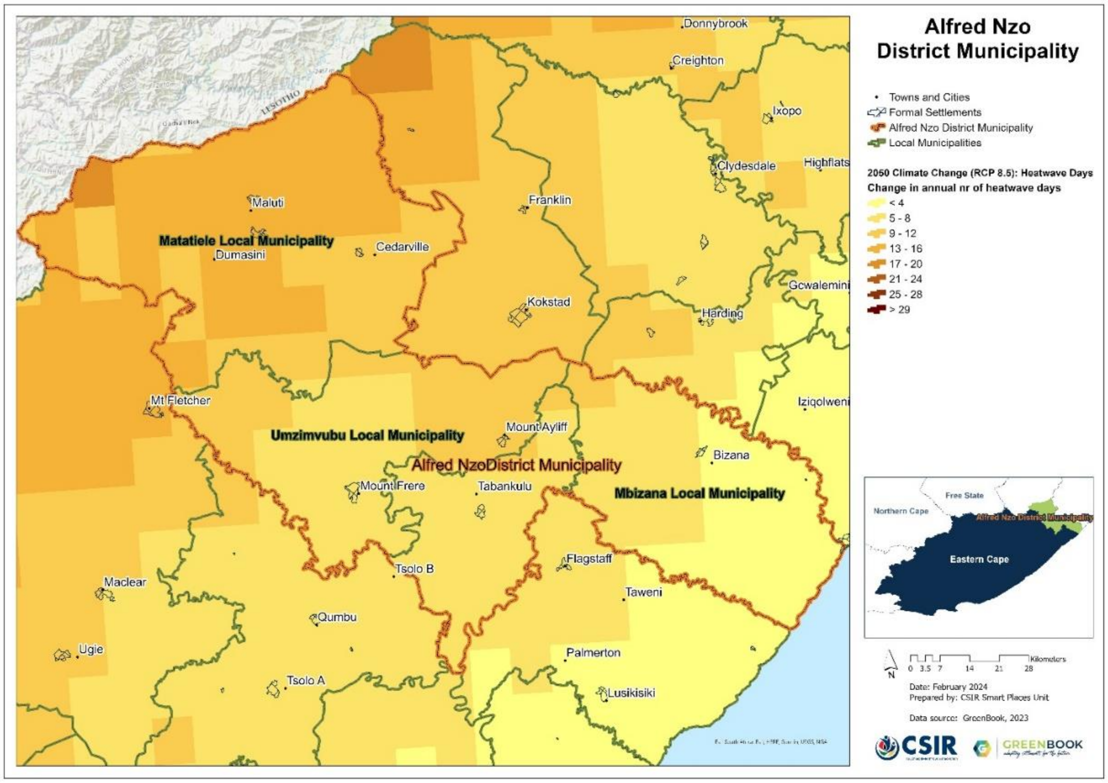


*Figure 16: Projected change in annual number of heatwave days across the Alfred Nzo District Municipality, assuming an (RCP 8.5) emissions pathway*

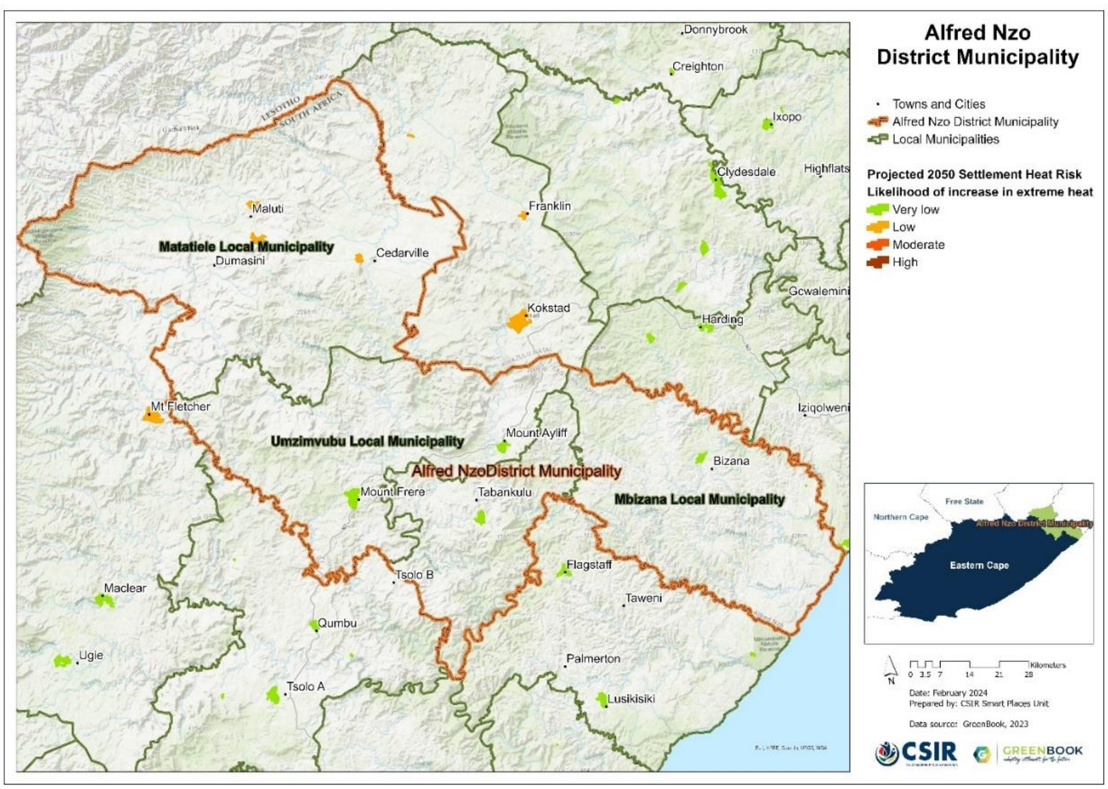


*Figure 17: Settlement-level heat risk across the Alfred Nzo District Municipality*

Figure 16 shows that the number of heatwave days in Matatiele LM could increase to 17-20 in some areas and 9-16 days for most areas of the LM but will stay below 4 days in the coastal area up to the settlement of Bizana. Figure 17 shows the resulting heat risk per settlement in the district. The settlements in the Matatiele LM have a low likelihood of increase in extreme heat and the settlements in Umzimvubu, Ntabankulu and Mbizana a very low risk in increase of extreme heat.

### 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 settlement.

The projected number of fire danger days for an 8x8 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.

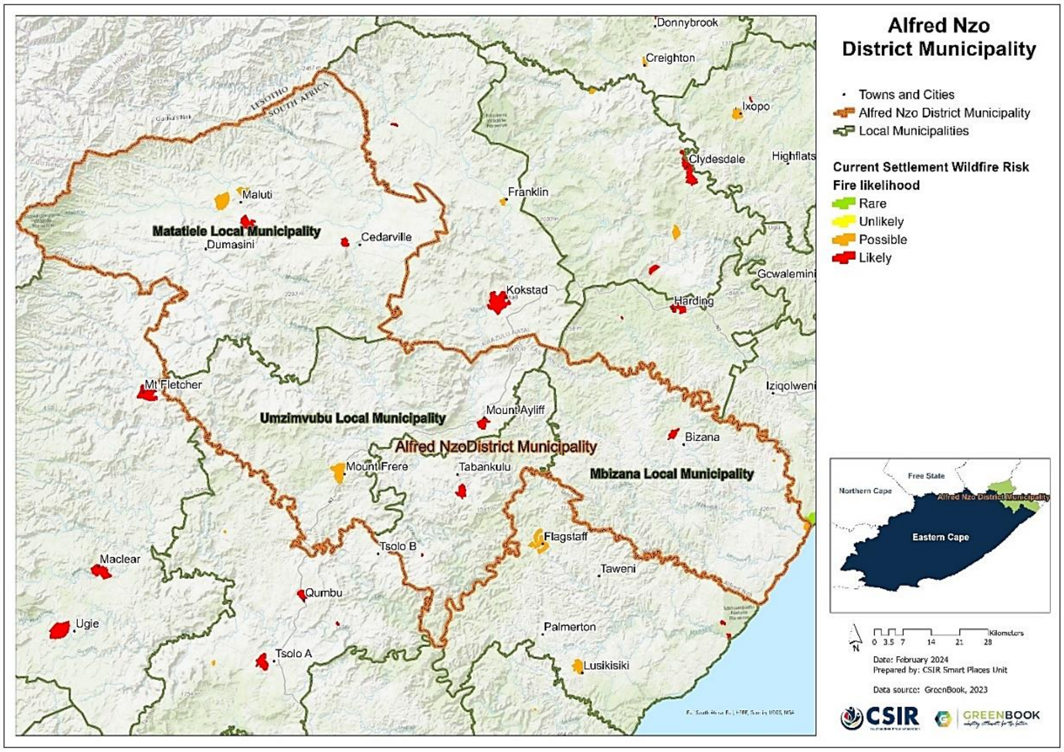


*Figure 18: The likelihood of wildfires under current climatic conditions across settlements in the Alfred Nzo District Municipality*

