

EXTREME RAINFALL

FLOOD RISK

EXTREME HEAT

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CLIMATE RISK AND VULNERABILITY ASSESSMENT REPORT

MANDENI LOCAL MUNICIPALITY

UNDERSTAND RISK

BUILD RESILIENCE

SUSTAIN OUR FUTURE

PLAN ADAPTIVE ACTION

MANDENI LOCAL MUNICIPALITY

PEACE UNITY PROGRESS

PREPARED FOR
Mandeni Local Municipality

PREPARED BY
Qpoint Group

MAY 2026

DEVELOPMENT OF THE CLIMATE CHANGE STRATEGY FOR MANDENI LOCAL MUNICIPALITY

Climate Risk and Vulnerability Assessment Report

Prepared for
MANDENI LOCAL MUNICIPALITY

by
QPOINT GROUP

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PROJECT TEAM AND CONTRIBUTORS

Gabriel Ngorima	Qpoint Group (Pty) Ltd
Lebohang Motyuoadi	Qpoint Group (Pty) Ltd
Sandile Sithole	Mandeni Local Municipality
Njabulo Mathonsi	Mandeni Local Municipality
Vasigaran Devan	Mandeni Local Municipality
Thokozani Nyawo	Mandeni Local Municipality
Thabani Zungu	Mandeni Local Municipality

Executive Summary

Mandeni Local Municipality is a coastal, urban-rural and industrial municipality in iLembe District Municipality. It is strategically located along the N2 and R102 corridors between Durban and Richards Bay and includes Mandeni town, Sundumbili, the Isithebe industrial node, SAPPI Tugela Mill, the uThukela River system, the aMatigulu/iNyoni estuary system, rural and traditional authority areas, agriculture, forestry, coastal recreation areas and important biodiversity assets.

The assessment confirms that climate risk in Mandeni arises when climate hazards interact with vulnerable people, exposed infrastructure, sensitive ecosystems and constrained institutional capacity. A heavy rainfall event becomes a disaster when drainage is blocked, houses are located in flood-prone areas, roads are damaged, wetlands are degraded, waste is dumped into channels and households have limited resources to recover.

The assessment identifies nine connected vulnerability themes. Flooding and stormwater failure are the most immediate municipal risks because they affect households, roads, bridges, drainage systems, water quality, sanitation, schools, clinics, public facilities and business continuity. Waste and watercourse pollution are not separate environmental issues: they increase flood risk by blocking drains and channels, and they increase health risk when polluted water spreads during rainfall. Coastal and estuarine risk is important because sea-level rise, storm surge, erosion and estuary mouth migration can affect coastal access, tourism assets, estuarine habitats and future development decisions. Drought, heat, fire, lightning, hail and strong winds are also material risks, especially for rural households, traditional dwellings, agriculture, schools, livestock, outdoor workers and emergency response services.

The assessment also finds that Mandeni has two types of climate vulnerability. The first is physical exposure: settlements, roads, watercourses, coastlines, wetlands, bridges, industrial sites and agricultural land are located in places that can be affected by climate hazards. The second is development vulnerability: poverty, unemployment, limited household savings, weak service access, drainage backlogs, waste-service gaps, poor road access, informal or traditional dwellings, degraded ecosystems and limited institutional capacity make recovery harder.

The highest priority locations are not limited to one ward. The coastal and estuary wards need careful management of coastal buffers, estuary boundaries, tourism access and future settlement or infrastructure decisions. The Mandeni-Sundumbili-uThukela corridor needs stronger drainage, waste, road, housing and floodline controls. The Isithebe-SAPPI industrial area needs air-quality and emissions screening, worker-health considerations and business-continuity planning. Northern and rural traditional authority wards need attention to water access, road access, fire, lightning, agriculture and land-allocation practices.

Mitigation is included at screening level because Mandeni's climate response includes both adaptation and emissions reduction. The evidence points to a small number of emissions-relevant systems that are carried into the Climate Change Strategy as priorities for developing a verified greenhouse gas inventory: large industry and manufacturing, purchased electricity, municipal and freight transport, waste disposal and waste burning, wastewater and sanitation, residential energy use, agriculture and biomass burning, and land-use systems such as wetlands, dunes and vegetation that also store carbon.

The Climate Change Strategy that follows this assessment must not simply list projects. It must convert the findings of this report into clear municipal decisions: where development must be avoided and not controlled, which drainage and waste hotspots require attention, which roads

and bridges are critical, which communities need early warning and relief readiness, where ecosystem restoration reduces risk, and which industrial and municipal activities require greenhouse-gas and air-quality screening. These findings are treated as screening priorities, and confirmation of local incident histories, current asset conditions and ward exposures is recommended before adopting site-specific designs or budgets.

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ABBREVATIONS

Abbreviation	Meaning
AQMP	Air Quality Management Plan
CBA	Critical Biodiversity Area
CRVA	Climate Change Risk and Vulnerability Assessment
CSIR	Council of Scientific Research and Industrial Research
DFFE	Department of Forestry, Fisheries and the Environment
DM	Disaster Management
DMC/DRMC	Disaster Management Centre / Disaster Risk Management Centre
DRR	Disaster Risk Reduction
EDTEA	KwaZulu-Natal Department of Economic Development, Tourism and Environmental Affairs
EFZ	Estuarine Functional Zone
EIA	Environmental Impact Assessment
ESA	Ecological Support Area
GHG	Greenhouse Gas
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change
IWMP	Integrated Waste Management Plan
KZN	KwaZulu-Natal
LED	Local Economic Development
LUMS	Land Use Management Scheme
MER	Monitoring, Evaluation and Reporting
MIG	Municipal Infrastructure Grant
MLM	Mandeni Local Municipality
MoF	Matrix of Functions
MTREF	Medium Term Revenue and Expenditure Framework
NAEIS	National Atmospheric Emission Inventory System
NEMA	National Environmental Management Act
NEM:AQA	National Environmental Management: Air Quality Act
NEM:WA	National Environmental Management: Waste Act
NWA	National Water Act
RCP	Representative Concentration Pathway
SDBIP	Service Delivery and Budget Implementation Plan
SDF	Spatial Development Framework
SMME	Small, Medium and Micro Enterprise
SPLUMA	Spatial Planning and Land Use Management Act
WBP	Ward-Based Plan

GLOSSARY

Term	Meaning
Adaptation	Adjustment in natural or human systems in response to actual or expected climate impacts, aimed at reducing harm or taking advantage of beneficial opportunities.
Adaptive capacity	The ability of households, communities, institutions, businesses and ecosystems to prepare for, respond to and recover from climate impacts.
Air-quality pressure	A condition where people or ecosystems are exposed to pollutants, such as particulate matter, sulphur dioxide, nitrogen oxides, carbon monoxide, volatile organic compounds, smoke, dust or odour.
Climate-sensitive system	A municipal, social, economic or ecological system whose functioning can be affected by climate hazards, for example roads, stormwater, water supply, waste, housing, agriculture, health or coastal access.
Compound risk	Risk created when hazards or stressors occur together or in sequence, such as heavy rain, blocked drains, illegal dumping and contaminated floodwater.
Critical Biodiversity Area	An area required to meet biodiversity targets and maintain species, ecosystems, ecological processes and ecosystem services.
Ecological Support Area	An area required to support the ecological functioning of Critical Biodiversity Areas and maintain ecological infrastructure.
Ecosystem-based adaptation	The use of biodiversity and ecosystem services, such as wetlands, dunes, forests and riparian buffers, to help people and systems adapt to climate change.
Estuary Functional Zone	The area around an estuary that supports estuarine processes and should be considered in land-use, flood, coastal and biodiversity planning.
Exposure	The presence of people, assets, infrastructure, ecosystems, livelihoods or services in places where hazards may occur.
Greenhouse gas	A gas that traps heat in the atmosphere and contributes to climate change, including carbon dioxide, methane and nitrous oxide.
Greenhouse-gas inventory	A quantified record of greenhouse-gas emissions and removals, prepared from activity data such as electricity, fuel, waste, wastewater, industrial and land-use records.
Hazard	A potentially damaging climate-related event or trend, such as heavy rainfall, flooding, drought, heat, lightning, hail, wind, fire, storm surge or sea-level rise.
Informal dwelling	A dwelling that is not built according to formal housing standards or formal approval processes, often constructed from temporary or makeshift materials.
Maladaptation	An action that appears to reduce risk in the short term but increases exposure, vulnerability or emissions in the long-term.
Mitigation	Actions that reduce greenhouse-gas emissions or enhance carbon sinks.
Mitigation screening	A preliminary review of emissions-relevant activities and data needs used to identify likely greenhouse-gas and air-quality sources before a verified greenhouse-gas inventory is prepared.
No-regret action	An action that reduces current risk and remains useful under a range of future climate scenarios, such as drainage maintenance, buffer protection or illegal-dumping control.
Resilience	The ability to anticipate, absorb, adapt to and recover from climate shocks while maintaining essential functions.
Risk	The potential for adverse consequences arising from the interaction of hazards, exposure and vulnerability.
Sensitivity	The degree to which an exposed person, asset or ecosystem is affected by a

Term	Meaning
	hazard, for example a settlement with poor drainage or a household dependent on unsafe water.
Traditional dwelling	A dwelling associated with traditional settlement forms and construction practices. It should be distinguished from an informal dwelling because the climate risks, tenure context, construction form and intervention options may differ.
Vulnerability	The tendency to be adversely affected, shaped by sensitivity and limited adaptive capacity.

1. Introduction, Purpose and Methodology

1.1. Introduction

This assessment examines how climate change can alter the frequency, intensity and consequences of climate-related hazards experienced by municipalities through infrastructure, land-use, public-health, economic and ecosystem systems, recognising that changes differ by hazard and location (IPCC, 2022). For a local municipality, climate risk is not a separate environmental issue; it is experienced through service-delivery systems, land-use decisions, infrastructure maintenance, ecosystem condition and the capacity of communities to prepare for and recover from shocks. This Climate Risk and Vulnerability Assessment (CRVA) applies the hazard-exposure-vulnerability risk framing to Mandeni Local Municipality by assessing how local exposure, sensitivity and adaptive capacity interact with existing development patterns.

At national level, South Africa's Climate Change Act (Act No. 22 of 2024), the National Climate Change Adaptation Strategy, and provincial and district planning frameworks are used to the integration of climate resilience into Integrated Development Plan (IDP), Spatial Development Framework (SDF), disaster risk management, land-use management, infrastructure, waste, water, public-health and local economic development functions. These planning responsibilities are distinguished from deferred statutory procedures: the Act commenced on 17 March 2025 subject to the exclusions in Proclamation 251 of 2025, including section 17. Mandeni's local implementation and coordination role is therefore considered separately from the provincial, metropolitan and district arrangements contemplated in that section. In Mandeni, this requires a coordinated response to flooding, coastal and estuary dynamics, drought, heat, wildfire, waste, air-quality pressure and greenhouse-gas mitigation through ordinary municipal planning and implementation processes.

1.2. Purpose and Objectives of the Vulnerability Assessment

The purpose of the assessment is to provide a municipal evidence base for climate adaptation and climate-resilient development in Mandeni. The report is intended to inform the future Climate Change Strategy, IDP alignment, SDF and LUMS controls, disaster risk planning, coastal and estuary management, waste management, infrastructure prioritisation, public health planning, agriculture support and municipal budgeting discussions.

The specific objectives are to identify current and future climate hazards, explain Mandeni-specific vulnerability factors, identify vulnerable locations, sectors and social groups, interpret existing municipal sector documents from a climate-risk perspective, provide a screening-level risk ranking and recommend adaptation options for consideration in the strategy phase.

The assessment is prepared as decision support for the current Climate Change Strategy. It identifies priority risks, data gaps and implementation implications, while confirming that statutory floodline modelling, hydraulic design, bridge capacity assessment, coastal modelling and a verified greenhouse-gas inventory remain separate technical tasks to be commissioned or confirmed where required.

1.3. Scope of the Vulnerability Assessment

The spatial scope is the whole Mandeni Local Municipality, including all 18 wards; Mandeni, Sundumbili and Isithebe; rural and traditional authority areas; the N2, R102 and local road corridors; SAPPI Tugela Mill; the Isithebe industrial estate; the uThukela River; the aMatigulu/iNyoni estuary; Tugela Mouth, Dokodweni and Mbizimbelwe coastal areas; wetlands,

rivers, forests and biodiversity corridors; agricultural land; public facilities; housing projects; and waste, water and stormwater systems.

The thematic scope covers people, settlements, infrastructure, ecosystems, economic activities, municipal institutions and governance arrangements. This assessment does not replace a statutory floodline study, hydraulic model, bridge capacity assessment, coastal erosion model, engineering design, environmental authorisation or full municipal greenhouse-gas inventory. Where such technical work is needed, this report identifies why it matters for climate risk.

1.4. Outputs of the vulnerability assessment

The main outputs of this vulnerability assessment are set out below. They provide the evidence base that the Climate Change Strategy uses to move from general climate awareness to practical municipal decision-making.

- An explanation of the climate hazards already affecting Mandeni and the hazards likely to become more important in future.
- A municipal vulnerability profile showing how exposure, poverty, service backlogs, settlement location, waste, drainage, ecosystem condition and institutional capacity interact.
- An interpretation of ward-level hazard maps, GreenBook future-risk maps, field observations and municipal sector plans from a climate-risk perspective.
- A screening-level ranking of the most vulnerable municipal systems and sectors, to guide the next phase of strategy development.
- Policy implications and adaptation options that can be carried into the Climate Change Strategy, IDP, SDF, LUMS, Disaster Management, IWMP, coastal, estuary, housing and LED planning processes.
- A preliminary mitigation and emissions screening that identifies the main data needed for a future municipal and community-scale greenhouse-gas inventory.

1.5. Guiding principles

The assessment is guided by municipal ownership, evidence-based decision-making, risk-based prioritisation, equity, spatial precision, ecosystem-based adaptation and integration with existing planning tools. These principles matter because climate adaptation will fail if it is treated as a separate environmental project rather than as part of ordinary land-use, infrastructure, waste, disaster, health and finance decisions.

- Municipal ownership: the findings must be usable by Mandeni departments and not remain a consultant-only product.
- Risk-based prioritisation: scarce resources should be directed to locations where hazards, exposed assets and weak coping capacity overlap.
- Equity and inclusion: poor households, children, elderly people, persons with disabilities, women, caregivers, informal traders, outdoor workers and rural households require specific attention.
- Spatial precision: ward-level and hotspot-level evidence is more useful than general municipal statements.
- Ecosystem-based adaptation: wetlands, dunes, estuaries, riparian buffers and biodiversity corridors must be treated as protective infrastructure.
- Avoiding maladaptation: the municipality should avoid responses that solve one problem but create new exposure elsewhere, such as approving development inside flood-prone areas

or hardening a dynamic coastline without a long-term plan. Upstream, downstream and alongshore effects, alternatives, lifecycle maintenance and ecosystem consequences are also assessed before flood or coastal interventions are recommended.

1.6. Methodological framework for the assessment process

The assessment followed a mixed evidence approach aligned with accepted climate-risk practice and risk framing used by the Intergovernmental Panel on Climate Change (IPCC) and Council for Scientific Research and Industrial Research (CSIR) GreenBook. The method combines document review, hazard-view interpretation, field observations, site photographs and municipal planning logic so that scientific screening information can be translated into practical municipal actions.

The evidence base included the Mandeni Integrated Development Plan (IDP), Spatial Development Framework (SDF), Spatial Development Plan (SDP), Land Use Management Scheme (LUMS), Human Settlements Sector Plan, Integrated Waste Management Plan (IWMP), Disaster Management Sector Plan, Summer Contingency Plan, Disaster Management Plan and Policy Framework, Coastal Management Programme, draft aMatigulu/iNyoni Estuary Management Plan, KwaZulu-Natal and iLembe Air Quality Management Plans, Biodiversity Sector Plan, Greening Plan, Local Economic Development (LED) Strategy, GreenBook hazard screening information, ward-based plans, risk maps, field notes, and site visit photographs. The draft estuary plan is used as planning context, not as proof of a recorded incident, adopted management control or statutory setback.

The risk ranking is a screening-level prioritisation. Each risk was tested against five questions: how likely the hazard is to occur; how serious the consequence could be; how many people, assets or services may be exposed; how sensitive the affected system is; and how much capacity exists to prevent, respond to or recover from the impact. This keeps the ranking transparent without pretending that detailed engineering or statistical modelling has already been completed.

The relative sector order in Table 7 is retained as a provisional qualitative priority. For the hazard and receptor combinations in Table 8, the following three-level likelihood and consequence convention is applied over an approximately five-year municipal planning horizon. These are professional screening judgements, not calculated event probabilities.

Table 1: Likelihood and consequence screening criteria

Score	Likelihood	Consequence
1 – Low	Uncommon on the available evidence within the planning horizon.	Limited local disruption; recovery generally achievable through routine capacity.
2 – Medium	Plausible, with regional or contextual evidence but uncertain local recurrence.	Material service, livelihood or ecological disruption requiring additional resources or coordinated response.
3 – High	Expected or repeatedly reported in the relevant setting; recurrence still requires verification.	Potential serious harm, displacement, prolonged critical-service loss, substantial livelihood loss or major ecological damage.

Likelihood is multiplied by consequence: scores of 1–2 is Low, 3–4 is Medium and 6–9 is High. Exposure, sensitivity and adaptive capacity inform consequence and response selection; they are not multiplied again as overlapping indices. Confidence is recorded separately, and Low risk

is not assigned merely because local records are missing. Departmental and community validation must confirm the ratings before site-specific investment decisions.

Table 2: Three by three screening risk matrix

Likelihood	Consequence 1	Consequence 2	Consequence 3
3 – High	3 – Medium	6 – High	9 – High
2 – Medium	2 – Low	4 – Medium	6 – High
1 – Low	1 – Low	2 – Low	3 – Medium

For this reason, the ranking must be read as a decision-support tool, not as a final capital-budget ranking. Before individual projects are costed, priority sites must be confirmed through ward validation, departmental asset information, floodline or stormwater studies where required, and updated incident records.