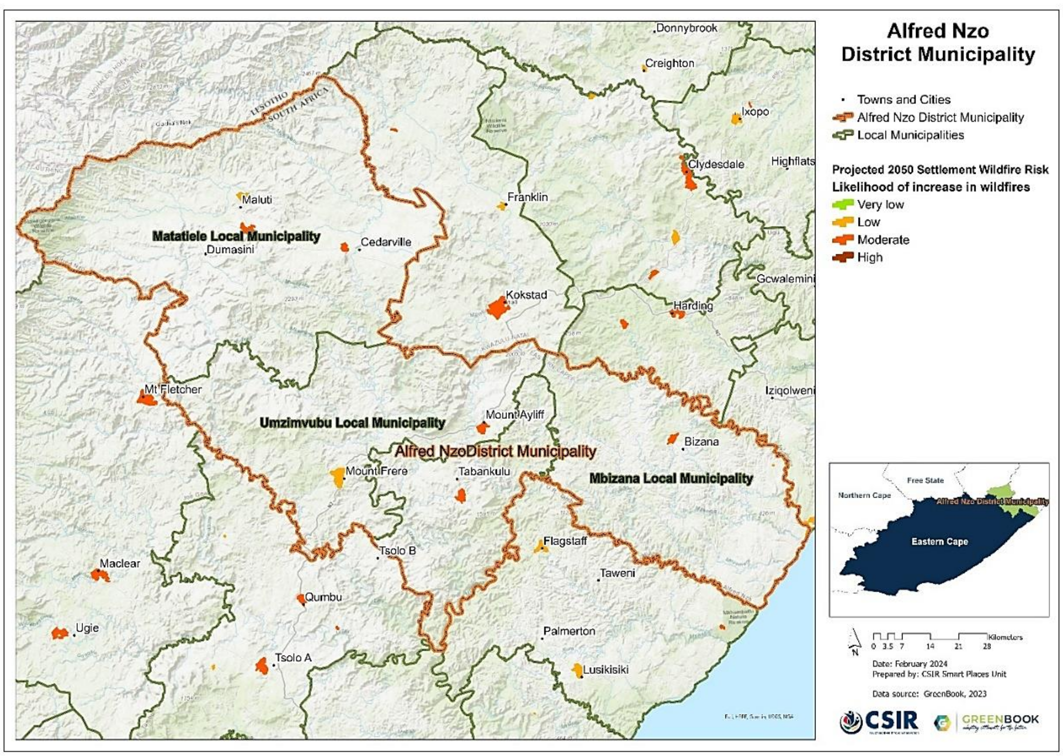


*Figure 19: The likelihood of wildfires under projected future climatic conditions across settlements in the Alfred Nzo District Municipality*

Under current climate conditions, the occurrence of wildfires is "likely" for the towns of Cedarville, Matatiele, Mount Ayliff, Tabankulu and Bizana. The settlements of Maluti and Mount Frere have a somewhat lower ("possible") wildfire risk. Under projected future climate conditions, the likelihood of increased wildfire risk is "moderate', and "low" for Maluti and Mount Frere.

### 2.3.4. Flooding

The flood hazard assessment 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.

Figure 20 depicts the flood hazard index of the individual quinary catchments present or intersecting with the 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. There is significant variation of the flood hazard index across the district, with medium to high flood risk over most of the district but high to very high flood risk in the Ntabankulu LM.

Figure 21 depicts the projected change into the future in extreme rainfall days for an 8x8 km grid. This was calculated by assessing the degree of change when projected future rainfall extremes (e.g., 95$^{th}$ 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. According to these data, Matatiele LM will see the least increase in extreme rainfall days (0 to 2 days), with the area around Dumasini even seeing a slight decrease in extreme rainfall days (1-2 days less). Mbizana will see an increase of 1-5 extreme rainfall days.

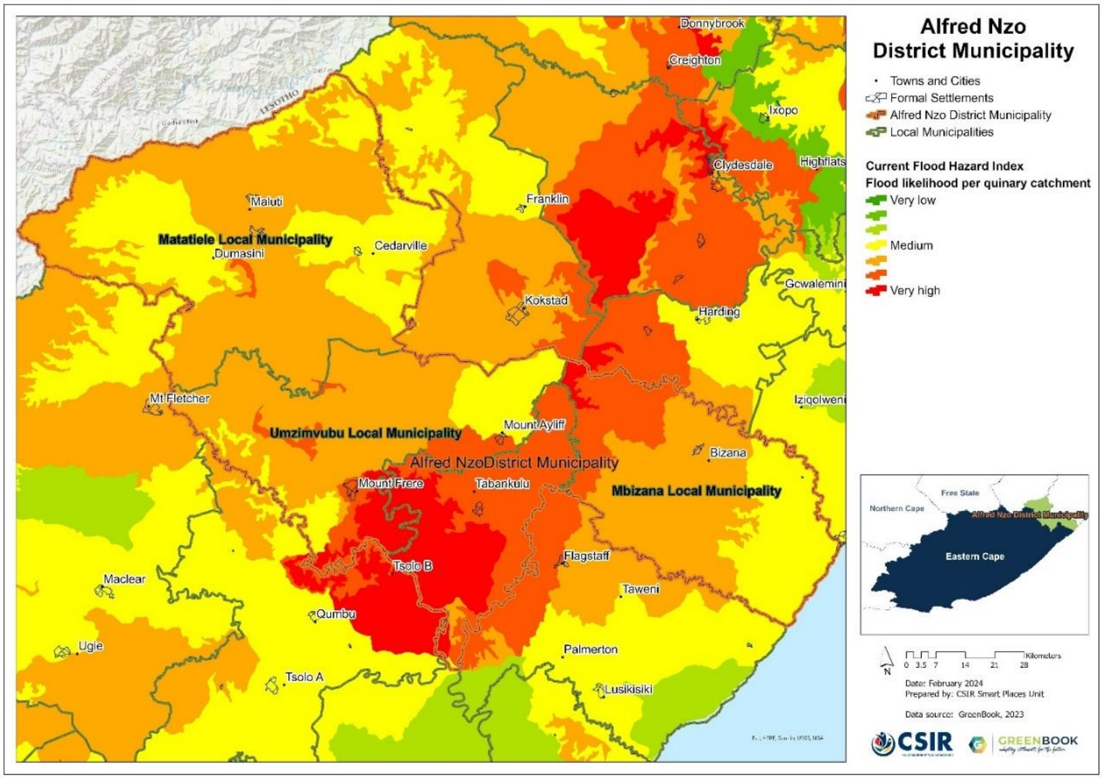


*Figure 20: The current flood hazard index across the Alfred Nzo District Municipality under current (baseline) climatic conditions*