1.6.1. Institutional Arrangements and Stakeholder Engagement Plan

Climate vulnerability cuts across municipal functions. Disaster Management provides hazard, response and early-warning information. Town Planning and Environmental Management control where development should or should not occur. Technical Services, roads, stormwater, waste, water and sanitation functions affect whether climate hazards become service-delivery failures. LED, agriculture, tourism and industry stakeholders are affected by disruption and transition risks. Traditional leadership is essential in rural and Ingonyama Trust areas because land allocation, settlement expansion, buffers and local enforcement cannot be addressed only through municipal offices.

Stakeholder engagement should therefore not be a once-off workshop. For this CRVA, the available stakeholder comments were treated as evidence. The comments are used to explain how existing municipal plans drive or reduce climate risk and how sectors such as waste, disaster management, infrastructure, spatial planning, human settlements and environmental management contribute to vulnerability.

For implantation, stakeholder engagement should be structured as departmental and ward-level validation. Disaster Management and Fire Unit should verify incident records and early-warning arrangements; Technical Services should verify roads, bridges, culverts and stormwater assets; Waste Management should verify illegal-dumping and waste-service hotspots; Human Settlements should verify exposed housing projects and vulnerable dwelling types; Town Planning and Environmental Management should verify SDF, LUMS, buffer and environmental constraints; iLembe District should support water-services and air-quality data; and traditional authorities and ward committees should validate local land-allocation, access and community-priority issues.

1.6.2. Ensuring Gender Responsiveness

Gender responsiveness in this report means looking at how climate hazards affect people differently. For example, flood impacts can create additional care burdens for women and caregivers; water shortages can increase the time spent collecting or securing water; heat and poor air quality can affect children, elderly people and chronically ill residents; and disrupted roads can affect school attendance, clinic access and informal trading. The report therefore considers vulnerable groups as part of every risk theme rather than treating gender as a separate add-on.

1.6.3. Methodology for Data Gathering and Management

The report uses available evidence, but it also recognises that some datasets are incomplete, outdated or uneven. Ward-based plans often rely on older Census data and should be used to understand structural vulnerability patterns, not as a precise current household count. The hazard maps are useful for screening and prioritisation, but they should be ground-truthed through GIS overlays, incident logs, floodline confirmation, asset condition assessments and ward-level validation before final capital budgeting decisions are made.

1.6.4. Validation status of the CRVA

The CRVA has been prepared from the municipal and technical evidence available at the time of reporting. This includes municipal plans, sector plans, risk maps, GreenBook screening maps, field notes, site photographs and consolidated stakeholder comments. It therefore represents a defensible municipal screening assessment, but it is not a substitute for final ward-level validation.

The Strategy phase should include confirmation of priority hotspots with the relevant municipal departments, ward structures, traditional leadership, Disaster Management, Waste Management, Technical Services, Town Planning, Environmental Management, Human Settlements, iLembe District Municipality and relevant provincial stakeholders. This validation is especially important for flood-prone settlements, traditional authority areas, coastal and estuary zones, industrial areas, illegal-dumping sites and public facilities used for emergency response. A validation record linking each ward map and proposed hotspot to site identifiers, coordinates, dated photographs, asset information, participants, corrections, differing views and agreed actions is recommended. Accessible participation through ward and traditional structures and documented sign-off before describing a site as validated are recommended.

2. About Mandeni Local Municipality

2.1. Geographic Profile

Mandeni Local Municipality is located on the KwaZulu-Natal north coast within iLembe District Municipality. It is positioned along the N2 national corridor and R102 route between Durban and Richards Bay. This corridor position is economically important, but it also exposes the municipality to road-disruption risk, logistics-related emissions, settlement pressure and infrastructure maintenance costs. The regional interpretation includes the adjoining municipalities of Maphumulo to the west, KwaDukuza to the south and uMlalazi to the north, together with the Indian Ocean to the east. The coast's connection to the wider uThukela Marine Protected Area (MPA), discussed in Section 2.6, is also recognised (Department of Environmental Affairs, 2019).

The municipality includes coastal land, estuaries, rivers, wetlands, low-lying areas, inland slopes, rural settlements, urban townships and industrial zones. This combination means Mandeni does not have a single climate-risk profile. Coastal areas face erosion, storm surge, sea-level rise and estuary mouth dynamics. Low-lying river and drainage areas face flooding and water-quality risk. Inland rural areas face water access, fire, lightning, road access and agricultural vulnerability. Urban and industrial areas face stormwater, waste, heat, air quality and business-continuity risks.

Planning response: Geographic risk is spatially uneven across the municipal area. The same storm can produce different impacts in a coastal settlement, a low-lying river corridor, a dense urban area, an industrial site and a dispersed rural village; location-specific spatial planning and infrastructure prioritisation are therefore recommended.

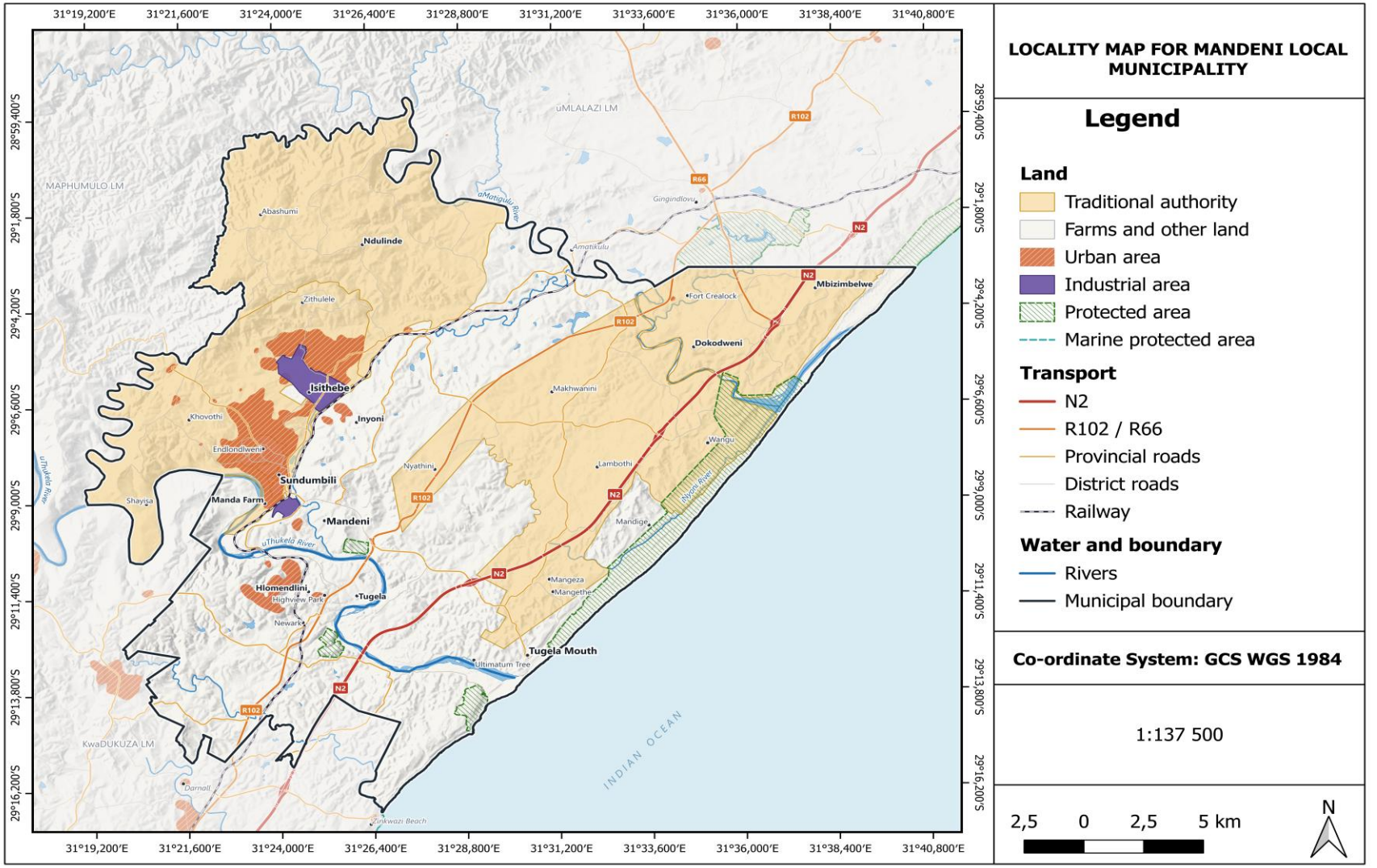

Figure 1: Municipal Context of Mandeni Local Municipality

2.2. Population and Socio-economic Profile

Municipal planning documents describe Mandeni as an 18-ward municipality with a mix of urban, peri-urban, rural and traditional authority settlements. The verified Census 2022 baseline of 180,939 residents and 40,436 households is used. The 2025 LED Strategy records an estimated population of approximately 154,632 people in about 40,179 households. Earlier municipal and sector plans use Census 2011 and Community Survey 2016 data, which remain useful for identifying structural vulnerability patterns, but should not be treated as fully current household counts.

The socioeconomic profile matters for climate risk because a household with low income, poor road access, weak housing, limited water or sanitation, poor drainage, no savings and limited insurance will experience the same storm differently from a higher-income household with secure services and transport. Climate vulnerability is therefore closely linked to poverty, unemployment, service backlogs, housing type, distance from services and dependence on climate-sensitive livelihoods.

Ward-based plans show that the municipality contains both dense urban or semi-urban wards, especially around Mandeni and Sundumbili, and extensive rural wards under traditional authorities. In many rural wards, traditional dwellings, dispersed settlement patterns, agriculture, livestock and limited-service access increase sensitivity to drought, fire, road disruption, water-quality problems and emergency-response delays. In dense urban and industrial wards, the climate concern is often drainage, waste accumulation, public health, heat, air quality and flooding of roads or public assets. Traditional and informal dwellings are assessed separately on the basis of construction condition, hazard location and service access; neither label is treated as a measure of vulnerability.

The accompanying settlement and housing-project map is used to locate potential exposure; the principally 2011 reference year of the settlement information is retained. Census 2022 residents are not allocated to those older polygons, and project occupation or completion is not inferred from a mapped boundary. It is recommended that updated socioeconomic, service and hazard data be linked before assigning ward-level social vulnerability scores.

Social vulnerability influences the severity of impacts and speed of recovery. The analysis therefore examines how low income, weak access roads, limited water or sanitation services and vulnerable housing can turn climate impacts into household financial shocks and municipal service-delivery pressures.

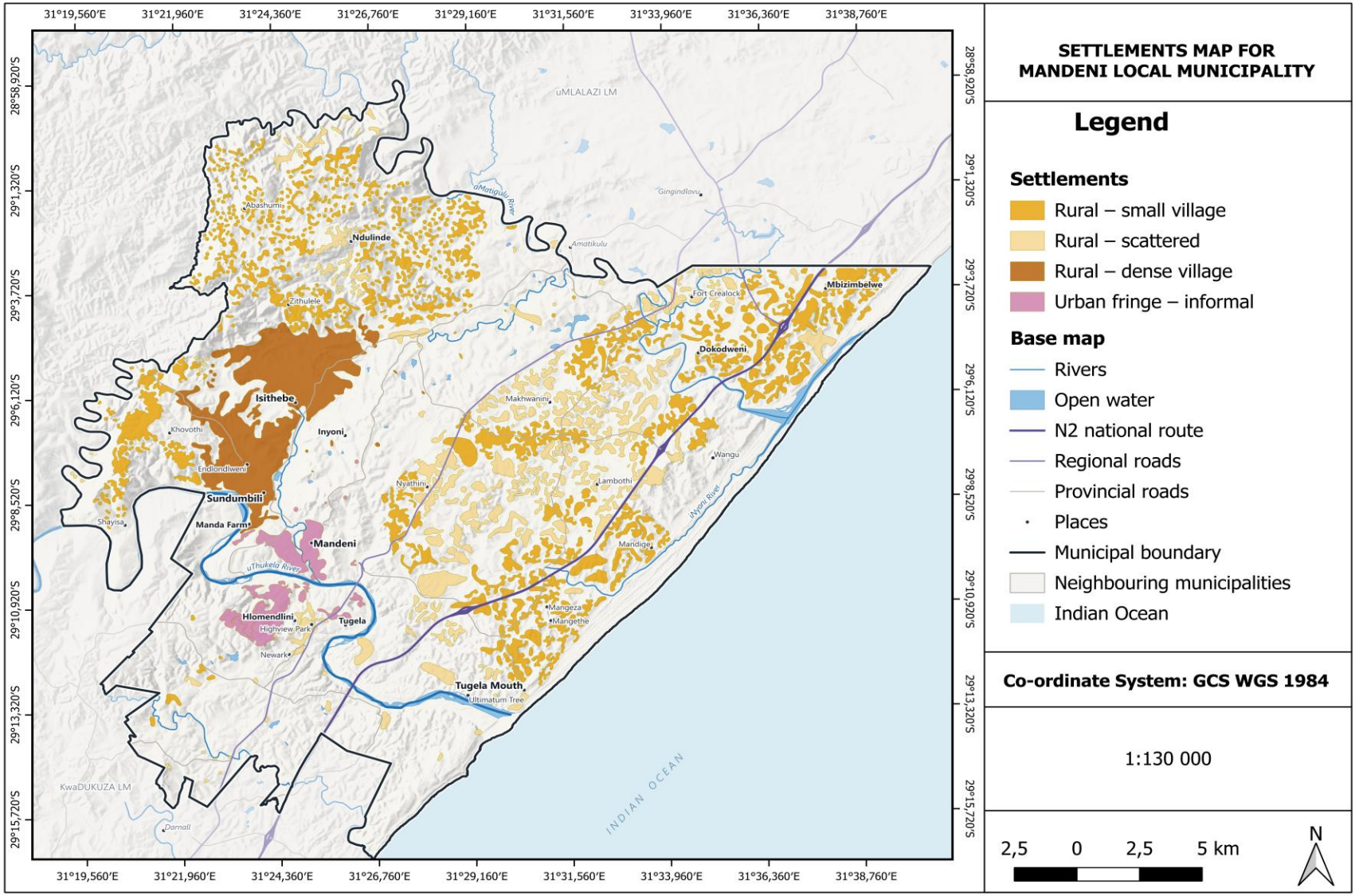

Figure 2: Settlement, agricultural land and housing-project context

2.3. Arable Land and Agricultural Land under Cultivation

Agriculture is a major land use and economic activity in Mandeni. Sugarcane, forestry, commercial farming, small-scale farming and livestock activities are all climate-sensitive. The agricultural land-category maps show large areas of primary and secondary agricultural land, mixed agricultural land and land under pressure from settlement and industrial activity. This means that climate risk must be assessed not only for households and roads, but also for soil, crop productivity, water availability, erosion and rural livelihoods. The mapped categories are used as agricultural planning context; they do not establish current cultivated hectares, crop yields or individual farm condition.

Agriculture can reduce or worsen climate risk. Well-managed agricultural land can protect soils, store carbon, support livelihoods and reduce erosion. Poorly managed slopes, exposed soils, overgrazing, burning, monocropping, invasive alien plants and settlement expansion into productive land can increase runoff, siltation, fire risk, flood damage and long-term food-security vulnerability. For Mandeni, climate adaptation in agriculture should therefore focus on water management, soil conservation, fire management, crop diversification, extension support and avoiding unnecessary loss of high-potential agricultural land. These measures are linked to the Conservation of Agricultural Resources Act 43 of 1983, the National Environmental Management Act 107 of 1998 and the National Water Act 36 of 1998. Attention to erosion, diffuse pollution, river and wetland margins, invasive species, Critical Biodiversity Areas, Ecological Support Areas and ecological corridors is recommended, in accordance with the relevant authority and activity requirement. Agricultural land is both an economic asset and a climate-sensitive system. The Climate Change Strategy should protect productive land, support farmers and reduce the fire, erosion, drought and runoff risks associated with poor land management.