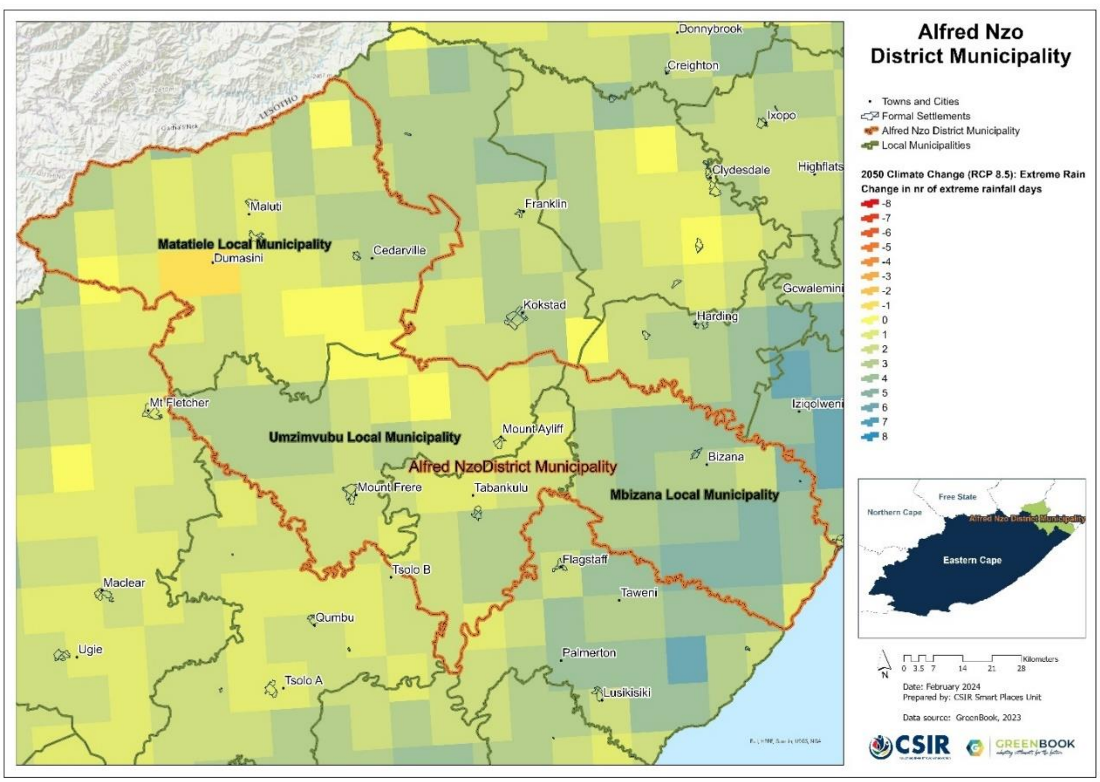


*Figure 21: Projected changes into the future in extreme rainfall days across the Alfred Nzo District Municipality*

Model projections of precipitation manifest uncertain due to several factors, including model sensitivity to spatial resolution at which processes are resolved. At 8x8km 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.

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. According to these data, Bizana will see the highest increase in flood likelihood, followed by Mzamba A, Matatiele and Maluti ("moderate" risk). In the other settlements the likelihood of flood risk increase is low to very low.

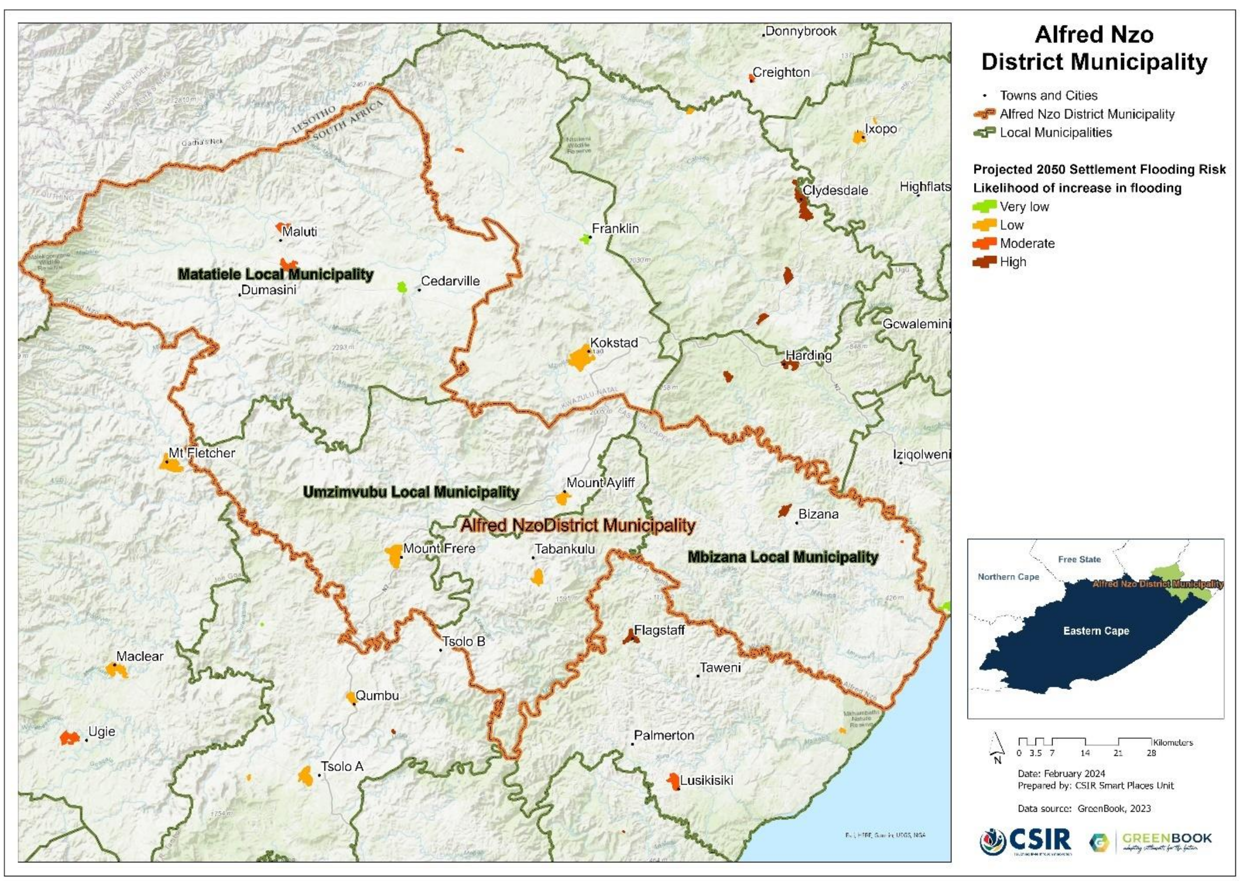


*Figure 22: Flood risk into a climate change future at settlement level across the Alfred Nzo District Municipality.*

### 2.3.5. Coastal flooding

The coastline of the Mbizana LM is about 24 km long. Ten estuaries are located on this largely very steep coast. However, the coast is sparsely populated with only one significant development between the Mtentwana and Mtamvuna estuaries. Isolated buildings are visible also at the Mnyameni and Mtentu estuaries.

Given the relatively steep coastal topography in Mbizana, the areas at highest risk of flooding and erosion are the estuaries (apart from gully erosion visible on the steep sandy coastal grasslands where coastal forest is missing). In the estuaries, 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 and erosion risk was 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.