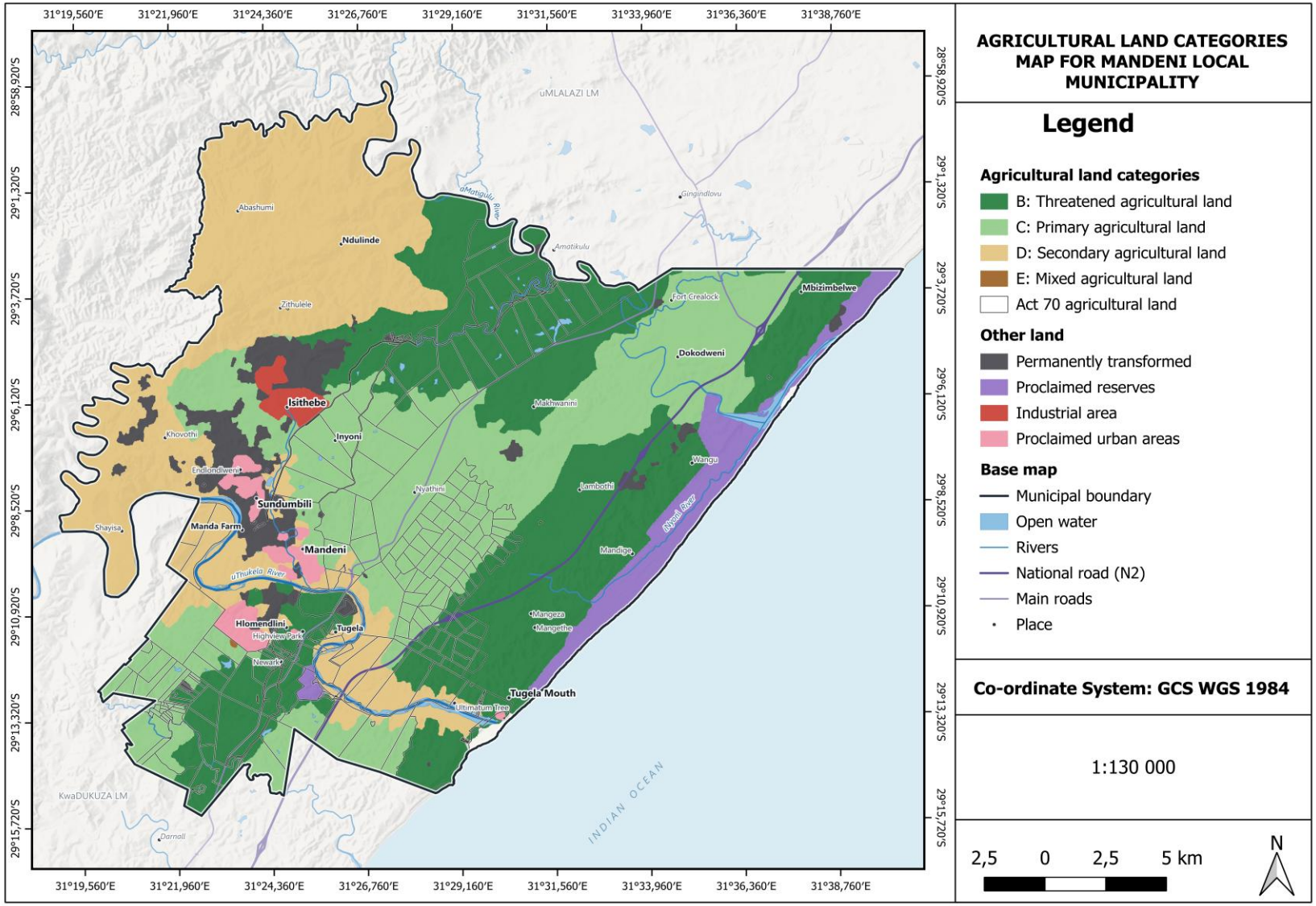

Figure 3: Agricultural Land Categories of the Mandeni Local Municipality

2.4. Soil, Geology and Topography

Mandeni contains coastal lowlands, river valleys, wetlands, estuarine areas, agricultural areas and inland slopes. Soil and slope conditions are important because they influence how water moves through the landscape. Disturbed, exposed or compacted soil can increase runoff and erosion. Steep or poorly stabilised slopes can fail or send sediment into watercourses. Low-lying and poorly drained areas can flood repeatedly if settlement, road design or stormwater systems do not account for natural flow paths.

This means that soil and topography must be built into climate-sensitive planning. Housing, roads, stormwater channels, culverts and public facilities should not be planned only around land availability; they must also be assessed against floodlines, slope, soil stability, wetland buffers, drainage capacity and long-term maintenance costs.

Planning response: Land availability must not be treated the same as climate suitability. Vacant land can create long-term municipal liabilities where it is exposed to floodlines, unstable slopes, wetlands, coastal processes or high stormwater maintenance needs.

2.5. Hydrology and Watercourses

The uThukela River, aMatigulu/iNyoni estuary system, wetlands, riparian corridors, drainage lines and flood-prone lowlands should be treated as a distinct climate-sensitive system. Hydrology influences flood routing, sediment movement, water quality, estuary mouth dynamics, wetland condition and the reliability of water-dependent livelihoods. Priority sites should therefore be interpreted with river, wetland, estuary functional zone, floodline, culvert and stormwater asset information when implementation actions are selected. The uThukela is recognised as a hydrological and ecological connection between upstream catchments, the estuary and the Indian Ocean. Downstream flood, water-quality and coastal risk assessment therefore includes upstream rainfall, land condition, sediment and pollution, and coordination across municipal and catchment boundaries is recommended (Department of Water and Sanitation, 2023).

For implementation, hydrology must be treated as a stand-alone planning layer. Priority flood, drainage, estuary and water-quality decisions should be checked against rivers, wetlands, drainage lines, riparian buffers, estuary functional zones, culverts, bridges, stormwater assets and updated floodline information. The river, wetland, estuary and flood-screening layers are distinguished by their source dates and purposes. A wetland inventory is not treated as a field delineation, and an estuary functional zone is not treated as a surveyed floodline or adopted coastal management line.

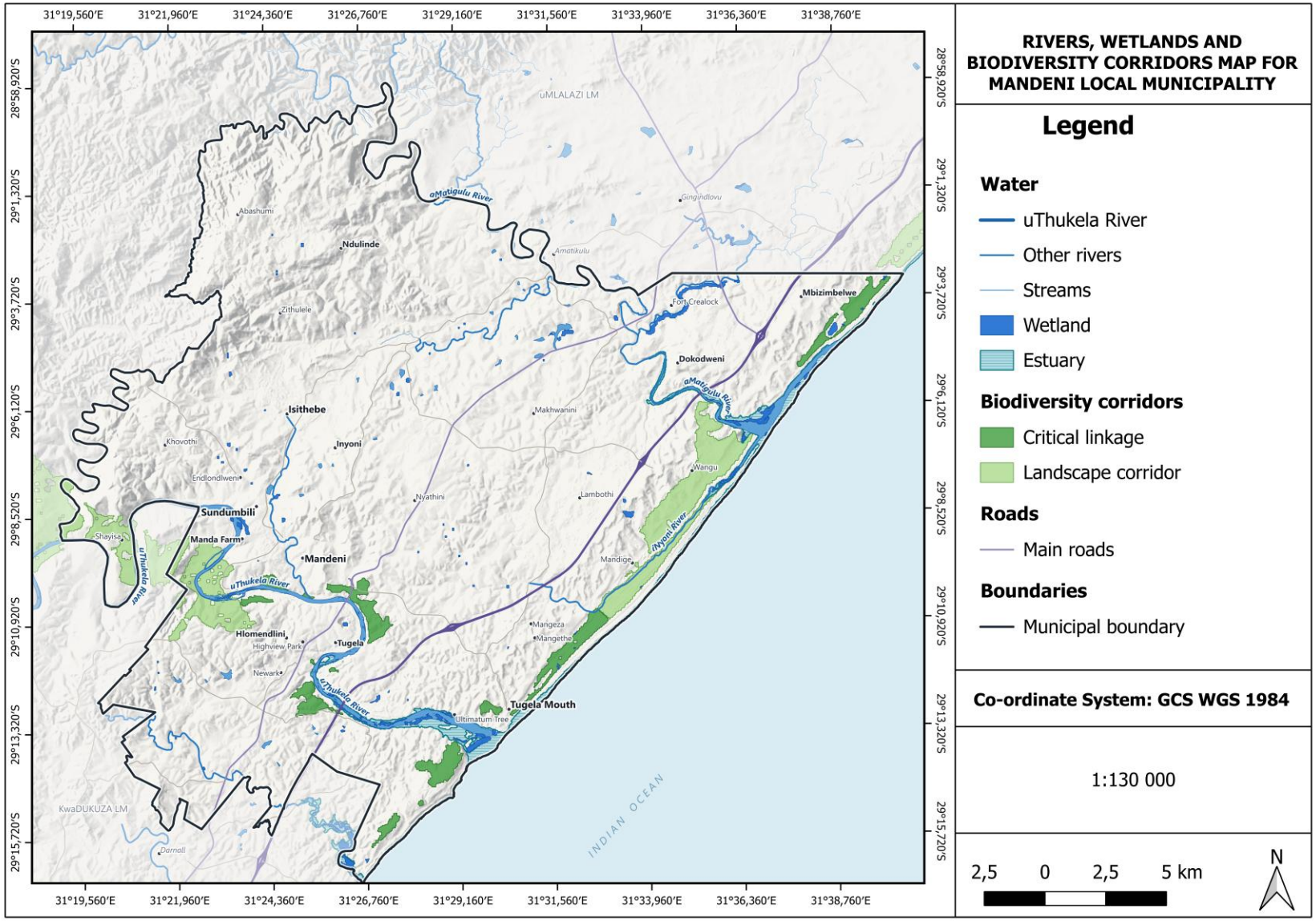

Figure 4: Major Rivers, Wetlands and Biodiversity Corridors of Mandeni Local Municipality

2.6. Vegetation, Biodiversity and Ecosystem services

Mandeni has important vegetation and biodiversity systems including forests, grasslands, protected areas, biodiversity corridors, Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs). Rivers and wetlands are addressed as part of the hydrology discussion above, but they remain linked to biodiversity because healthy riparian and wetland systems support ecological function as well as flood attenuation and water filtration. Interpretation of the accompanying conservation map distinguishes CBA and ESA planning categories from legally proclaimed protected areas and protected-area expansion focus areas; overlapping categories are not added together (Ezemvelo KZN Wildlife, 2014).

The iLembe Biodiversity Sector Plan identifies Critical Biodiversity Areas and Ecological Support Areas as land-use planning priorities. In climate terms, this means that biodiversity is not only about species protection. It is also about maintaining the natural systems that help protect people and municipal assets. When wetlands are drained, burnt, polluted or filled; when dunes are damaged; when riparian vegetation is removed; or when biodiversity corridors are fragmented, Mandeni loses natural protection and increases future repair costs. Carbon storage in vegetation and soils is also recognised; no quantified local carbon stock or sequestration rate is claimed. The scope of ecosystem monitoring includes invasive plants and tree-health threats, including surveillance for possible polyphagous shot hole borer; the evidence reviewed does not establish an infestation in Mandeni, and suspected symptoms require specialist confirmation (University of Pretoria FABI, n.d.).

The assessment links the uThukela River and estuary to the wider uThukela Marine Protected Area, which extends beyond Mandeni. Its importance for marine biodiversity and fisheries-related livelihoods is recognised, and ocean warming, altered currents, sea-level rise, storm exposure and changes in estuarine salinity are considered potential pressures. Coordinated catchment, coastal and marine monitoring is recommended; these pathways are not presented as measured local trends (Department of Environmental Affairs, 2019). Ecosystems should be treated as municipal risk-reduction assets. Protecting wetlands, riparian buffers and biodiversity corridors reduces future costs by lowering flood, erosion, water-quality, heat and coastal exposure.

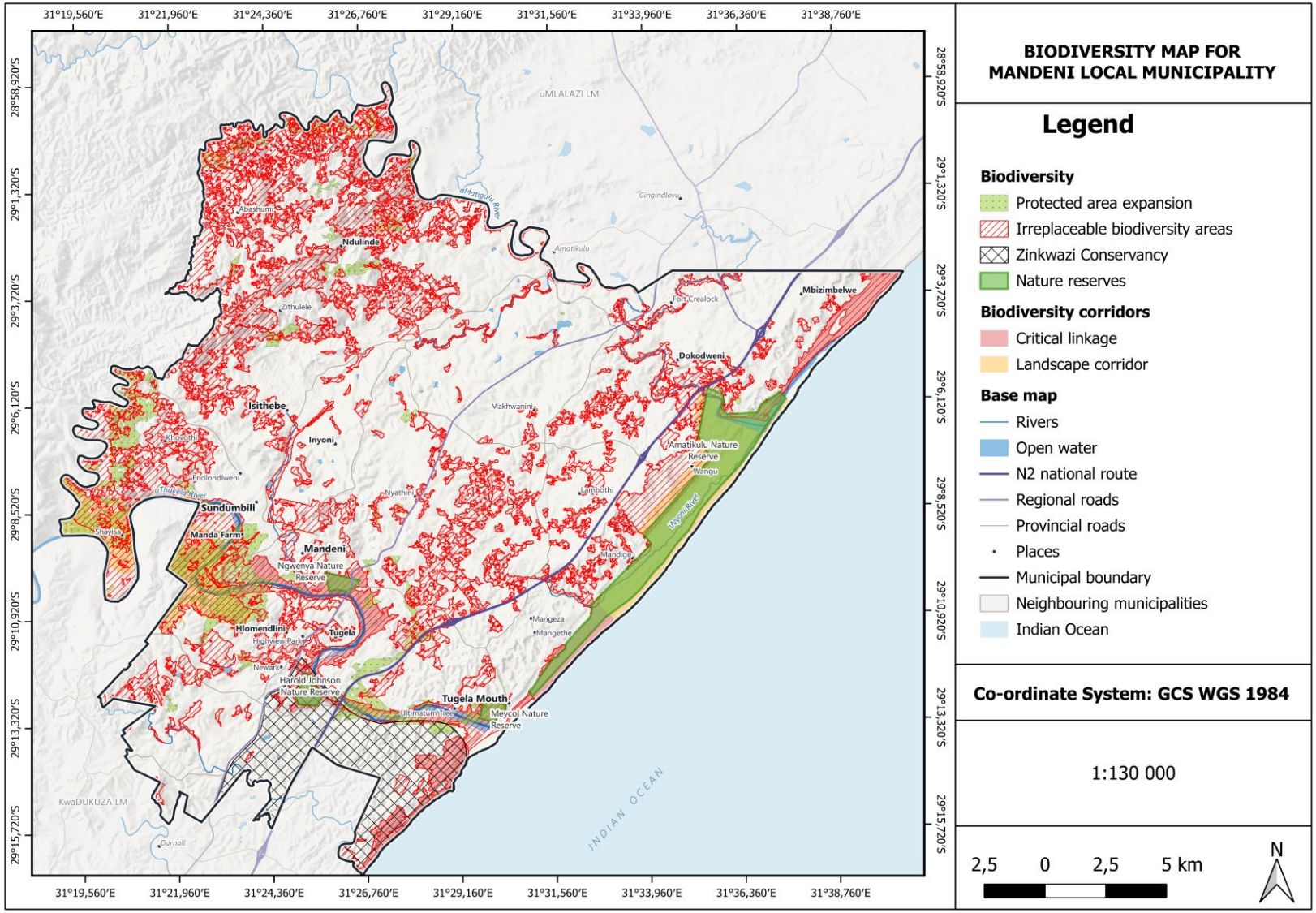

Figure 5: Biodiversity priorities and ecological connections

2.7. Climate

Mandeni is assessed within KwaZulu-Natal's summer-rainfall coastal setting. Climate screening information from the GreenBook indicates that future heat, wildfire, drought, flooding, coastal flooding and coastal erosion risks should be considered in planning. The important point is that future climate change can place additional stress on systems that are already under pressure: stormwater, roads, bridges, waste, water, sanitation, public health, agriculture, coastal access and municipal response capacity. This municipal planning and regional screening context is distinguished from a measured local climate series.

Climate impacts can be understood through municipal functions. Hotter conditions increase heat stress, water demand, fire danger and electricity demand. Heavier rainfall increases drainage failure, flooding, erosion, road closure and water contamination. Drier periods increase water insecurity, agricultural stress and fire risk. Stronger coastal processes increase erosion and access risk. The municipality therefore needs adaptation that works under uncertainty: maintain drainage, protect buffers, avoid unsafe development, rehabilitate natural systems, improve early warning and strengthen waste control.

It is recommended that at least 12–24 months of reconciled local Fire and Disaster Management records be obtained to identify recurrent impacts and locations. For climate-trend analysis, longer quality-controlled rainfall and temperature series, with station metadata and an explicit baseline, are required. Regional maps or a short incident record are not used to infer a measured local trend or attribute an individual event to climate change. Future climate change increases the cost of weak maintenance, weak enforcement and poor land-use decisions. Adaptation should therefore be embedded within stormwater, roads, waste, housing, disaster readiness, environmental management and public-health coordination.

Table 3: Climate-sensitive systems, exposures and potential consequences

Climate-sensitive system	Main climate exposure	Potential consequence
Settlements and households	Flood, wind, heat, lightning, fire, drought, poor access	Housing damage, displacement, injury, public-health impacts, income loss, slow recovery
Roads, bridges and access routes	Flooding, erosion, scouring, storm debris, blocked culverts	Road closures, emergency access failure, isolation of communities, business disruption
Stormwater, waste and drainage	Heavy rainfall, dumping, sedimentation, blockages	Local flooding, watercourse pollution, disease risk, higher maintenance costs
Water and sanitation	Drought, flood contamination, infrastructure damage	Water insecurity, unsafe sources, sanitation failures, health risks
Coasts, dunes and estuaries	Storm surge, erosion, sea-level rise, mouth migration, flooding	Loss of access/infrastructure, tourism impacts, habitat degradation, increased disaster exposure
Agriculture and rural livelihoods	Drought, heat, fire, erosion, extreme rainfall, pests	Crop/livestock losses, income and food-security stress, biomass-burning risks
Industry and logistics	Flooding, heat, power disruption, air-quality regulation, transition risk	Business interruption, emissions exposure, worker health, investment risk
Public facilities and emergency	Flood, fire, heat, wind, power/water	Reduced emergency response, unsafe

Climate-sensitive system	Main climate exposure	Potential consequence
shelters	failure	shelters, service disruption

2.8. Administrative and institutional profile

Mandeni operates in a multi-level governance environment. The municipality is responsible for local planning, land-use management, local roads and stormwater functions, waste management, environmental management, disaster management coordination and local economic development. iLembe District Municipality has important responsibilities in relation to water services, district planning and air-quality management. Provincial and national departments are involved in human settlements, agriculture, environment, transport, disaster management, coastal management and water resources.

Traditional authority areas are especially important. A significant portion of Mandeni is under traditional governance and Ingonyama Trust arrangements. This does not only affect land ownership; it affects climate risk. If settlement expansion, local access roads, dumping sites or community facilities are planned without environmental screening, the municipality may inherit future risk that is expensive to correct. Effective climate adaptation must therefore include traditional authorities in land-use decisions, buffer awareness, disaster preparedness and ward-level hotspot validation.

The ward and traditional-authority mapping in Figure 6 below is used to support departmental and ward validation. Retention of site coordinates and affected-asset identifiers alongside ward numbers is recommended, because ward-wide categories can conceal local differences. Traditional governance is central to adaptation. Land allocation, settlement expansion, local access roads, dumping control and community facilities in traditional authority areas must be linked to climate screening so that new exposure is not created faster than the municipality can manage it.