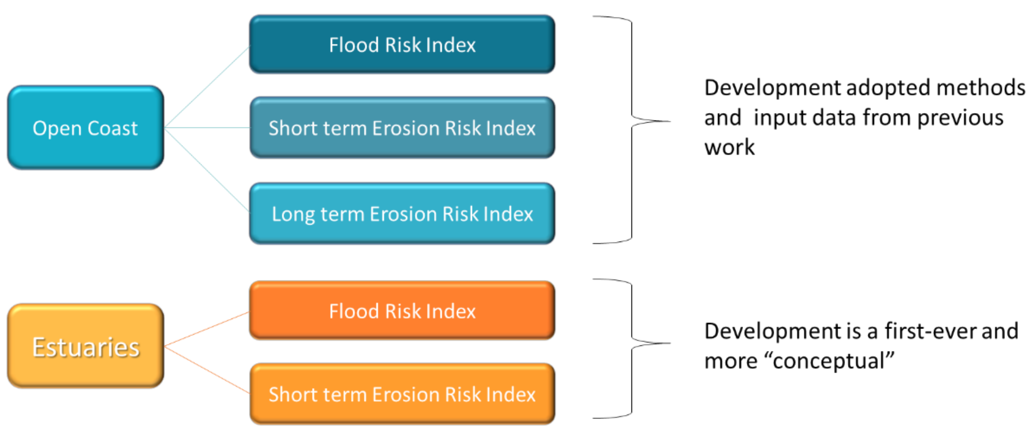


*Figure 23: Coastal climate risk indices developed by DEFF (2020)*

A visual assessment of all five coastal risk indices revealed that estuarine flood risk is the coastal risk with the largest spatial extension. Estuarine flooding is caused by rainfall in the respective river catchments leading to event-based increased river flow. Estuarine flood risk was established through a conceptual expert desktop assessment. The nine national estuarine types (here e.g. “small temporarily closed” or “predominantly open”) were ranked from “very high” to “very low” in terms of their susceptibility to flooding. Subsequently, the four coastal biogeographical regions in South Africa, Cool Temperate, Warm Temperate, Subtropical and Tropical were used as proxy for the expected Mean Annual Run-off in the catchments. According to these proxies, the topographic elevation within each estuary was classified in 2.5m intervals into Very high, High, Medium, Low and Very Low flood risk classes. Figure 21 indicates that the estuarine flood risk zonations can reach relatively far inland, depending on the estuary’s topography (DEFF 2020).

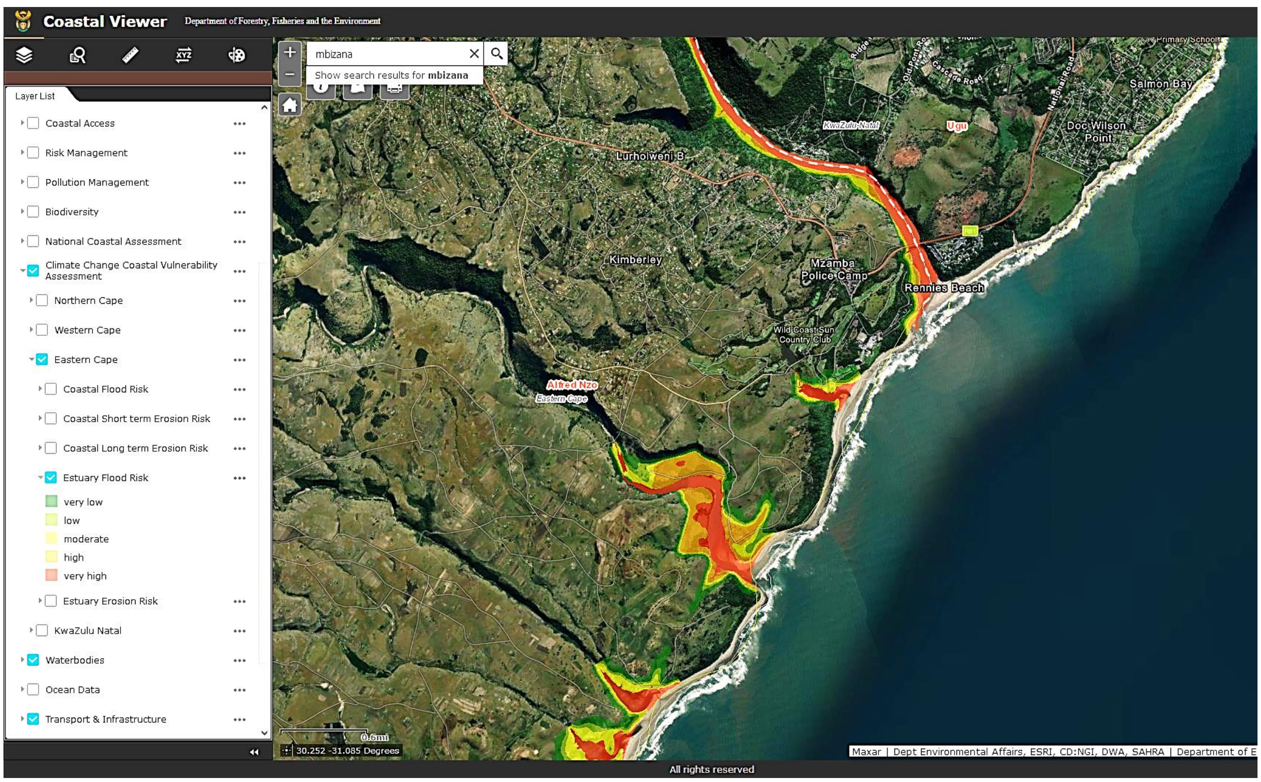


*Figure 24: Estuarine flood risk in Mbizana*

## 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 Alfred Nzo 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 25 indicates the catchment(s) related to the district. The main catchment in the Alfred Nzo District is the Mzimvubu-Tsitsikamma Primary catchment. The eastern ranges of Mbizana are drained by the Pongola-Mtamvuna Primary Catchment.

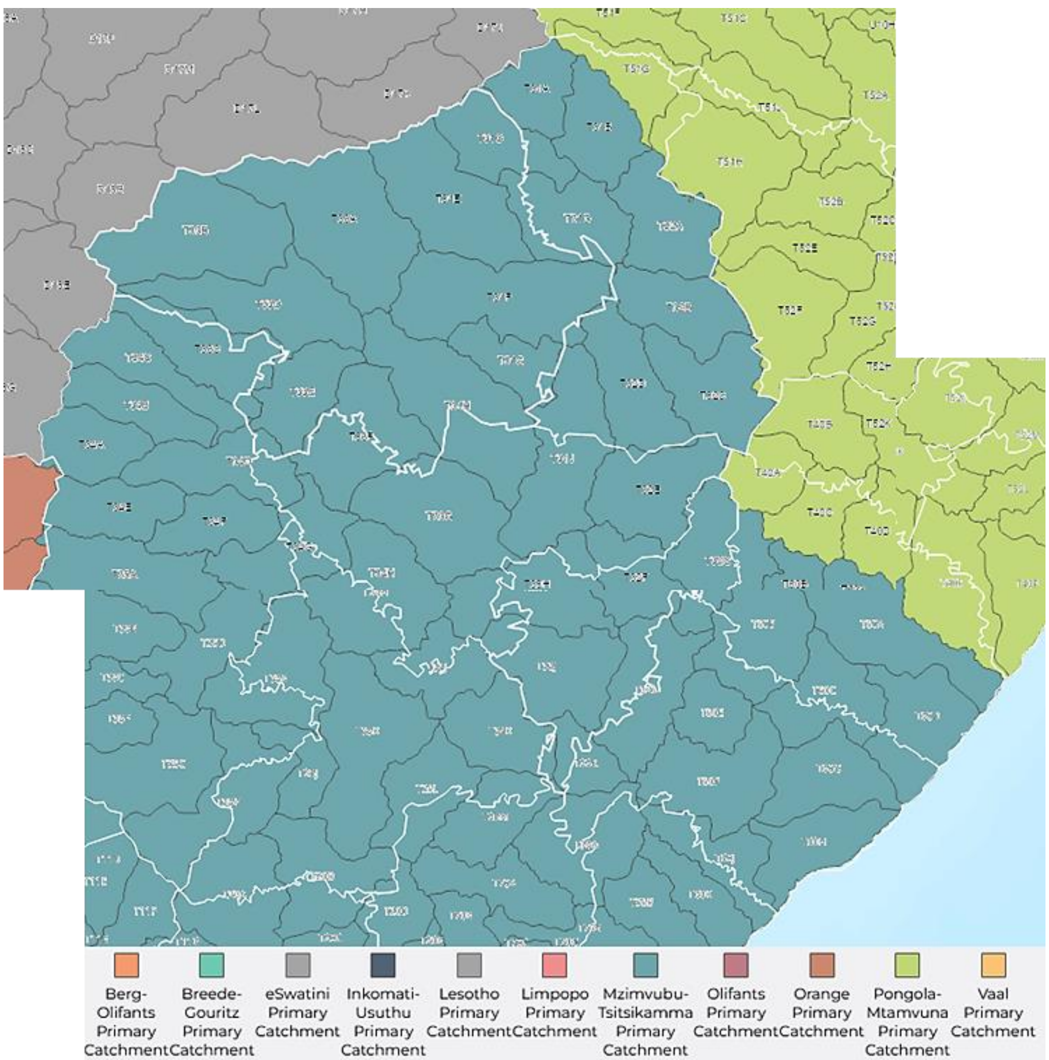


*Figure 25: Quaternary catchments found in the Alfred Nzo District Municipality*

Figure 26 indicates the 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 Alfred Nzo DM, most settlements get their water supply from a combination of groundwater and surface water. Some settlements, such as Cedarville are largely groundwater dependent, while Mount Ayliff is largely surface water dependent.

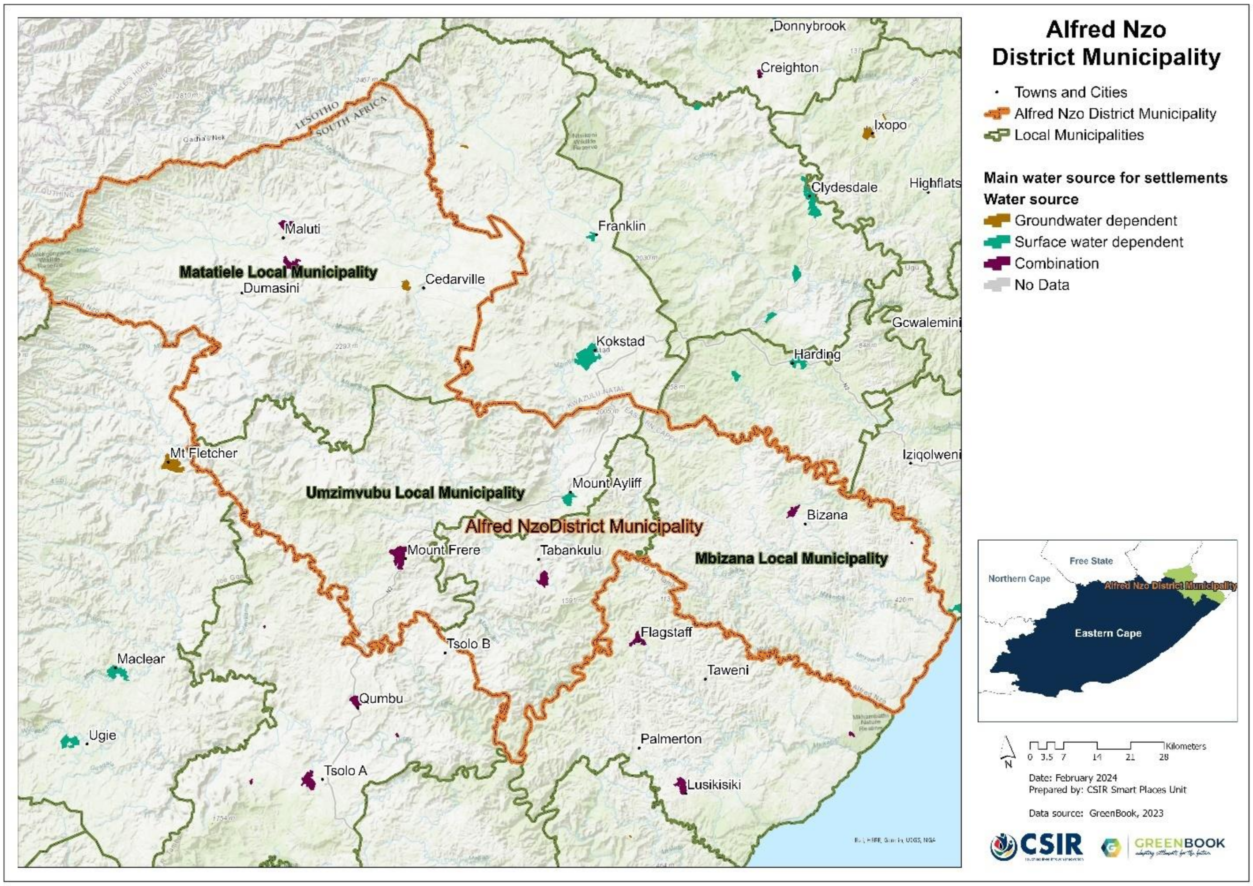


*Figure 26: Main water source for settlements in the Alfred Nzo District Municipality*

Figure 27 indicates the occurrence and distribution of groundwater resources across the district municipality, showing distinctive recharge potential zones, while Figure 28 indicates the projected change in groundwater potential. Currently, the groundwater recharge potential throughout the DM is very high (>4.26), with a slightly lower, albeit still high, recharge potential towards the inland municipalities (Figure 27). Towards 2050, the groundwater recharge potential is projected to increase slightly for most of the DM, with pockets of no increase towards the coast, and pockets of significant increase towards the inland.

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. According to this map, Cedarwille, Mount Frere and Tabankulu have a low risk of groundwater depletion in 2050 and Maluti, Matatiele and Bizana a moderate risk.

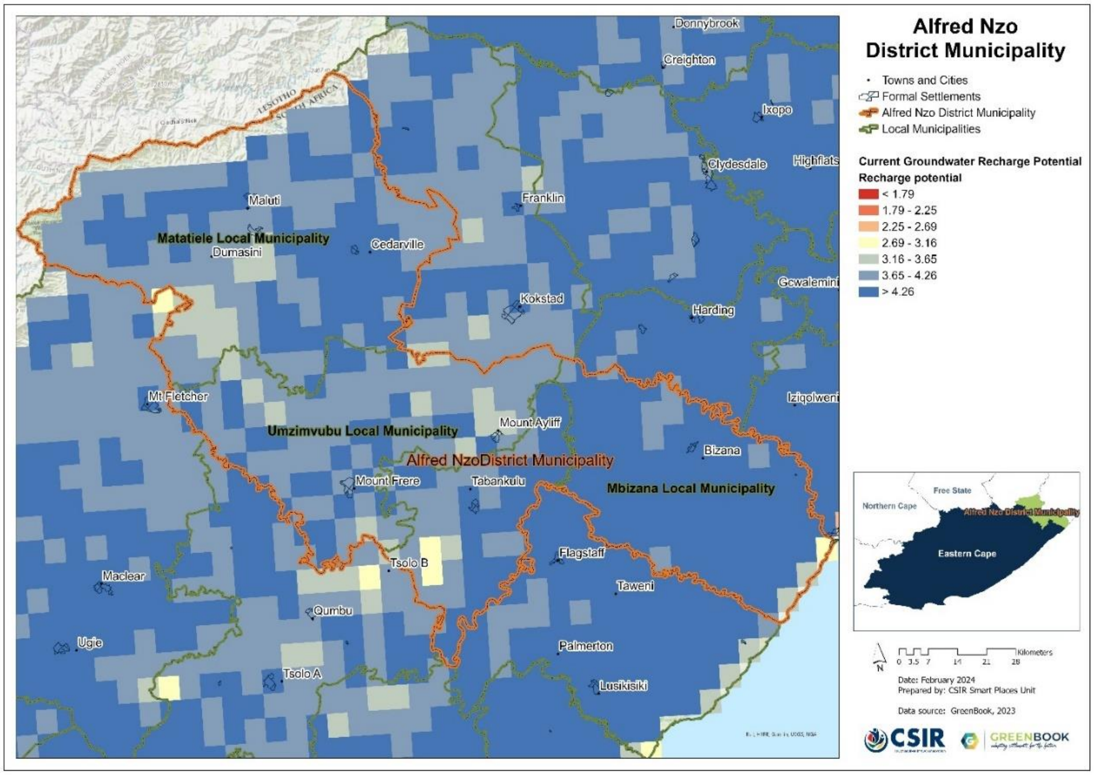


*Figure 27: Groundwater recharge potential across the Alfred Nzo District Municipality under current (baseline) climatic conditions*