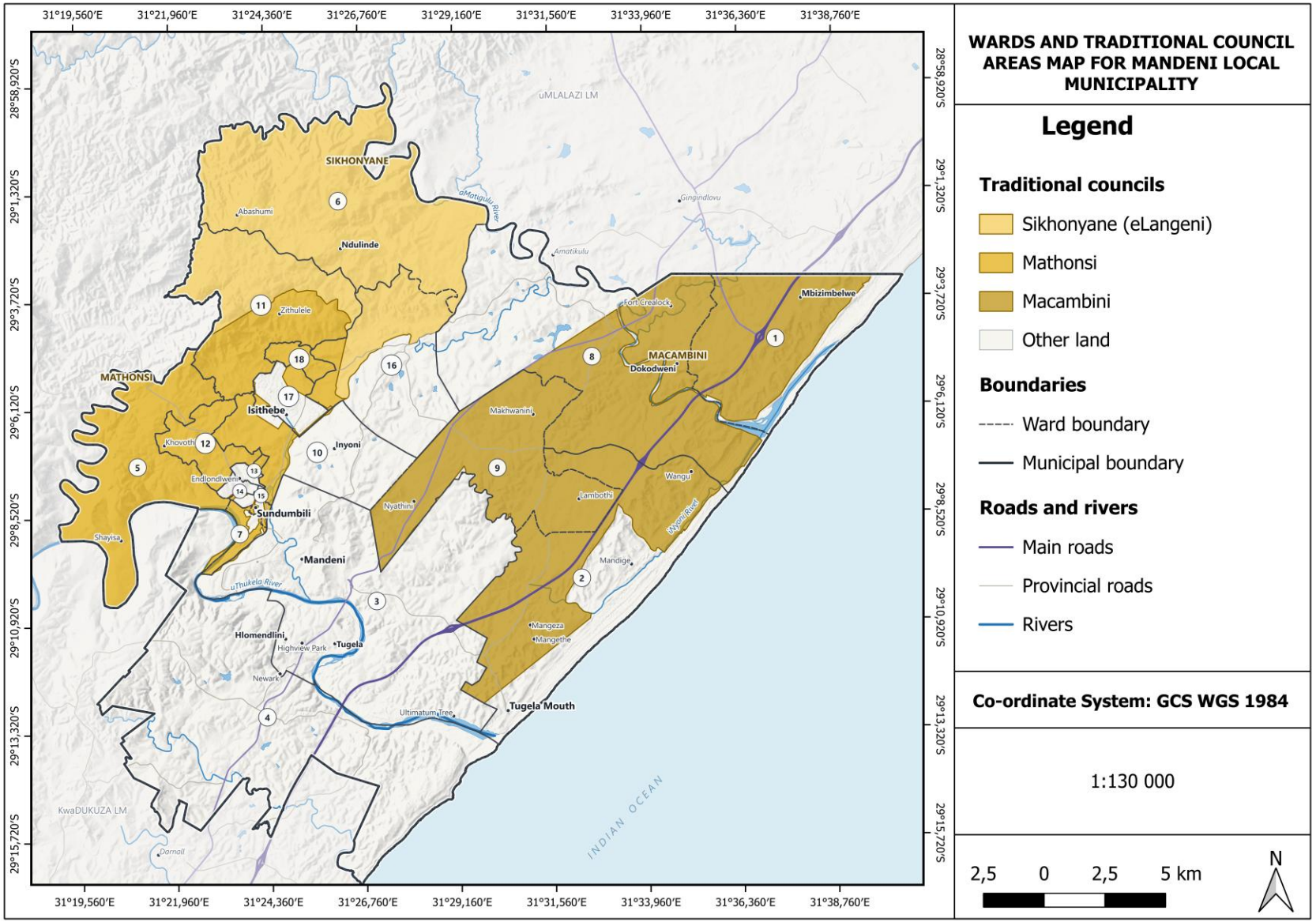

Figure 6: Municipal Wards and Traditional Areas

3. Vulnerability Assessment to Current Climate Hazards

3.1. Analysis of Observed Climate Hazards and Climate-related Pressures

This section explains how current hazards and existing municipal pressures already create vulnerability. It avoids treating climate change as a distant future problem. Current climate risk in Mandeni is multi-hazard and place-specific. Heavy rainfall can become flooding when it meets blocked drainage, undersized culverts, poor stormwater maintenance, illegal dumping or low-lying settlement. Drought becomes more damaging where households rely on communal sources, tankers, springs, streams or boreholes and where sanitation and water quality are weak. Heat becomes a health risk where shade, cooling, water access and public-health messaging are inadequate. Coastal storms become disasters where development is too close to dynamic beaches, dunes and estuary mouths.

Table 4: Observed climate hazards and climate-related pressures

Hazard / pressure	Where it matters	Main impacts
Heavy rainfall, flooding and stormwater failure	All wards, with particular concern in low-lying, poorly drained, bridge/culvert and stormwater-stressed areas.	Road closures, damaged houses, blocked drainage, water contamination, sanitation failure, erosion, business disruption, emergency-access problems.
Coastal erosion, storm surge, sea-level rise and estuary mouth migration	Coastal zone, beaches, dunes, Tugela Mouth, Dokodweni, aMatigulu/iNyoni estuary and coastal access points.	Loss of beach access, damage to recreational infrastructure, erosion, exposed facilities, tourism impacts, unsafe development exposure.
Drought, water scarcity and water-quality stress	Rural and traditional settlements, agriculture, livestock areas, households using unsafe or distant sources.	Reduced water availability, reliance on tankers or unsafe sources, crop/livestock stress, public-health risk.
Extreme heat	Dense settlements, schools, clinics, outdoor work sites, informal dwellings, traditional dwellings, public spaces with low shade.	Heat illness, higher water and electricity demand, occupational stress, fire risk and impacts on children, elderly people and chronically ill residents.
Lightning, hail and strong winds	All wards, with stronger concern in exposed rural settlements, schools, community halls, livestock areas and weak roofing areas.	Roof damage, injuries, powerline damage, livestock loss, school/clinic disruption.
Veld and structural fires	Settlement-vegetation interfaces, sugarcane/agriculture areas, waste-burning areas, rural settlements and industrial interfaces.	House and crop loss, injuries, air-quality impacts, evacuation and response pressure.
Waste, illegal dumping and watercourse pollution	Illegal dumping hotspots, drains, culverts, streams, wetlands, flood-prone roads and areas lacking reliable collection or disposal options.	Blocked drainage, polluted floodwater, disease/vector risks, watercourse degradation, higher clean-up costs and increased fire risk.
Air-quality pressure and emissions exposure	Industrial zones, major transport corridors, waste-burning areas, biomass-burning areas and households using solid or liquid fuels.	Particulate exposure, respiratory risk, odour complaints, worker-health exposure, regulatory risk and greenhouse-gas-relevant-emissions.

3.1.1. Rainfall, flooding and stormwater characteristics

Rainfall-driven flooding is identified as a priority current climate risk for Mandeni. This is because a single heavy-rainfall event can affect several municipal systems at once: roads, bridges, drains, houses, schools, clinics, water quality, sanitation, waste movement, public open spaces and emergency access. The field notes identify poor drainage and flooding in parts of Sundumbili, damage to public infrastructure, dumping near access routes and houses described as located on or near flood-prone land, requiring verification against surveyed flood information. These observations are used to identify how rainfall interacts with existing development and maintenance conditions, subject to confirmation of incident dates, locations and affected assets.

Stormwater risk is closely linked to waste. When plastic, tyres, rubble, organic waste and building material are dumped near roads, drains or streams, the drainage system becomes less effective. During heavy rainfall, dumped waste can block culverts and channels, contaminate floodwater and spread public-health risks downstream. This is why waste management is treated in this report as a climate-risk issue, not only a cleanliness issue. The uThukela is also assessed as a connected catchment: upstream high flows and sediment can affect flood routing, banks, water quality, estuary function and the receiving coastal environment. Coordination of drainage and river-management interventions with the relevant upstream, district and catchment authorities is therefore recommended.

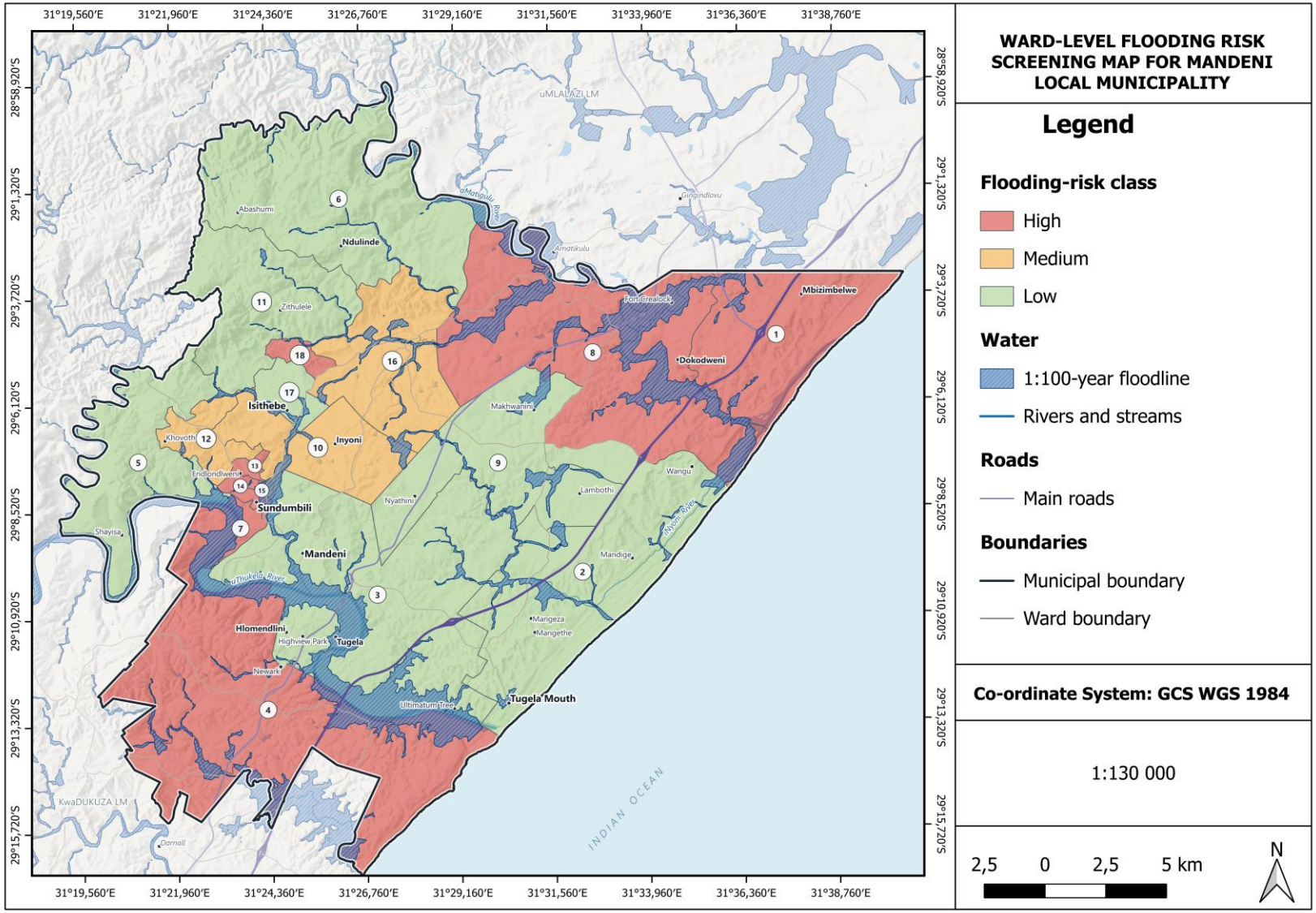

Figure 7: Ward-level Flooding Risk of Mandeni Local Municipality

3.1.2. Temperature, heat and drought characteristics

Heat is less visible than flooding but is a serious vulnerability driver. Heat affects elderly residents, children, persons with disabilities, people with chronic illness, outdoor workers, learners, clinic users, informal traders and workers in industrial, construction, agricultural and transport activities. It can increase demand for water and electricity, worsen air-quality impacts and increase fire risk when vegetation is dry.

Drought and dry periods are also important because many rural households and agricultural activities depend on reliable water availability. Drought can reduce crop production, stress livestock, reduce water quality, increase conflict over water sources and worsen sanitation risks. For Mandeni, heat and drought planning should be connected to rural water services, water-quality monitoring, fire preparedness, agriculture support and public-health communication. The potential ecological effects of low river flows, falling groundwater levels and wetland drying are also considered. These conditions can concentrate pollutants, reduce habitat quality and ecosystem services, and increase vegetation stress and fire susceptibility. Drought preparedness is therefore linked to water-resource and ecological monitoring, invasive-plant and tree-pest surveillance, restoration and fire management; these are potential pathways, not measured local trends.

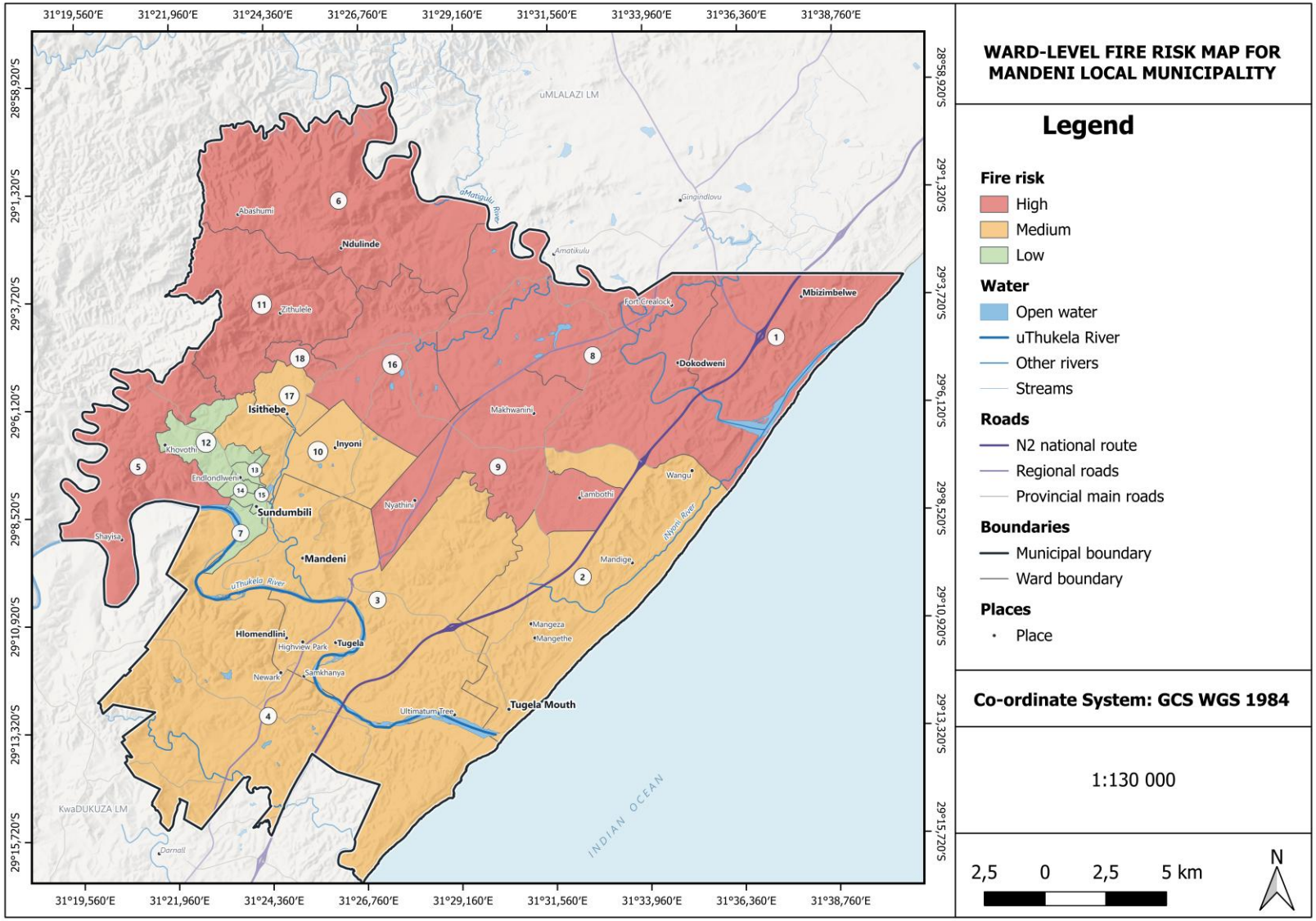

Figure 8: Ward-level fire risk in the Mandeni Local Municipality

3.1.3. Municipal Seasonal Change Calendar

The seasonal calendar below is not meant to predict the weather. It explains when municipal functions should be most alert to certain hazards. It also shows why climate adaptation must be part of routine maintenance and budgeting.

Table 5: Mandeni seasonal climate and disaster-readiness calendar

Period	Main concerns	Municipal preparedness and response measures
Pre-summer and spring	Drainage, culvert and illegal-dumping clean-up; firebreak inspection; early-warning checks.	Inspect and clear priority drains, culverts and channel; remove waste from drainage corridors; confirm shelters and ward contact lists; inspect firebreaks; prepare public communication through Disaster Management, Technical Services, Waste Management and ward structures.
Summer rainfall and storm season	Flooding, lightning, hail, strong wind, heat, water-quality contamination and road closures.	Activate early warnings; monitor low-lying roads and bridges; prepare rapid response for blocked drains; test emergency-shelter readiness; communicate heat, lightning and flood safety messages; record incidents with photographs, GPS points and responsible departments.
Post-storm period	Damage assessment, relief, repairs, clean-ups, water-quality testing and hotspot update.	Undertake joint damage assessments; prioritise repairs to access routes, stormwater and public facilities; remove flood-displaced waste; test affected watercourses where pollution is suspected; update the municipal hotspot register
Dry season	Drought monitoring, fire danger, dust, heat and biomass burning.	Monitor vulnerable water sources; maintain firebreaks; strengthen no-burning and fire-safety awareness; support agricultural and livestock risk communication; plan shade, cooling and water-access measures for schools, clinics and outdoor work sites
Annual IDP and budget cycle	Use incident evidence and the hotspot register to prioritise maintenance, capital projects and community awareness.	Climate risk should affect budget choices, not only environment.