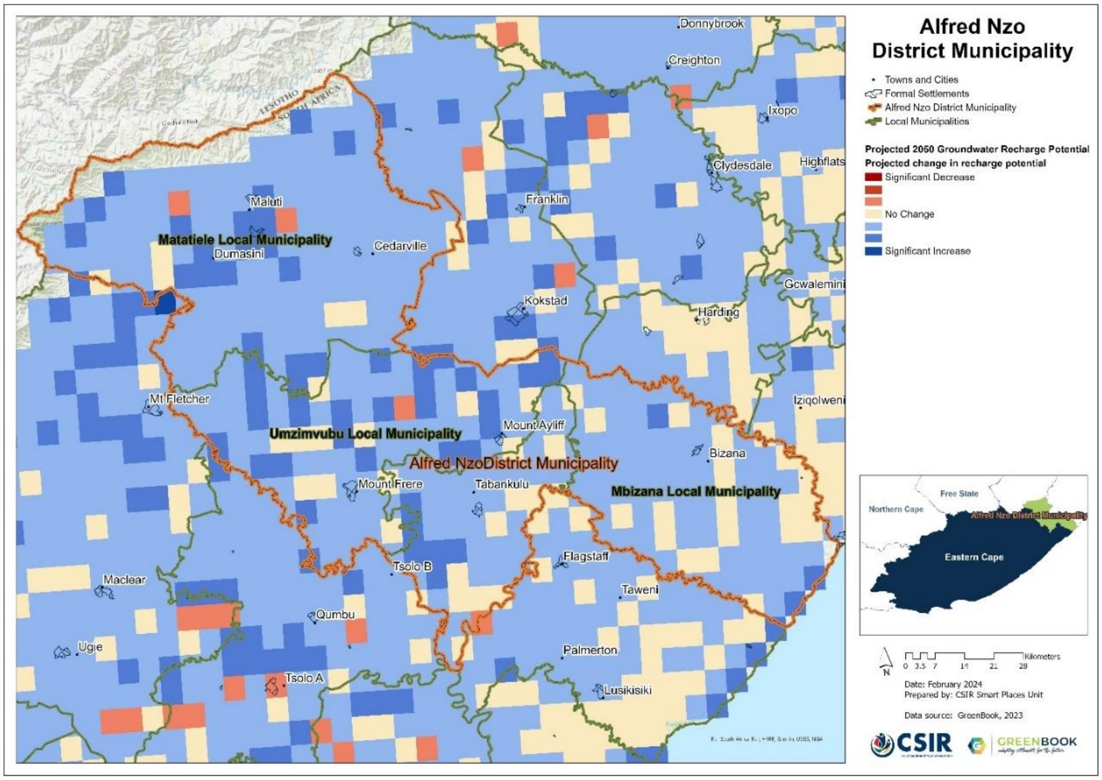


*Figure 28: Projected changes in groundwater recharge potential from baseline climatic conditions to the future across the Alfred Nzo District Municipality*

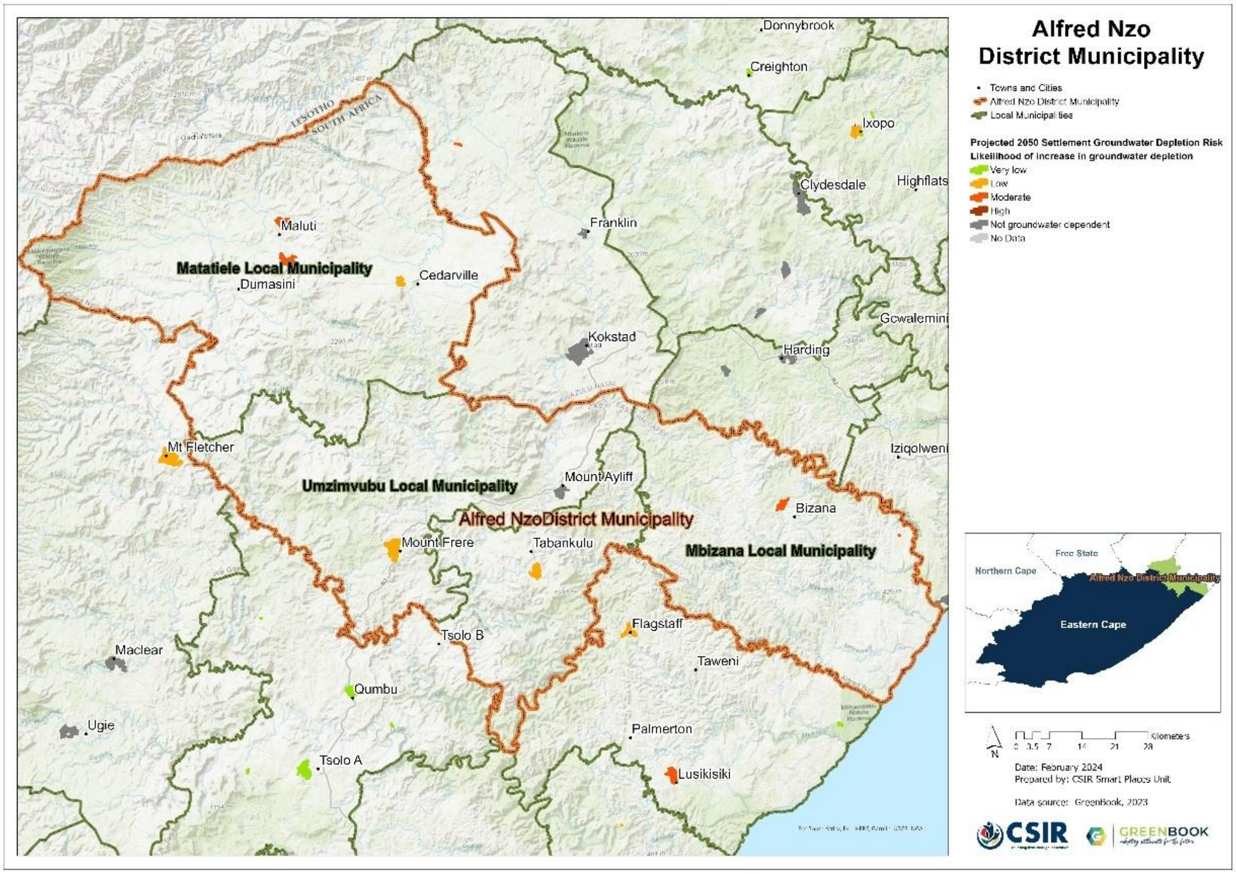


*Figure 29: Groundwater depletion risk at settlement level across the Alfred Nzo District Municipality*

Table 4 provides an overview of current water supply vulnerability (i.e., demand versus supply) for the local municipalities in the Alfred Nzo 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. 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.

*Table 4: Current water supply and vulnerability across the Alfred Nzo District Municipality*

| Local Municipality | Water Demand per Capita (l/p/d) | Water Supply per Capita (l/p/d) | Current Water Supply Vulnerability |
|---|---|---|---|
| Matatiele | 103.78 | 19.49 | 5.32 |
| Umzimvubu | 147.62 | 37.00 | 3.99 |
| Ntabankulu | 106.36 | 39.89 | 2.67 |
| Mbizana | 63.12 | 24.16 | 2.61 |

According to these data, for all four LMs in the district, currently the water demand is much higher than the actual water supply, leading to water supply vulnerabilities between 2.61 (Mbizana) and 5.32 (Matatiele), which is very high in the national comparison. Figure 30 shows the Top-10 most at-risk local municipalities for climate change impacts on water supply based on current vulnerabilities, indicating that all four LMs in Afred Nzo District are among these, namely Matatiele (2nd most vulnerable countrywide), Umzimvubu (3rd), Ntabankulu (7th) and Mbizana (8th most vulnerable).