3.2. Qualitative Assessment of Vulnerability Factors

A qualitative assessment is necessary because not all climate risk can be measured with numbers. It is possible to know that a community is highly vulnerable even before a detailed engineering model is available: if houses are close to a river or floodline, drains are blocked, roads are poor, people rely on unsafe water, waste is dumped in channels and residents have limited money to recover, the vulnerability is obvious and should not wait for perfect data.

To strengthen accountability, the event register should be maintained as an interdepartmental evidence base. Disaster Management should record hazard dates, warnings, affected areas and relief actions; Technical Services should record affected roads, culverts, stormwater channels and bridges; Waste Management should record dumping or blocked-drain contributions; Human Settlements should record affected houses and relocation needs; Environmental Management should record watercourse, wetland, estuary and pollution impacts; and iLembe District should provide water-services and air-quality inputs where relevant. It is recommended that at least the previous 12–24 months of records be obtained from Mandeni Disaster Management, the Fire Unit and iLembe District, with source, date, location, impacts, response and verification status retained. The register should be reviewed before the IDP/SDBIP budget cycle.

3.2.1. Extreme Event Records in Mandeni

Mandeni disaster planning documents identify floods, lightning, hail, strong winds, heat, fire, drought, storm surge and related hazards as relevant to the municipality. The Summer Contingency Plan describes Mandeni as prone to multiple summer-season hazards, including floods, lightning, hail, strong winds and heat. The Disaster Management Sector Plan also emphasises that climate change response must be incorporated into disaster contingency planning, land-use planning, infrastructure design and human-settlement decisions.

The draft aMatigulu/iNyoni Estuary Management Plan is used as contextual material and remains unapproved. Separate dated incident records and coastal observations are required to confirm estuary-mouth migration or the closure of Dokodweni Beach associated with a particular flood event. The potential effects of flooding on estuary functioning, coastal access, recreation, tourism and public safety are therefore assessed without attributing those effects to the April 2022 floods on the basis of the draft plan.

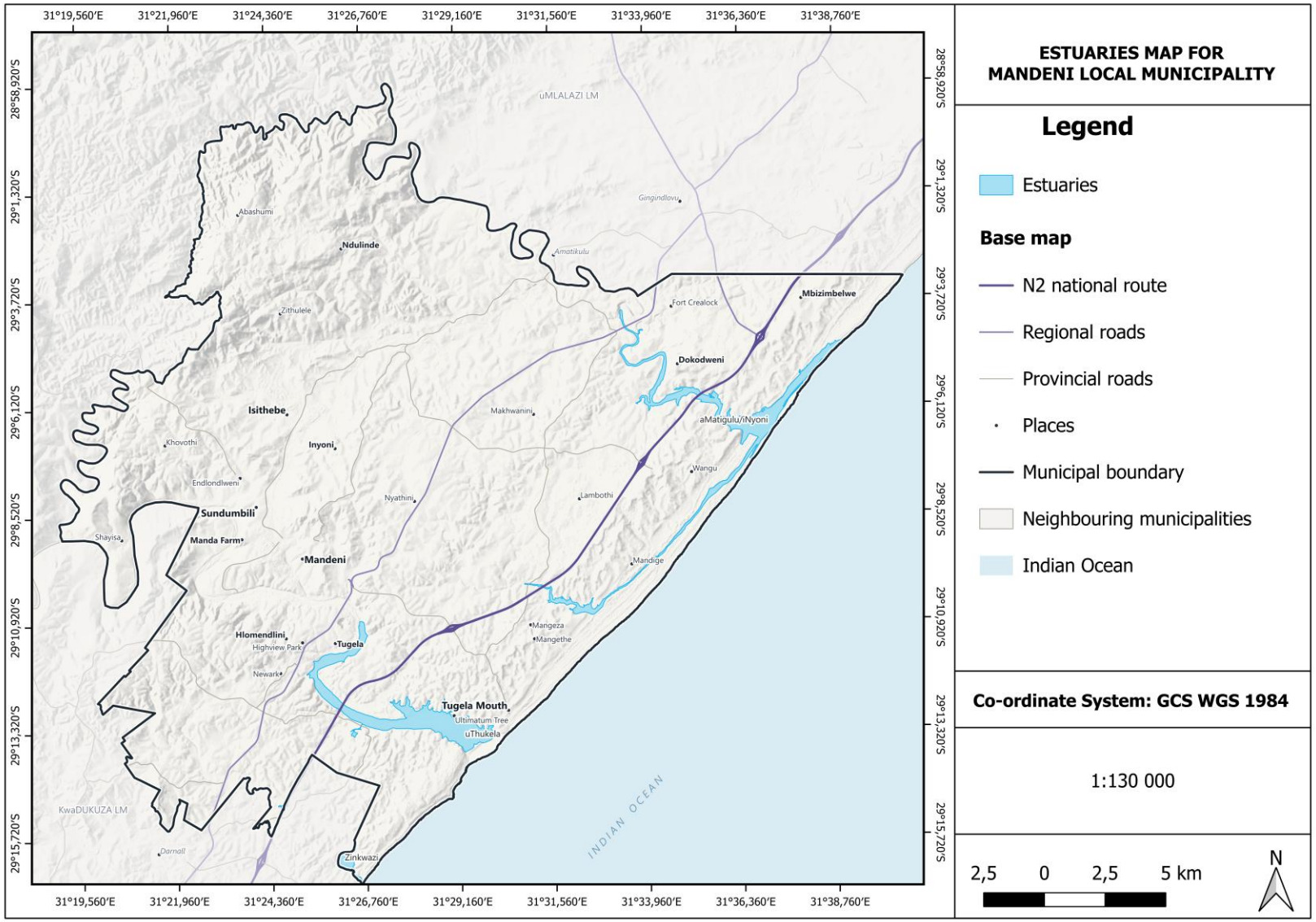

Figure 9: Estuarine functional zones in the municipal coastal context

3.2.2. Analysis of Vulnerability Factors in the Municipality

The main vulnerability drivers in Mandeni are development and service-delivery related. The first driver is settlement location. Houses and community facilities located near floodlines, wetlands, estuaries, steep slopes, drainage channels, unstable banks or coastal dynamic zones are exposed to future damage. The second driver is infrastructure condition. Undersized, blocked or poorly maintained stormwater systems turn ordinary rainfall into local flooding. The third driver is waste management. Illegal dumping, tyres, rubble and waste burning create drainage, public-health and air-quality risks.

The fourth driver is ecosystem degradation. Wetlands, riparian buffers, dunes and estuaries help absorb and slow water, stabilise soil, filter pollutants and protect the coast. When they are degraded, the municipality loses natural risk reduction. The fifth driver is poverty and limited adaptive capacity. A household with low income and weak access to services is less able to recover from flood, fire, wind, heat, drought or disease outbreaks. The sixth driver is governance complexity. In traditional authority areas, adaptation depends on municipal and traditional governance working together.

Relevant environmental legislation has been linked to vulnerability factors to strengthen compliance, enforcement and implementation alignment:

Illegal sand mining should be treated as an additional vulnerability driver where it occurs in river, bank, floodplain or coastal systems. Unauthorised extraction can destabilise banks, deepen or redirect flow paths, increase erosion, damage infrastructure foundations, disturb aquatic habitats, reduce water quality and increase downstream sedimentation. Sites affected by sand mining should be mapped and linked to enforcement, river-health monitoring and infrastructure-risk assessment. A coordinated compliance programme covering routine inspections, complaints, permit and authorisation conditions, and referrals to the competent authorities for dumping, water pollution, sand extraction and encroachment into sensitive areas is recommended. Verification of location, activity and authorisation status is required before identifying an offence or assigning enforcement responsibility.

Table 6: Legislative instruments relevant to climate risk planning, compliance and enforcement

Legal instrument	Climate-risk relevance for Mandeni	Planning and enforcement implication
Climate Change Act, 2024	The commenced climate-response provisions are applied to reduce vulnerability, strengthen adaptive capacity and support mitigation planning, subject to the exclusions described in Section 1.1.	It is recommended that adaptation and mitigation screening be integrated into IDP, SDF, LUMS, disaster, waste, water and LED processes, in coordination with iLembe District and the Province. Reporting duties must reflect the provisions in force.
National Environmental Management Act (NEMA)	Provides environmental management principles, including sustainable development, precaution and pollution prevention.	Use environmental screening and authorisation requirements to prevent new exposure in sensitive or high-risk locations.
National Water Act (NWA)	Protects water resources, watercourses and regulated water-use activities.	Link floodlines, wetlands, riparian buffers, illegal sand mining and water-quality monitoring to compliance and enforcement actions.
National	Regulates waste management, illegal	Treat dumping hotspots as flood, fire,

Legal instrument	Climate-risk relevance for Mandeni	Planning and enforcement implication
Environmental Management: Waste Act (NEM:WA)	dumping and waste disposal.	water-quality and public-health risks, and align enforcement with the IWMP.
National Environmental Management: Air Quality Act (NEM:AQA)	Regulates air-quality management, atmospheric emissions and AEL/NAEIS reporting.	Use air-quality and emissions data for industrial, transport, waste-burning and biomass-burning risk screening.
Disaster Management Act	Requires integrated disaster risk reduction, preparedness, response and recovery.	Use incident records and early-warning systems to inform ward hotspot validation, seasonal preparedness and budget priorities.
SPLUMA and municipal LUMS	Guide spatial planning and land-use decision-making.	Avoid approval of new development in flood-prone, coastal, wetland, estuary and high-risk infrastructure areas unless risk is technically assessed and managed.

3.2.3. Gender-related Vulnerabilities

Gender-related vulnerability is not only about counting women and men. It is about understanding who carries the consequences of a climate event. During floods or water shortages, women and caregivers may carry additional care and water-security responsibilities. Children may miss school because roads are flooded, bridges are damaged or homes are affected. Elderly people and persons with disabilities may struggle to evacuate or reach clinics. Informal traders and SMMEs may lose income when roads, markets or CBD areas are disrupted.

Outdoor workers, farm workers, construction workers, waste workers, traffic workers, lifeguards and informal traders are more exposed to heat, wind, lightning and poor air quality because much of their work takes place outside. Rural households and small-scale farmers may also face higher climate sensitivity because livelihoods depend on water availability, land condition, livestock health and road access. It is recommended that Disaster Management and Human Settlements, with iLembe water-services support, address accessible warnings, evacuation, shelter privacy and sanitation, caregiver needs and continuity of safe water. The recommended approach also includes recording reach and outcomes by sex, age and disability where appropriate, with protection of personal information, and linking the measures to departmental budgets and the monitoring framework in Section 5.2.10.

3.2.4. Risk Mapping of Vulnerable Locations

The risk maps uploaded for this assessment materially improve the report because they move the analysis from general statements to location-based interpretation. The flooding and fire maps provide ward-level screening evidence; hail, lightning and strong-wind exposure requires validation against incident records. The biodiversity, protected-area, rivers, wetlands, housing, water infrastructure and land-use maps show where hazards interact with sensitive land uses and vulnerable services.

Mandeni can be read through four vulnerability clusters. The first is the coastal and estuary cluster, including Tugela Mouth, Dokodweni, Mbizimbelwe, the aMatigulu/iNyoni system and coastal traditional authority areas. Here the key concerns are coastal erosion, storm surge, estuary mouth migration, coastal access, tourism safety and development controls. The second is the Mandeni-Sundumbili-uThukela corridor, where the main concerns are flooding, stormwater, waste, roads, housing, public facilities and dense settlement. The third is the Isithebe-SAPPI industrial and logistics cluster, where climate risk includes air quality, emissions, flooding, heat, energy and business continuity. The fourth is the rural and agricultural cluster, where water access, fire, lightning, road access, agricultural resilience, traditional land allocation and service backlogs are central.

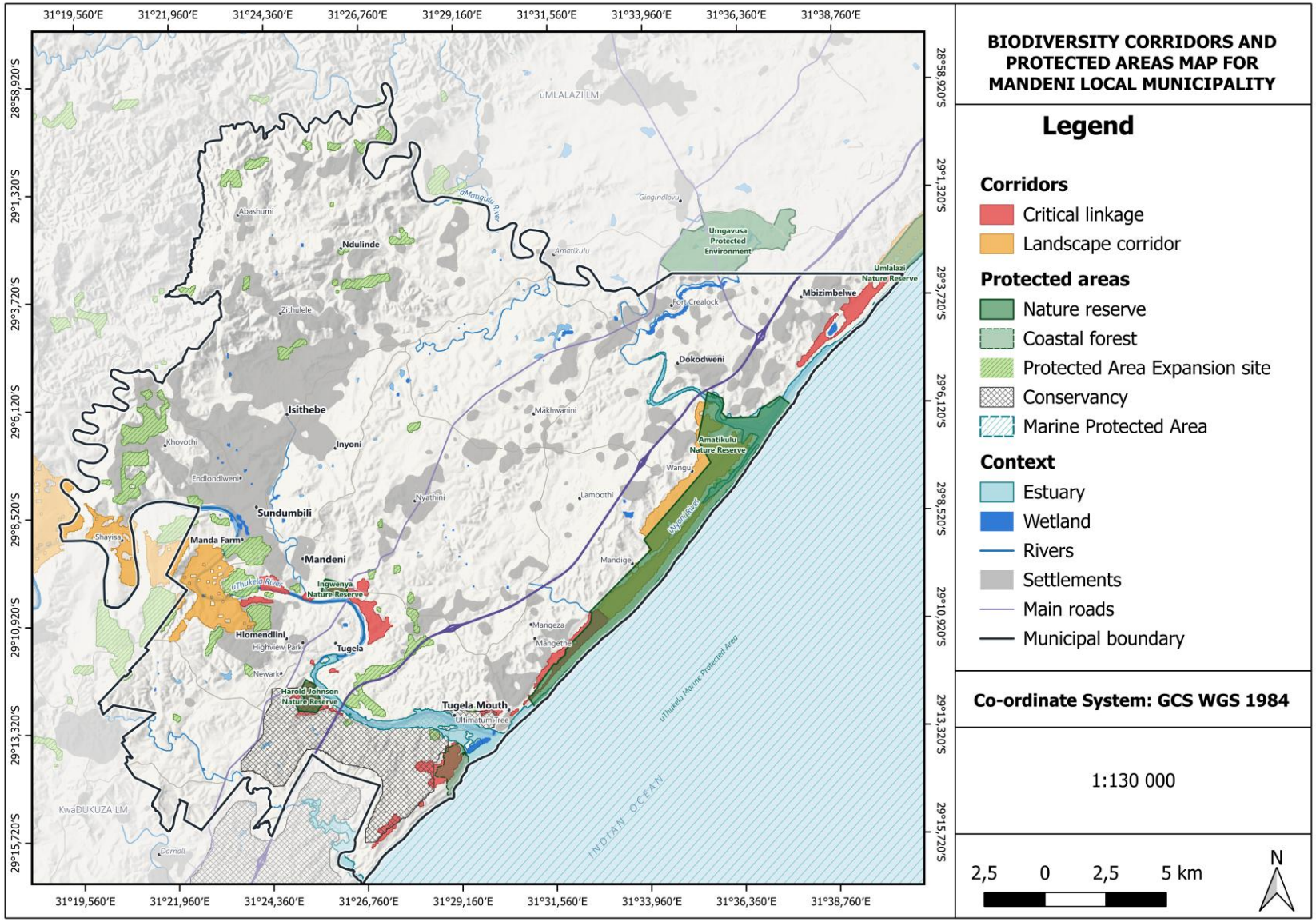

Figure 10: Protected areas, wetlands, environmentally-sensitive areas and conservation corridors in the Mandeni Local Municipality

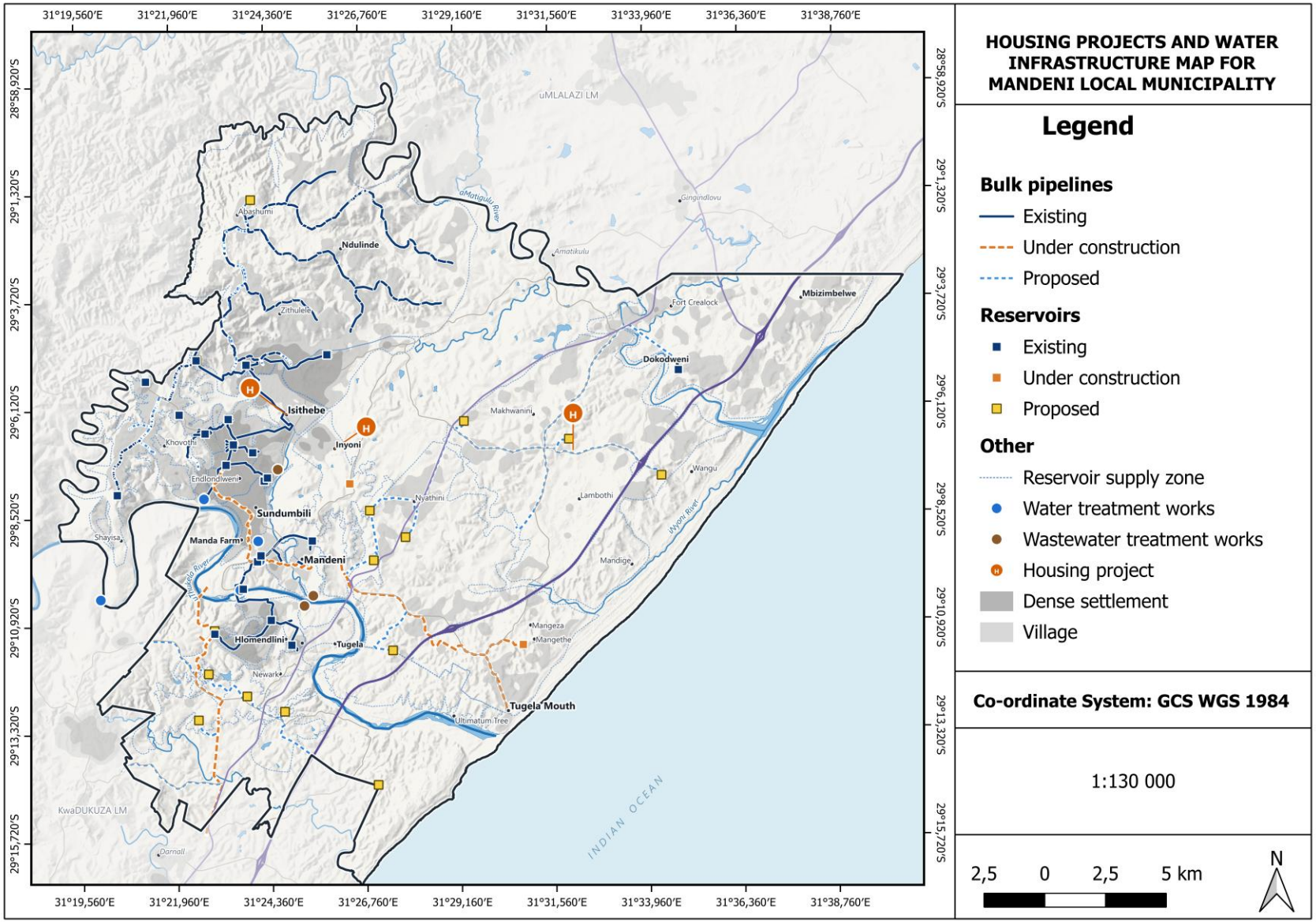

Figure 11: Housing projects and water infrastructure in the Mandeni Local Municipality

3.2.5. Assessing Community Functions using Matrix of Function

The Matrix of Function approach asks what happens to ordinary community life when a climate hazard occurs. In Mandeni, the most climate-sensitive functions are access to safe water, household sanitation, road access, school attendance, clinic access, waste removal, electricity, emergency response, informal trading, agriculture, coastal recreation and public facilities.