Further, the relative change in the future vulnerability of local municipalities was modelled for the high and medium population growth scenarios, taking into account either the exposure to climate change impacts based on local runoff impacts (E1) or as part of the regional bulk water supply impacts (E2). In some cases, the future vulnerability is impacted most by population growth, while in others it is due to the exposure to potential climate change impacts on supply and demand. Figure 31 shows the Top-10 most at-risk local municipalities for climate change impacts on water supply based on overall climate change risk and regional water supply (E2 Scenario). The Figure shows that all four LMs in in Alfred Nzo are among the Top-10 most vulnerable LMs when it comes to regional bulk water supply impacts, which is very concerning.

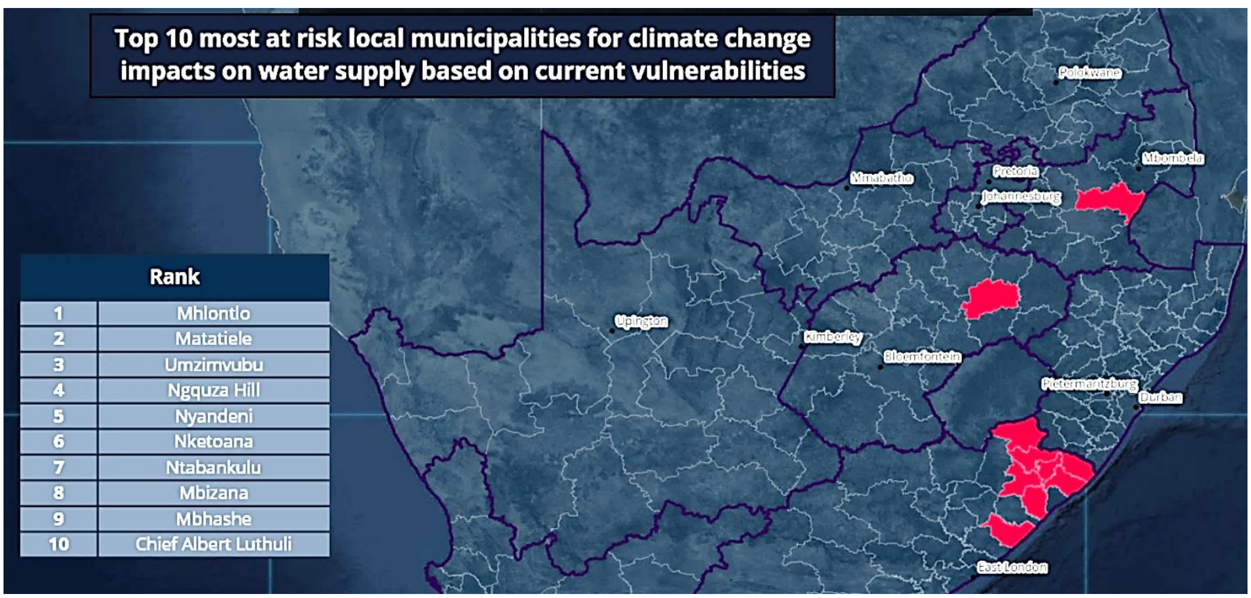


*Figure 30: Top 10 most at-risk local municipalities for climate change impacts on water supply based on current vulnerabilities[2].*

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] https://pta-gis-2-web1.csir.co.za/portal/apps/GBCascade/index.html?appid=74fc5a7337f3446 0b7a09242d0770229

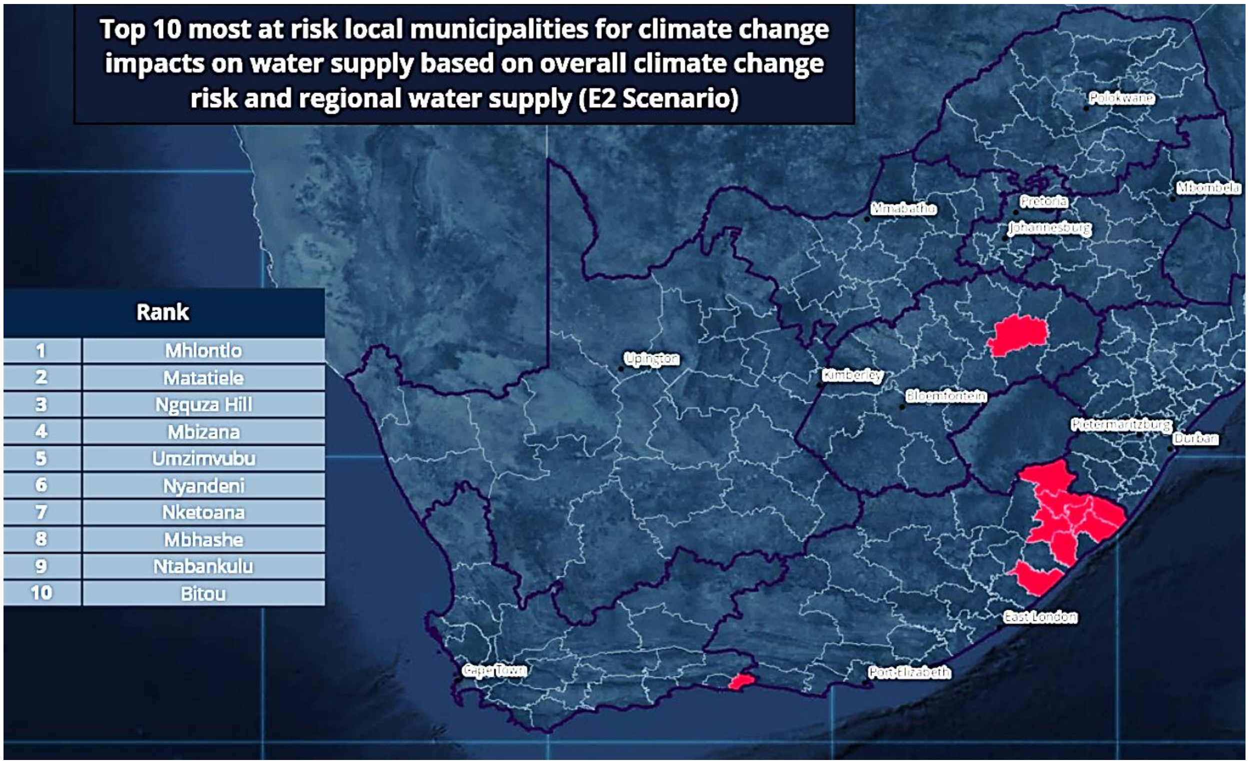


*Figure 31: Top 10 most at-risk local municipalities for climate change impacts on water supply based on overall climate change risk and regional water supply (E2 Scenario)[3].*

### 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

[3] https://pta-gis-2-web1.csir.co.za/portal/apps/GBCascade/index.html?appid= 74fc5a7337f34460b7a09242d0770229

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.

Matatiele

Matatiele's main agricultural commodities are beef cattle and milk and cream. AFF contributes 1.64% to Matatiele's GVA production and 6.04% to its total employment.

Umzimvubu

Umzimvubu's main agricultural commodities are maize for grain, beef cattle and sorghum. AFF contributes 1.67% to Umzimvubu's GVA production and 5.66% to its total employment.

Ntabankulu

Ntabankulu's main agricultural commodities are beef cattle and small-scale farming products, given that the entire LM is occupied by traditional settlements. Consequently, (commercial) AFF contributes only 1.03% to Ntabankulu's GVA production and 3.64% to its total employment. Ntabanulu LM contributes the least to the national AFF GVA.