A flood does not only wet the ground. It can close a road, stop a learner from reaching school, delay an ambulance, damage a fence or bridge, contaminate water, spread waste, disrupt a market, increase municipal clean-up costs and reduce household income. A heatwave does not only increase temperature. It can raise water demand, worsen respiratory health, increase electricity demand and affect outdoor work. This functional understanding is important because it shows why climate risk belongs in municipal budgeting, not only in environmental reporting.

3.2.6. Prevailing Climate Change Hazards and their associated Impacts on Economic Sectors

Manufacturing and industry are important to Mandeni, especially SAPPI Tugela Mill and the Isithebe Industrial Estate. These facilities create employment and economic value, but they also face physical risks from flooding, water stress, heat, energy interruptions and logistics disruption. They also create transition and emissions-related risks as air-quality control, greenhouse-gas reporting, energy costs and low-carbon expectations become more important. This constitutes emissions-source screening, not a completed greenhouse-gas inventory or forecast. Ambient air pollution is assessed separately from greenhouse-gas accounting; verified operator activity data, inventory boundaries, a base year and emission factors are required for the inventory work described in Section 5.3.

Agriculture is vulnerable to drought, heat, extreme rainfall, erosion, pests, fire and changes in water availability. Sugarcane and other agricultural systems may be affected by both too little water and too much water. Smallholders and livestock owners are more vulnerable where extension support, water access, fire protection and road access are limited.

Tourism and coastal recreation depend on safe beaches, accessible roads, stable dunes, estuary health and attractive landscapes. Coastal erosion, storm surge, estuary mouth migration, polluted water and damaged access routes can directly reduce tourism value. The aMatigulu/iNyoni and uThukela systems therefore need to be treated as climate-sensitive economic assets, not only ecological features.

Waste, retail and informal economic activity are also vulnerable. Illegal dumping and repeated clean-ups are already visible. If waste systems do not improve, heavy rainfall will move waste into drains and watercourses, increasing flood damage, health risk and repair costs. Informal traders and SMMEs are vulnerable to flooding, heat, poor air quality and road closures because a single disruption can affect daily income.



Figure 12: SAPPI Tugela Mill

Industrial activity is assessed for physical climate risks, air-quality exposure and transition risk.

3.2.7. Screening-level Ranking of Vulnerable Sectors and Systems

The ranking below is screening-level and is intended to guide focus, not to replace detailed engineering, financial or environmental studies. The sectors ranked highest are those where several factors overlap: recurring hazard exposure, number of people or services affected, likely consequences for municipal functions, evidence from maps or field observations, and limited capacity to prevent or recover from the impact.

Table 7: Screening-level sector vulnerability ranking

Priority	Sector or system	Why it is highly vulnerable
1	Stormwater, roads, bridges and drainage	Heavy rainfall, blocked drains, road closures and repeated repair costs can affect the whole municipality.
2	Settlements and housing	Houses in flood-prone areas and poor drainage increase displacement and damage risk. Informal dwellings and traditional dwellings are assessed separately, according to construction condition, hazard location and access to services.
3	Waste management and watercourses	Illegal dumping and weak enforcement increase flooding, pollution, disease and fire risks.
4	Coastal and estuary systems	Storm surge, erosion, sea-level rise and estuary mouth migration affect safety, ecosystems and tourism.

Priority	Sector or system	Why it is highly vulnerable
5	Water, sanitation and public health	Drought, floods and pollution affect safe water, sanitation, disease exposure and clinic demand.
6	Agriculture and rural livelihoods	Drought, heat, fire, erosion and extreme rainfall affect crops, livestock, soil and income.
7	Industry, air quality and logistics	Industrial emissions, road corridors, heat, floods, energy transition and worker health create combined risks.
8	Tourism, SMMEs and informal trade	Road closures, beach safety, polluted water, flooding and heat can reduce income and visitor value.

The ranking is therefore a screening-level prioritisation. It must be validated through ward-level engagement, incident records and departmental asset information before it is converted into project budgets or engineering designs. Table 7 is retained as a relative sector planning order. In Table 8, the likelihood and consequence method in Section 1.6 is applied separately to hazard and receptor combinations over an approximately five-year planning horizon. L and C are ordinal professional judgements, and the product is a screening priority rather than an event probability.

Table 8: Provisional hazard and receptor screening priorities

Hazard and receptors	L	C	L × C / rating	Validation priority
Rainfall flooding: settlements, drainage and access	3	3	9 — High	Confirm recurrence, exposed assets and hydraulic constraints.
Waste obstruction and polluted runoff during storms	3	3	9 — High	Confirm current hotspots, drainage links and water quality.
Coastal inundation, erosion and estuarine change	2	3	6 — High	Verify event extents, coastal processes and affected assets.
Drought: water services, agriculture and ecosystems	2	3	6 — High	Check source reliability, demand and incident history.
Heat: people and public or work facilities	3	2	6 — High	Verify heat-health outcomes and facility conditions.
Vegetation and interface fires: settlements and livelihoods	2	3	6 — High	Obtain georeferenced Fire Unit records and response constraints.
Lightning, hail and wind: roofs, facilities and work areas	2	2	4 — Medium	Confirm vulnerable structures and event severity.
Climate disruption of industrial and logistics dependencies	2	3	6 — High	Check operator exposure, continuity plans and critical routes.

Low-to-moderate confidence is assigned separately from the ratings because local incident and asset records are incomplete. These are provisional screening judgements: missing data do not justify a Low rating, Medium does not remove the need to prevent serious harm, and overlapping receptor losses must not be double-counted. Ward and technical validation are required before costing site-specific projects. The score bands are Low 1–2, Medium 3–4 and High 6–9.

3.3. Waste system Climate Vulnerability and Mitigation Evidence from the IWMP

The 2021 IWMP is the most detailed available municipal source on waste generation, service coverage, collection, infrastructure, illegal dumping, recycling, staffing and finance. It was designed for the 2019-2024 period and relies mainly on 2016-2019 data. It must therefore be used as a historical screening baseline rather than a statement of current 2026 performance. This distinction is important for the Climate Change Act requirement to use the best available science, evidence and information: older evidence remains valuable when its date, uncertainty and limitations are explicitly recorded (GIBB, 2021).

Waste vulnerability in Mandeni is driven by both service access and physical exposure. The IWMP recorded that 34.81% of households had access to a basic service in 2016, while 65.2% did not and 58.54% used their own refuse dump. It separately estimated that only 17.6% of theoretical 2019 domestic waste generation was represented in formal collection and disposal data. These indicators use different denominators and must not be treated as interchangeable, but together they provide a strong screening signal that a substantial amount of waste may be unmanaged, burned, buried, dumped or missing from municipal records. Under heavier rainfall, such waste can obstruct drains and culverts, be transported into rivers and estuaries, and contaminate floodwater; under heat and dry conditions, organic waste decomposes faster and open burning or waste fires become more damaging (GIBB, 2021). Regular waste-minimisation, source-separation, recycling and anti-burning engagement with businesses, informal traders and taxi associations at commercial centres, markets and taxi ranks is recommended. Waste Management should coordinate with Communications and Public Safety; tracking participation, collection reliability and hotspot recurrence alongside the IWMP measures is recommended.

The table below converts the principal IWMP findings into climate-risk, mitigation and implementation implications. Quantities are historical planning values and must be remeasured before they are adopted as statutory baselines or used to claim greenhouse-gas reductions.

Table 9: IWMP climate risk, mitigation and implementation evidence

IWMP evidence and confidence	Climate-risk interpretation	Climate Change Strategy / Act-readiness implication
Data age and quality: the plan is dated 2021, intended for 2019-2024 and uses mostly 2016-2019 data. The characterisation sorted 152.18 kg in one day and was assigned about 70% confidence. A municipal WIS and direct SAWIS reporting were absent.	Current waste generation, service coverage and emissions cannot be inferred reliably without new measurement. Data weakness reduces adaptive capacity and creates reporting risk.	Undertake a representative 12-month baseline; create a WIS; reconcile SAWIS, invoices and weighbridge records; record data source, date, uncertainty and responsible official.
Service coverage: 34.81% of households received a basic service in 2016; 65.2% did not; 58.54% used an own refuse dump.	Rural and traditional-authority households have greater exposure to dumping, burning, polluted runoff and post-storm service delays. This is an equity and public-health vulnerability.	Prioritise service expansion using hazard, poverty, road-access and dumping-hotspot overlays rather than uniform expansion alone; track reliable service by ward.
Collection mass: 25,239.9 t/year was estimated for 2019, while 4,443.6 t/year was annualised from six months of disposal data - 17.6%. The implied uncollected or unaccounted quantity was	The gap suggests a potentially large unmanaged-waste burden, but also reflects weak records. Both conditions increase flood, fire, health and governance risk.	Weigh and code every load by origin, waste type and destination; distinguish generated, collected, diverted, treated, exported and disposed quantities.

IWMP evidence and confidence	Climate-risk interpretation	Climate Change Strategy / Act-readiness implication
about 20,796.3 t/year, but the report calls for verification.		
Organic waste: 36.7% of the sampled domestic stream, approximately 9,263 t/year in the 2019 theoretical baseline, including 30.3% food and 6.4% garden waste.	Biodegradable waste drives landfill methane, odour and leachate and becomes a stronger nuisance and health risk during hot weather or delayed collection.	Phase in green-waste chipping/composting and large-generator food-waste diversion; use historical disposal series and IPCC methods to quantify methane.
Mainstream recyclables: 39.2%, approximately 9,894 t/year. Organics plus recyclables equal a theoretical 75.9% of domestic waste.	Plastic, paper, glass and metals contribute to drain blockage, river and coastal litter, but also provide avoided-disposal, circular-economy and green-job opportunities.	Introduce source-separation pilots, drop-off/buy-back capacity, agreements with private recyclers and formal support for reclaimers; report tonnes recovered by material.
Nappies were 18.1%, while actual hazardous and health-care-risk waste was 1.39%. Later broad tables appear to combine these categories and overstate hazardous waste.	Nappies require reliable containment and collection for health reasons, but incorrect classification would distort facility design, cost and GHG accounting.	Correct the classification before target setting; separately manage household hazardous waste, e-waste, oils, lamps, batteries and health-care-risk waste.
Illegal dumping and burning: mapped hotspots included the R102, Kwasithebe, Sundumbili, Mandeni and wards 13-14. Dumping recurred after clean-up; waste burning was observed in and next to skips.	This is a compound flood, water-quality, vector, air-quality and fire risk. Clean-up without service, access and enforcement changes produces repeated loss.	Maintain a GPS hotspot and recurrence register; overlay drains, rivers, wetlands, flood zones and sensitive facilities; implement a zero-burning protocol and incident log.
Infrastructure and fleet: 108 skips were recorded, 13 worn out; the ward table listed no skips in wards 13-15 despite a narrative claim that all wards were served. The fleet comprised three compactors and one utility vehicle, with no replacement plan or dedicated backup.	Inconsistent asset data, vehicle breakdowns, flooded roads and full skips can interrupt collection and intensify dumping, burning and stormwater blockage.	Verify all assets in GIS; climate-screen skip and facility locations; prepare backup-vehicle, alternative-route, storm and fire-contingency arrangements.
Disposal and industrial system: municipal waste travelled roughly 80 km one way to the King Cetshwayo facility; the iSithebe transfer-station shelter had burnt down and the site was reported outside permit requirements. A partial industrial survey quantified over 14,200 t/year, with two generators representing about 91% of reported mass.	Long-haul disposal raises fuel emissions and exposure to road closure and fuel-price shocks. Transfer-station workers and informal reclaimers face heat, storm, fire and occupational risk. A small number of industrial generators provide high leverage for circular action.	Compare disposal options on full cost, carbon, compliance and route resilience; climate-proof the transfer station; conduct material-flow studies and an iSithebe industrial-symbiosis programme.
Institutional and financial capacity: only 8 of 31 earlier targets were complete, 4 were in progress and 19 had not	Implementation and finance constraints are core adaptive-capacity limitations. Unfunded targets and weak ownership	Assign an owner, budget, deadline and indicator to each action; verify and escalate historical cost estimates;

IWMP evidence and confidence	Climate-risk interpretation	Climate Change Strategy / Act-readiness implication
commenced. Missing items included a WMO, WIS, SAWIS reporting, annual monitoring, composting and a drop-off centre. Historical backlog estimates were R11.694 million capital plus R1.664 million per year operating expenditure.	create repeated clean-up and emergency costs.	integrate actions into the IDP/SDBIP and publish annual progress.

Using the IWMP screening quantities, recovering 25% of organics and 25% of mainstream recyclables would divert about 4,789 tonnes per year (19.0% of the 2019 theoretical stream). Recovering 50% of organics and 25% of recyclables would divert about 7,105 tonnes per year (28.2%), while 50% recovery of both would divert about 9,579 tonnes per year (38.0%). These are material-flow scenarios, not calculated greenhouse-gas reductions. Avoided emissions must be assessed against the actual treatment route, transport, contamination and landfill conditions (GIBB, 2021).

Data corrections required before statutory or investment use include: separating nappies from hazardous waste; treating the 2020-2023 quantities in IWMP Table 28 as annual rather than weekly values; reconciling the different organic-waste totals; recalculating garden-waste diversion targets; and resolving the SAWIS disposal figures that greatly exceed the domestic generation estimate. The revised baseline should retain an uncertainty log so that decision-makers can distinguish verified data from assumptions (GIBB, 2021).

3.4. Screening-level Vulnerability Assessment: Available Indicators and Limitations

3.4.1. Description of Screening-level Vulnerability Methodology

A full statistically defensible ward-level vulnerability index requires current GIS layers, updated socioeconomic data, asset-condition information, incident logs and climate hazard layers. Those datasets were not all available in a consistent form. The assessment therefore uses a screening-level vulnerability method based on three dimensions: exposure, sensitivity and adaptive capacity. This is consistent with accepted vulnerability-assessment practice and allows Mandeni to identify where more detailed analysis is required before projects are designed or costed. If a ward-level index is commissioned, the recommended procedure is to document indicator definitions and reference years, reconcile boundaries, intersect verified hazard and receptor layers, and record missing data. Any normalisation and weighting should be stated and tested for sensitivity before technical and community validation; no current numerical ward index is calculated here.

Table 10: Vulnerability indicators used for the screening assessment

Dimension	Indicators considered
Exposure	Flood and fire risk maps, recorded wind, lightning and hail hazards, coastal and estuary location, rivers and wetlands, roads and bridges, housing projects, industrial areas and agricultural land.
Sensitivity	Poverty, unemployment, construction and service conditions in informal dwellings and, separately, traditional dwellings, weak drainage, poor road access, water and sanitation limitations, waste hotspots, degraded wetlands and reliance on climate-sensitive livelihoods.
Adaptive	Access to services, waste collection, disaster preparedness, enforcement capacity,

Dimension	Indicators considered
capacity	early warning, municipal maintenance, traditional-authority coordination and availability of technical studies.

3.4.2. Results of Screening-level Vulnerability Assessment

The screening assessment indicates that Mandeni has no single vulnerability hotspot. Instead, it has several types of high vulnerability. Coastal and estuary wards are vulnerable because physical exposure is high and development decisions can lock in long-term risk. Urban and semi-urban wards around Mandeni and Sundumbili are vulnerable because drainage, dense settlement, waste accumulation and public infrastructure are exposed to flooding and heat. Rural traditional authority wards are vulnerable because of water access, road access, fire, lightning, agriculture and land-use governance. Industrial areas are vulnerable because of air-quality exposure, emissions, energy demand, stormwater and business-continuity concerns.

The results are used to prioritise ground-truthing. During the Strategy phase, priority locations should be validated by ward, GPS point, affected asset, responsible department and required action, using current building and asset records, incident points and service information. Preparation of the proposed first 20 sites for review with ward committees, traditional leaders and affected communities is recommended, with retention of a correction log and technical sign-off before confirming the list or costing works. This includes floodline confirmation, culvert and stormwater condition assessment, illegal dumping hotspot mapping, water-quality testing, coastal erosion monitoring, estuary mouth migration records, public facility risk screening and industrial emissions or energy-use proxy data.

3.4.3. Site Evidence: What the Field Photographs mean for Climate Risk

The site photographs are used to identify observed conditions requiring assessment. The images show coastal exposure, water-edge conditions, dark water, dumped waste, tyres and rubble, disturbed land and industrial activity. The potential climate-risk pathways are interpreted below; the photographs alone do not establish contaminant concentrations, long-term erosion rates or the recurrence of an event.



Figure 13: Coastal beach and dune exposure

Figure 13 shows coastal beach and dune exposure, including exposed roots and water-edge conditions. Storm surge, sea-level rise, heavy rainfall and estuary dynamics can further weaken dunes and banks. Checks of coastal access, tourism facilities and new development against coastal buffers, dune condition, estuary boundaries and coastal setback information are therefore recommended before investment decisions are made. The supplied photograph caption does not record a date, ward or GPS coordinates; location verification and coastal-process assessment are required before attributing a long-term erosion trend.



Figure 14: Watercourse requiring water-quality investigation

Figure 14 shows dark water and visible waste material. Heavy rainfall and flooding can transport contaminants downstream, exposing residents and ecosystems to harm and increasing clean-up costs. Recording the site for water-quality, stormwater and public-health investigation is therefore recommended, with follow-up sampling and referral to the competent authority where a pollution source or non-compliance is established.



Figure 15: Illegal dumping despite no-dumping signage and skips

Figure 15 shows dumped waste near a no-dumping sign and skip infrastructure. Waste can be washed into drains, culverts and watercourses during heavy rainfall, increasing local flooding, polluted floodwater, vector breeding and fire risk. Recurrence monitoring, enforcement, collection-service review, community engagement and linkage to the IWMP hotspot programme are therefore recommended.



Figure 16: Tyre and rubble dumping

The photograph shows tyre, rubble and mixed waste dumping. Tyres can hold water and create mosquito-breeding conditions; rubble and tyres can block drainage channels; and burning tyres produces harmful smoke and greenhouse-gas-relevant emissions. Tyre and rubble hotspots are therefore assessed as combined waste, drainage, fire, air-quality and public-health risks.

4. Assessing Future Climate Change Risk

4.1. Future Climate Maps

This chapter summarises what the CSIR GreenBook climate-hazard screening indicates for Mandeni. The approximately 8 x 8 km climate grids used for some indicators are distinguished from catchment indices and settlement exposure classes; the layers do not all use the same resolution, units or reference periods (CSIR, 2019; Engelbrecht, 2019; Beraki, 2019). This is useful for a municipal vulnerability assessment because it identifies pressures relevant to current and future risk. It should not be used on its own to approve or reject a specific development application, confirm a statutory floodline, design a culvert, or determine a coastal setback. Those decisions still require the correct technical studies.

For Mandeni, the maps must be interpreted together with the municipal evidence already discussed in Chapter 3: ward-level hazard maps, the Disaster Risk Management Sector Plan, the SDF and LUMS, the Integrated Waste Management Plan, the Coastal Management Programme, field notes, and site photographs. The mapped hazard and exposure indicators are interpreted alongside the municipal documents and supplied site evidence to assess local vulnerability.

A low or moderate modelled exposure rating does not automatically mean low real-world risk. A place can become highly vulnerable if it has blocked drains, illegal dumping, poor road access, weak stormwater infrastructure, settlement in flood-prone land, poor sanitation, limited water supply, or sensitive coastal and estuary conditions. The maps are therefore interpreted as screening evidence, with local vulnerability and the limitations of each layer considered explicitly.

4.2. Climate Projections

4.2.1. Heat Extremes and Heat Stress

For baseline heat conditions, the GreenBook defines a very hot day as a day on which maximum temperature exceeds 35°C. A heat-wave day occurs when maximum temperature exceeds the average maximum temperature of the warmest month at that location by at least 5°C for at least three consecutive days. The very-hot-day and heatwave-day scales are interpreted as annual day counts, not temperatures or numbers of heatwave episodes; 35°C is the threshold used to define a very hot day (Engelbrecht, 2019). These indicators show the frequency of conditions that can affect health, learning, outdoor work, household comfort, water demand and electricity demand (CSIR, 2019).

The mid-century GreenBook screening classifies the potential increase in heat exposure of the main mapped Mandeni–Sundumbili footprint as Low. This classification is interpreted alongside the technical study's 2021–2050 projections relative to 1961–1990, including the low-mitigation Representative Concentration Pathway (RCP) 8.5 (Engelbrecht, 2019). Built-up areas such as Mandeni town, Sundumbili and Isithebe require particular attention because hard surfaces, dense development and limited shade can amplify the regional climate signal. Even a lower screening class can translate into serious impacts for outdoor workers, learners in hot classrooms, older people, people with chronic illness and households without cooling options (CSIR, 2019).

Treating heat as a public-health and service-delivery issue is therefore recommended. The Climate Change Strategy should screen clinics, schools, old-age support services, public buildings, informal trading areas, taxi ranks, factories and outdoor worksites for heat exposure. Tree cover, shaded public spaces, cool roofs, ventilation, reliable water access and heat-warning communication are practical adaptation measures. Heat risk also affects labour productivity in agriculture, construction, municipal maintenance and industrial operations.

4.2.2. Wildfire and Fire Danger

The GreenBook current-fire indicator represents the likelihood of wildfire at the wildland-urban interface, where developed land meets fire-prone vegetation. In Mandeni this is relevant to rural settlements, sugarcane and forestry areas, grassland edges, road reserves and peri-urban settlement interfaces. The GreenBook signal should be read together with the ward-level fire-risk map and local information on vegetation, burning, road access and response capacity (CSIR, 2019).

For mid-century, the GreenBook reports projected fire-danger days for 8 x 8 km grid cells under RCP 8.5 and identifies settlements where wildfire exposure may increase. A fire-danger day is defined using the McArthur fire-danger index, with values above 24 indicating dangerous fire-weather conditions. The screening therefore points to a growing planning concern, but actual losses will depend on land management, firebreaks, settlement layout, emergency access, response time, illegal dumping and biomass burning (CSIR, 2019).

Future fire-risk management is linked to rural settlement planning, firebreak maintenance, vegetation management, sugarcane and forestry practices, emergency access and public awareness. Fire risk also has an air-quality dimension. Burning vegetation, sugarcane residue, waste and tyres worsens respiratory exposure and adds to greenhouse-gas and particulate emissions. This connects the fire-risk discussion to the air-quality and waste findings in the report.

4.2.3. Drought and Water Stress

The GreenBook drought indicator describes changes in drought tendency relative to the 1986-2005 baseline. For the 1995-2024 period, increasingly negative values indicate a stronger drought tendency relative to that baseline. A model published in 2019 is not interpreted as an observed Mandeni drought record through 2024 (Beraki, 2019). This is relevant to Mandeni because drought affects not only farming, but also rural water supply, household hygiene, sanitation, livestock, vegetation condition, fire danger, estuary freshwater inflow and water-dependent economic activity (CSIR, 2019).

For the 2035-2064 period, the GreenBook screening indicates a stronger drought tendency under the RCP 8.5 scenario and identifies settlements where exposure to increasing drought may rise. The planning concern is greatest where households depend on communal systems, boreholes, rivers, springs, tankering or other vulnerable sources, and where sugarcane, small-scale farming and livestock depend on reliable water availability (CSIR, 2019).

Drought is therefore treated as a water-security, public-health, livelihood and ecosystem risk. Rural wards, traditional-authority areas and farming areas require source protection, water conservation, leak reduction, emergency water planning, wetland and riparian protection, and

support to farmers. Reduced freshwater inflow can also change estuary salinity, water quality and ecological functioning. Where prolonged low flows and wetland drying occur, aquatic habitats, pollutant dilution and ecosystem services may deteriorate, while vegetation stress can increase fire and invasive-species pressures. Coordination of water-resource, biodiversity, restoration, fire and public-health measures is therefore recommended.

4.2.4. Extreme Rainfall and Inland Flooding

The GreenBook current-flood indicator is a flood-hazard index for quinary catchments that intersect the municipality. It is derived from catchment characteristics and design rainfall and is averaged at catchment scale. The index is useful for broad screening, but it does not represent a surveyed floodline and cannot show every blocked culvert, dumping hotspot, damaged drain, eroded channel or undersized crossing (CSIR, 2019).

The mid-century GreenBook screening compares future extreme daily rainfall with current rainfall at an 8 x 8 km grid scale; values above 1 indicate an increase in extreme rainfall. It also identifies settlements that may face increased urban-flood exposure under RCP 8.5. In Mandeni, the most serious consequences are likely where heavier rainfall intersects with blocked drains, informal dumping, weak roadside drainage, low-lying settlement, floodplain occupation and public infrastructure close to rivers or wetlands (CSIR, 2019).

Flood risk is assessed through rainfall, maintenance, waste management, land use and infrastructure condition. Field observation record discoloured watercourses, dumping despite signage, tyre and rubble dumping, and reported drainage-related flooding in parts of Sundumbili; water-quality sampling is required to confirm contamination. Under more intense rainfall, these conditions can worsen local flood impacts. Drain and culvert maintenance, floodline enforcement, wetland protection and dumping control are therefore core climate-adaptation measures.

4.2.5. Coastal Flooding

The GreenBook coastal-flood screening identifies coastal areas and settlements that may be exposed to coastal flooding now and under future climate conditions. For Mandeni, the signal is most relevant to low-lying coastal and estuarine settings around Tugela Mouth, Dokodweni, the aMatigulu/iNyoni system, coastal access points, tourism areas and infrastructure close to the shoreline or estuary margins. The screening is a prompt for detailed investigation rather than a site-specific inundation boundary (CSIR, 2019).

The practical meaning for Mandeni is that coastal flooding cannot be separated from estuary and river management. Coastal storms, sea-level rise, estuary-mouth migration, high river flows and intense rainfall can occur together. When these processes overlap, water may back up in estuaries and low-lying areas, affecting roads, tourism facilities, houses, sanitation systems, public safety and emergency response.

The GreenBook screening is used to identify where detailed coastal and estuary floodline work is required. It should inform the SDF, LUMS, coastal-access planning, disaster readiness and public communication, with future sea-level rise, storm surge and estuary functioning assessed over the life of proposed assets. Where houses or facilities are already exposed, risk management should combine warnings, maintenance, safe evacuation, drainage, community engagement and strict control of new development.

4.2.6. Coastal Erosion

The GreenBook coastal-erosion indicator models the potential extent of erosion caused by coastal storms and sea-level rise. In the current screening, the darkest categories represent areas that could be affected even under a relatively frequent 1-in-10-year storm combined with 0.35 m of sea-level rise, while lighter categories represent additional areas exposed under more severe, less frequent events. The future settlement-exposure indicator identifies settlements with more structures exposed under the higher likelihood erosion scenarios (CSIR, 2019).

For Mandeni, the broad screening suggests that modelled erosion exposure is not uniform. This is not interpreted as an absence of risk. Figure 13 shows exposed roots and water edges in dynamic beach and estuary environments indicate locations requiring inspection and precautionary management; they do not establish erosion rates or geotechnical instability.

Precautionary management of coastal erosion is recommended. This means protecting dunes, avoiding unnecessary disturbance of coastal vegetation, controlling vehicle and pedestrian access, maintaining coastal buffers, and screening new development against applicable coastal setback lines, erosion risk, flood risk and estuary functional zones. Beach and estuary access should be designed so that it does not weaken dunes, riverbanks or sensitive habitats.

4.3. Combined Future Risk Interpretation for Mandeni

The maps are interpreted together because future risk arises through interacting hazards, exposure and existing vulnerability. The principal combined risks are set out below.

- A hotter Mandeni means higher health risk for elderly residents, children, outdoor workers, informal traders and industrial workers, especially where shade, water and ventilation are limited.
- More intense rainfall means drainage problems become more damaging. Blocked drains, dumping, damaged culverts and settlement in flood-prone areas can become greater service-delivery and public-health risks.
- Drought risk increases pressure on rural water supply, agriculture, livestock, fire danger, wetlands and estuary health.
- Coastal flooding and estuary dynamics create long-term risk for Tugela Mouth, Dokodweni, coastal access, tourism assets and low-lying infrastructure.
- Fire risk links climate, land management, air quality and emergency access. Poor vegetation management, waste burning and limited access routes can worsen future losses.
- Future risk can be greatest where climate exposure overlaps with poverty, service backlogs, weak infrastructure, traditional land-governance complexity, sensitive ecosystems and limited institutional capacity.

Use of the CRVA in the Climate Change Strategy is recommended to determine how climate risk affects municipal decisions: where settlement expansion is supported or restricted, which stormwater assets are maintained first, where illegal dumping requires permanent intervention, where coastal development is too risky, where public facilities need heat and flood readiness, and where ecosystem protection is also infrastructure protection.

Sufficient screening evidence is available for practical action, subject to the limitations of the individual map layers. Enough evidence already exists to justify no-regret action: protect wetlands and estuaries, enforce floodline and coastal controls, fix drainage and waste hotspots,

strengthen fire readiness, protect rural water sources, and make heat risk visible in clinics, schools, work sites and public spaces. More detailed studies are still needed because hazard directions, spatial detail and confidence vary between indicators.

5. Policy Implications of the Vulnerability Assessment Results and Recommendations

Mainstreaming climate change into existing municipal planning tools, using the findings of this CRVA, is recommended. The municipality already has many relevant instruments: the IDP, SDF, Spatial Development Plan, LUMS, Disaster Management Sector Plan, Summer Contingency Plan, IWMP, Human Settlements Sector Plan, Coastal Management Programme, draft Estuary Management Plan, LED Strategy, Greening Plan and district or provincial air-quality plans. Consistent application of climate-risk decisions across these plans is recommended, while retaining the distinction between adopted instruments and draft contextual material.

The Climate Change Act sets objectives for climate adaptation to reduce vulnerability, strengthen resilience, improve adaptive capacity and use best available evidence. The Act commenced on 17 March 2025 subject to the exclusions in Proclamation 251 of 2025, including section 17. Mandeni's local planning responsibilities are distinguished from the deferred provincial, metropolitan and district assessment arrangements, and coordination with iLembe District and the Province is recommended. For Mandeni, this means that climate risk influences land-use approvals, infrastructure maintenance, housing location, waste-service expansion, coastal access, disaster preparedness, public-health coordination, industrial engagement and budget prioritisation.

5.1. Climate Response Scenarios

The scenarios below are written to support decision-making. They are used as qualitative municipal response choices, rather than quantified climate or loss forecasts. It is recommended that the Municipal Manager coordinate Scenario C through the departmental leads in Table 12, with Council oversight and district/provincial liaison.

Table 11: Climate response scenarios for Mandeni Local Municipality

Scenario	Municipal response	Likely outcome
A: Business as usual	Climate risks are acknowledged but existing land-use, maintenance, waste, housing and infrastructure practices continue with limited coordination.	Flood repairs, clean-ups, relief costs, drainage failures, unsafe settlement exposure and ecosystem degradation are likely to become more expensive.
B: Basic resilience	The municipality improves drainage maintenance, waste hotspot management, early warnings, coastal buffers and disaster readiness in priority locations.	Current losses are reduced, but long-term risks remain if new development continues in unsafe locations or if sector plans are not integrated.
C: Climate-compatible development	Climate risk is built into IDP, SDF, LUMS, capital budgeting, housing, waste, disaster, coastal, estuary, agriculture, air-quality and LED decisions.	Mandeni reduces avoidable losses, protects natural buffers, improves service reliability, supports vulnerable communities and lowers future municipal liabilities.

The table below links priority climate risks to affected sectors, existing municipal instruments and recommended adaptation responses so that officials can see how the assessment informs implementation.

Table 12: Risk-to-planning matrix

Climate risk	Affected sectors/functions	Existing municipal instruments	Recommended adaptation response	Lead/support functions
Flooding, stormwater and drainage failure	Roads, bridges, settlements, schools, clinics, business continuity	IDP, SDF, LUMS, Disaster Management Sector Plan, stormwater and roads planning	Maintain a drainage/culvert hotspot register; enforce applicable floodline controls; prioritise repeated-loss routes and public facilities; assess future rainfall and asset life in design reviews.	Technical Services; Disaster Management; Town Planning; Ward Committees
Waste, illegal dumping and polluted watercourses	Waste services, stormwater, public health, ecosystems, community safety	IWMP, Waste by-laws, Disaster Management Plan, Environmental Management functions	Prioritise dumping hotspots near drains, culverts, wetlands, streams and dense settlements; combine enforcement, service review and education.	Waste Management; Environmental Management; Law Enforcement; Communications
Coastal flooding, erosion and estuary dynamics	Coastal access, tourism, estuary ecology, roads, sanitation, settlements	Coastal Management Programme, draft Estuary Management Plan, SDF, LUMS	Apply verified coastal controls; assess estuary functional zones, future sea-level rise, storm surge and erosion in SDF/LUMS decisions; retain access management, evacuation planning and local erosion monitoring.	Environmental Management; Town Planning; Disaster Management; Tourism/LED
Drought, heat and fire risk	Water services, agriculture, schools, clinics, workers, rural settlements	Disaster Management Sector Plan, Summer Contingency Plan, IDP, Greening Plan, agriculture support plans	Strengthen early warnings, rural water planning, shade/cooling interventions, firebreaks and public-health communication.	Disaster Management; iLembe District; Agriculture/LED; Health stakeholders
Industrial, transport and air-quality risk	SAPPI, Isithebe, logistics corridors, workers, nearby	AQMPs, LED Strategy, SDF, AEL/NAEIS	Develop an industrial emissions and air-quality screening	Environmental Management; iLembe District;

Climate risk	Affected sectors/functions	Existing municipal instruments	Recommended adaptation response	Lead/support functions
	settlements	systems, Climate Change Strategy	protocol, business-continuity engagement and mitigation data request.	EDTEA; Industry stakeholders
Agriculture, rural livelihoods and land-use pressure	Commercial and small-scale farming, livestock, traditional authority areas, food security	SDF, LED Strategy, agriculture programmes, traditional authority engagement	Protect high-potential land, reduce erosion and fire risk, support climate-smart agriculture and validate risks with traditional leaders.	LED/Agriculture; Traditional Authorities; Environmental Management; Ward Committees

5.2. Recommended Adaptation Options

The following adaptation options are recommended for consideration in the Climate Change Strategy. They are not presented as a full implementation plan because that belongs in the strategy. They are presented here as the climate-risk response options that logically follow from the vulnerability assessment.