Mbizana

Mbizana's agricultural main commodities are beef cattle, sugarcane and sub-tropical fruit. AFF contributes 0.78% to Mbizana's GVA production and 2.96% to its total employment. The total AFF GVA production of Mbizana Municipality contributes 0.03% to the national AFF GVA.

Agriculture is the main economic activity in the district but only contributes 1.44% to the district's GDP. Currently, it has a limited base for economic expansion due to the fact that the majority of farming is traditional subsistence farming. Commercial farming is limited to the Cedarville area in the northeast of the district. Despite the limited agricultural potential of the district's soils, ranging from non-arable to moderate potential for agriculture (Figure 32) the district has been considered to have “favourable conditions for the development of the agricultural sector and it is therefore critical to assess the potential of this industry and devise methods of exploiting this untapped potential. The district has also been selected as one of the regions to undertake the implementation of AgriParks initiative” (COGTA 2020 and 2023).

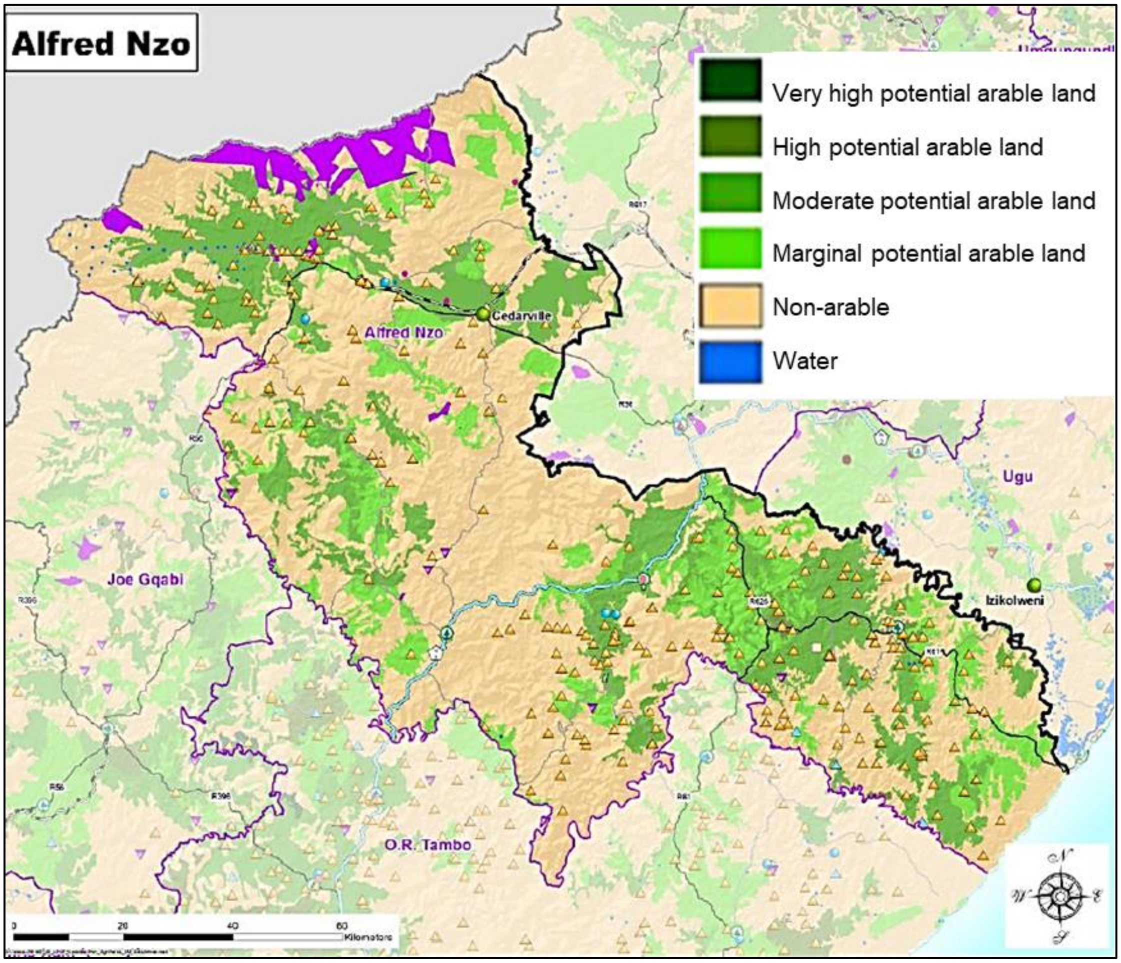


*Figure 32: Agricultural potential in the Alfred Nzo District (Source: COGTA 2023)*

# 3. Recommendations

To summarise, compared to other districts in South Africa, Alfred Nzo’s heat risk in terms of average temperature increase and current and projected very hot and heatwave days is low to very low. The risk of droughts will stay about the same as experienced currently, and the risk of wildfires, being relatively high already, sees only a low to moderate risk of increase in the future. The largest climate risk for the district is likely to arise from an expected increase in extreme rainfall, leading to an increase in flood risk, specifically in Bizana, followed by Mzamba A, Matatiele and Maluti.

The high dependency of the population on (subsistence) agriculture on soils which are moderately arable at best is a factor contributing to the extreme economic vulnerability of the district's population overly living in traditional settlements. The expected increase in extreme weather events harbours a risk of destroying crops, eroding soils and damaging housing and service infrastructure. The district has seen high levels of destruction by flood events in the recent past already.

The highest growth pressure (even excluding the Eastern Seaboard Development) is experienced in Mbizana, specifically the settlement of Bizana and Mzamba A. This results in high vulnerability of service delivery and natural resources but might also result in high flood risk due to increased rainfall, if spatial development is not regulated.

A high vulnerability of the population currently is due to the insufficient drinking water supply, despite the high amount of rainfall, which currently covers only a fraction of the actual water demand per capita (section 2.4.1). All four LMs of the district are among the Top-10 most at-risk local municipalities for climate change impacts on water supply based on current vulnerabilities as well as projected growth an bulk water supply challenges.

Further, should the Eastern Seaboard Development come into fruition, the expected developments will exacerbate inherent settlement vulnerabilities and need to take place in awareness of:

- Areas at risk of flooding due to extreme rainfall events and estuarine flooding
- Areas at risk of erosion due to extreme rainfall events and coastal storms
- Availability of water supply infrastructure

Therefore, in response to these climate risks and impacts, the following adaptation goals are recommended:

1. To ensure water security for human consumption under a changing climate: Given the water scarcity challenges in the country, developing comprehensive strategies for water resource management is crucial. Moreover, the projected and envisioned population growth make it necessary for the district to take action to ensure water security for consumption. 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) and making more use of groundwater.

2. To protect biodiversity and improve sustainable use of natural resources: Especially the natural coastal environment is considered endangered (due to high development pressure elsewhere) and might come under severe pressure due to rapid population

increase in Mbizana, 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 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.

3. To increase resilience of the agricultural sector to more extreme events such as storms as well as indirect risks such as pests and diseases: The District's agricultural sector contributes significantly to the livelihoods of local residents. As agriculture is arguably one of the most vulnerable sectors to the impacts of climate change in South Africa, it is essential to increase its resilience to these anticipated changes, and their impacts. This can be done by providing farmers with access to (i) training in sustainable farming techniques; (ii) training in farming practises that prevent damage to crops and soil erosion from floods; (iii) financial risk management tools; and (iv) diversification of livelihoods and income sources, i.e., to help the rural population to better withstand shocks and stresses arising from climate change impacts.

4. To increase the adaptive capacity of human settlements to climate change and extreme events: To reduce the vulnerability of human settlements to climate-related hazards and extreme events, it is essential to increase their capacity to adapt to such impacts and events. The district could increase the adaptive capacity of settlements by adopting design standards and practices that take into account future climate change impacts, to ensure that Alfred Nzo's settlement fabric is resilient to the anticipated climate conditions and extreme events (e.g., climate proofing infrastructure and buildings).

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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