5.2.1. Land-use and Settlement-risk Controls

Use of the SDF, LUMS, Human Settlements Sector Plan and Coastal Management Programme, informed by the draft Estuary Management Plan, is recommended to prevent new climate risk from being created. This means strict screening of development applications against verified floodlines, wetlands, applicable riparian buffers and coastal setback lines, estuary functional zones, biodiversity corridors and known drainage constraints. A standard screening record is recommended for capital projects, housing, land-use and coastal proposals covering hazard, exposure, vulnerability, future climate scenarios, ecosystem effects, lifecycle costs and transferred risks. It should identify when specialist technical studies are required before a decision.

5.2.2. Flood, Drainage and Stormwater Risk Reduction

Inclusion of a practical drainage and culvert hotspot register in the Climate Change Strategy is recommended. This should identify blocked, undersized, damaged or high-risk drains, culverts, bridges and channels. Each hotspot should be linked to a ward, GPS point, photographs, responsible department, maintenance status and whether waste is a contributing factor. This allows pre-summer maintenance and capital planning to target the places where risk and repeated costs overlap. Where capacity, stability or future exposure is uncertain, it is recommended that Technical Services commission the necessary floodline, hydraulic, culvert/bridge-capacity and, where indicated, geotechnical studies before works are approved. The studies should assess alternatives, upstream and downstream effects, maintenance requirements and ecosystem impacts.

5.2.3. Waste, Illegal Dumping and Watercourse Pollution

The IWMP already identifies key waste-management needs: illegal dumping hotspot assessment, by-law enforcement, skip placement, public awareness, improved waste collection and staff or equipment capacity. The CRVA adds a climate interpretation: illegal dumping is a flood, fire, water-quality and public-health risk. Prioritising dumping hotspots that are near drains, culverts, streams, wetlands, flood-prone roads, schools, clinics and dense settlements is recommended. Regular waste-minimisation, source-separation, recycling and anti-burning engagement with businesses, informal traders and taxi associations at commercial areas, markets and taxi ranks is recommended. Waste Management should coordinate this work with Communications and Public Safety/Law Enforcement, recording participation, service reliability and hotspot recurrence. Suspected offences should be investigated or referred to the competent authority within the applicable mandate.

5.2.4. Coastal, Dune and Estuary Adaptation

Dunes, estuaries and coastal buffers are treated as protective infrastructure. The aMatigulu/iNyoni estuary requires careful attention to the Estuary Functional Zone, mouth migration, coastal protection zone and applicable development controls. Distances of 32 m or 100 m are not applied as universal development setbacks; the relevant coastal, watercourse and environmental requirements must be confirmed for each proposal. Avoiding new fixed infrastructure in dynamic coastal and estuary zones is recommended unless detailed technical studies confirm that the risk can be managed over the asset life. Future sea-level rise, storm surge and erosion should inform SDF/LUMS review and development conditions, with adjacent shoreline effects and estuary functioning assessed before protective works are selected.

5.2.5. Rural water, Sanitation and Public Health Resilience

Rural water and sanitation vulnerability is treated as a climate priority. Drought, flooding and poor water quality can affect household health, schools, clinics and livelihoods. It is recommended that he municipality, together with iLembe District and relevant departments, identify settlements using unsafe or distant water sources, areas with sanitation systems vulnerable to flooding, and locations requiring emergency water planning or water-quality monitoring.

5.2.6. Fire, Wind, Lightning and Hail preparedness

Mandeni aligns fire, wind, lightning and hail preparedness with the Disaster Management Sector Plan and Summer Contingency Plan. Rural settlements, schools, community halls, livestock areas, powerlines, agricultural land and high-fire-risk vegetation interfaces are priority areas. Practical measures include firebreaks, lightning protection in high-risk areas, awareness campaigns, safe shelter identification and clear warning communication.

5.2.7. Ecosystem-based Adaptation

Wetlands, riparian buffers, dunes, estuaries, forests and biodiversity corridors are integrated into adaptation planning. This means restoring degraded wetlands, removing invasive alien plants, protecting riparian vegetation, rehabilitating dunes, avoiding development in sensitive areas and linking ecosystem restoration to flood attenuation, water filtration, bank stabilisation, cooling and coastal defence.

5.2.8. Industry, Air quality and Mitigation screening

Mandeni's mitigation work begins with emissions and air-quality screening for major industrial, logistics, waste-burning, biomass-burning and domestic fuel-burning sources. The provincial AQMP identifies Mandeni among the areas with a high modelled probability of exposure to multiple air-pollution sources (KwaZulu-Natal Department of Economic Development, Tourism and Environmental Affairs, 2024). SAPPI Tugela Mill, Isithebe Industrial Estate, major routes, waste-burning areas and residential fuel-use areas are therefore identified for practical mitigation inventory development during the Climate Change Strategy phase. Air-pollutant exposure and regulatory compliance are distinguished from greenhouse-gas accounting; air-quality complaints or pollutant measurements cannot be converted directly into a municipal carbon total.

5.2.9. Agriculture and Rural livelihoods

Agriculture adaptation focuses on practical resilience: soil conservation, erosion control, fire management, water harvesting where appropriate, climate-smart agriculture, support to small-scale farmers, livestock water planning, crop diversification and protection of high-potential agricultural land. Sugarcane and forestry are also assessed for fire, drought, rainfall variability and biomass-burning risks. It is recommended that soil conservation, invasive-plant control and diffuse-pollution management be aligned with the Conservation of Agricultural Resources Act, the National Environmental Management Act and the National Water Act, while riparian areas, biodiversity corridors and sensitive habitats are protected.

5.2.10. Governance and Finance

The CRVA informs municipal budgeting by helping distinguish between repeated response costs and prevention investment. If the municipality spends repeatedly on clean-ups, flood repairs and emergency relief without dealing with the underlying drivers, costs will continue. Climate-risk budgeting prioritises actions that reduce future liabilities: drainage maintenance, waste enforcement, ecosystem protection, safe settlement planning, public facility readiness and industrial engagement.

The matrix below translates the vulnerability findings into initial actions. Timeframes run from approval of the implementation programme: immediate actions fall within 0–2 years, medium-term implementation within 3–5 years, and longer-term renewal or relocation beyond year 5 where studies justify it. Urgent maintenance and preparedness should proceed before the next relevant season. Before costing site-specific works, it is recommended that the first 20 hotspots be selected from the validated register using hazard, exposure, vulnerability and service-criticality evidence; no validated list of 20 sites is available in this assessment. The lead function for each action should identify the budget owner, operating and capital requirements, cost-estimate stage and funding eligibility, linking the action to the IDP, Service Delivery and Budget Implementation Plan (SDBIP), Medium Term Revenue and Expenditure Framework (MTREF) and departmental budget. The cost bands are low for routine operational work, medium for additional studies or minor works, and high for substantial capital or multi-year work; these bands are indicative, not monetary estimates. Progression from site validation and project scoping to cost estimates, budget alignment and funding applications is recommended; the listed funding pathways are potential sources, not secured allocations. Waste recovery and ecosystem restoration may support local employment, subject to approved scopes, resources and procurement.

Table 13: Implementation sequencing and priority action matrix

Action	Lead and support functions	Timeframe	Cost band	Indicator / funding pathway
Pre-summer drainage, culvert and bridge clean-up register	Lead: Technical Services Support: Waste Management; Disaster Management; Ward Committees	Before the next main summer storm season; repeat annually	Low-Medium	Register approved; kilometres of drains and numbers of culverts inspected/cleared recorded separately; repeated blockages monitored. Funding: operational budget, IDP/SDBIP and eligible MIG capital upgrades.
Illegal-dumping and watercourse pollution hotspot programme	Lead: Waste Management Support: Environmental Management; Law Enforcement; Communications; communities	Start within 0–3 months; monitor quarterly	Low-Medium	Hotspots mapped; enforcement actions; clean-up volumes and recurrence rate; business/trader/taxi engagement and reach recorded. Funding: IWMP, operational enforcement and eligible EPWP/community programmes.
Ward-level floodline, stormwater and exposed-settlement validation	Lead: Town Planning and Technical Services Support: Human Settlements; Disaster Management; traditional leaders; iLembe District	Scope in 0–3 months; priority validation and studies in 3–12 months	Medium-High	Validated ward maps, GPS points and priority technical studies commissioned. Funding: IDP/SDBIP, provincial support and infrastructure grants.
Coastal and estuary buffer and access management	Lead: Environmental Management Support: Town Planning; Disaster Management; Tourism/LED; provincial coastal stakeholders	Assess urgent risks in 0–12 months; implement priority works in 3–5 years	Medium	Applicable coastal controls verified and applied; erosion monitoring points and access-risk sites recorded. Funding: coastal/environmental programmes, IDP and potential partner funding.
Heat-risk screening for schools, clinics, taxi ranks and outdoor work sites	Lead: Disaster Management and Environmental Management Support: Health/Education stakeholders; Technical Services; LED	Screen within 0–12 months and before summer; priority measures within 0–2 years	Low-Medium	Priority sites screened; shade/cooling measures identified; heat communication issued. Funding: IDP/SDBIP, greening budget and donor/green finance.
Rural water, sanitation and drought-readiness validation	Lead: iLembe District with MLM support Support: Disaster Management;	Readiness assessment within 0–12 months;	Medium-High	Vulnerable settlements identified; water-quality monitoring sites and emergency water plan

Action	Lead and support functions	Timeframe	Cost band	Indicator / funding pathway
	Environmental Management; traditional leaders; ward committees	priority upgrades within 3–5 years		updated. Funding: district water budgets, disaster grants and provincial support.
Industrial emissions and air-quality screening protocol for SAPPI, Isithebe and corridors	Lead: Environmental Management / iLembe Air Quality Support: EDTEA; industry; LED; Disaster Management	Data plan within 0–6 months; initial inventory work within 3–12 months	Low-Medium	Data-request protocol; AEL/NAEIS review; engagement record and mitigation opportunities list. Funding: AQMP implementation, industry partnerships and climate-finance readiness.
Community validation and gender-responsive adaptation package	Lead: Disaster Management and Ward Committees Support: Environmental Management; Human Settlements; traditional authorities; civil society	Immediate (0-2 years)	Low	Validated ward summaries, correction log and sign-off; participation and support reached, disaggregated by sex, age and disability where appropriate; accessible warnings, shelters and safe-water measures. Funding: operational budget, ward-based programmes and partner support.

The following core indicators are recommended for quarterly departmental reporting and annual IDP review. The responsible function should confirm each baseline, its reference date and data source; an unknown baseline must not be recorded as zero. Collection frequencies may differ as shown, but the working group should consolidate progress quarterly. Targets should be agreed after the baseline and available resources are verified.

Table 14: Monitoring, Evaluation and Reporting Framework

Indicator	Baseline to confirm	Reporting frequency	Responsible function
Kilometres of priority drains inspected/cleared before summer; number of culverts inspected/cleared; repeat blockages recorded separately	2026 pre-summer register	Quarterly and pre-summer	Technical Services
Number of illegal-dumping hotspots mapped and cleared; number recurring after intervention	IWMP/hotspot register	Quarterly	Waste Management
Number of flood-prone households, public facilities and access routes validated by ward	Ward validation baseline	Biannual/annual	Disaster Management; Human Settlements; Technical Services
Number of coastal/estuary	Coastal/estuary risk	Annual	Environmental

Indicator	Baseline to confirm	Reporting frequency	Responsible function
access and buffer-risk sites assessed	register		Management; Town Planning
Number of schools, clinics, taxi ranks and outdoor work sites screened for heat risk	Heat-risk screening baseline	Annual before summer	Disaster Management; Health/Education stakeholders
Number of water-quality or polluted-watercourse sites tested after storm events	Watercourse hotspot baseline	Event-based and quarterly summary	Environmental Management; iLembe District
Number of firebreak, lightning, wind and hail preparedness actions implemented in high-risk wards	Disaster readiness baseline	Seasonal	Disaster Management
Availability of municipal operations data for GHG inventory: electricity, fleet fuel, waste, wastewater and buildings	Data availability checklist	Annual	Environmental Management; Finance; Technical Services
Number of people receiving warnings or targeted support, disaggregated by gender, age and disability where appropriate	Disaggregated indicator baseline	Annual IDP review	Disaster Management; Social/Community services; Ward Committees
Number of climate actions included in IDP/SDBIP/MTREF with allocated budget or funding pathway	Current IDP/SDBIP baseline	Annual	Municipal Manager; Budget/Treasury; relevant departments

An interdepartmental climate-risk working group chaired by the Municipal Manager or delegated senior official is recommended to coordinate climate implementation. Council should oversee policy adoption and expenditure, with the Municipal Manager accountable for implementation and departmental leads responsible for their assigned actions. The working group should report quarterly through management to the relevant Council committee, coordinate with iLembe District and provincial functions, and meet at least quarterly, maintain the hotspot/action matrix, prepare IDP/SDBIP/MTREF inputs, confirm departmental evidence, track MER indicators and identify funding pathways through operational budgets, capital budgets, provincial programmes, infrastructure grants, industry partnerships and donor or green-finance opportunities.

5.3. Preliminary Mitigation Inventory and Emissions Screening

This CRVA includes emissions at screening level because mitigation is part of Mandeni's climate response. This section is a mitigation inventory screening, not a verified greenhouse-gas inventory. It identifies the main emissions-relevant systems and the records required to develop a municipal and community-scale inventory during the Climate Change Strategy phase. A full inventory requires a stated reporting year, agreed boundaries, verified electricity consumption, fuel use, fleet records, waste tonnages, wastewater data, industry energy data, NAEIS and AEL information, and agreed emission factors and documented quality checks.

A mitigation inventory is used to identify emissions sources, estimate their magnitude from verified activity data, establish operational responsibility and assess feasible reduction

measures. The inventory starts with ordinary municipal and business records: electricity accounts, fuel slips, fleet registers, waste tonnages, landfill records, wastewater plant data, industry reports, building energy use, traffic information and agricultural burning records. These records are then converted into emissions using recognised emission factors and reported as carbon dioxide equivalent, or CO2e.

The Climate Change Act provides for greenhouse-gas emitting sectors, sectoral emissions targets, listed greenhouse gases and emitting activities, carbon budgets, greenhouse-gas mitigation plans and the National Greenhouse Gas Inventory. This legislative framework is distinguished from operative duties: applicable commencement provisions, thresholds and regulations must be confirmed before reporting obligations are assigned. To prepare Mandeni's local evidence base, it is recommended that activities that fall, or may fall, within the national mitigation system be identified, including activities not directly operated by the municipality. Private emitters subject to applicable reporting requirements report through national systems, but their risks and opportunities still affect Mandeni through employment, land use, air quality, infrastructure demand, transition risk and public health.

The iLembe Air Quality Management Plan gives Mandeni an important starting point. It identifies industrial operations, domestic fuel burning, vehicle emissions, waste treatment and disposal, agriculture, biomass burning and greenhouse gases as emissions categories for the district. It also records that Mandeni and KwaDukuza are the main local municipalities where industrial emissions are concentrated, while traffic emissions along the N2 and other corridors are relevant to both KwaDukuza and Mandeni. The plan further notes that industry is localised to KwaDukuza and Mandeni and is a dominant contributor to the district emission load, although the inventory is likely underestimated because of AEL and NAEIS reporting gaps. This gives Mandeni a clear reason to develop its own municipal emissions data request and screening process rather than relying only on general provincial statements (iLembe District Municipality, 2022).

In this CRVA, the emissions inventory is therefore treated as preliminary screening. It identifies likely emissions sources, required data and mitigation opportunities. The quantified inventory belongs in the Climate Change Strategy phase, where municipal operational emissions are separated from wider community-scale emissions.

Table 15: Preliminary emissions and mitigation inventory screening for Mandeni

Emissions source	What this means for Mandeni	Data needed for the inventory	Mitigation direction
Large industry and manufacturing	SAPPI Tugela Mill, Isithebe Industrial Estate and other industrial activities are important to employment and local revenue, but they also create energy, fuel, process, air-quality and transition-risk issues. These emissions are not all controlled by the municipality, but they matter for local planning and business continuity.	AEL and NAEIS reports; electricity and fuel use; boiler and process data; backup generator use; industrial water use; existing mitigation plans; air-quality monitoring and complaints.	Engage industry on energy efficiency, renewable energy, cleaner production, emissions reporting, air-quality compliance, flood and heat resilience, and just-transition risks to workers and suppliers.
Electricity use	Purchased electricity is a major indirect emissions	Municipal electricity accounts; streetlight	Energy-efficiency retrofits, LED streetlights, solar PV

Emissions source	What this means for Mandeni	Data needed for the inventory	Mitigation direction
	source. For the municipality, this includes offices, public facilities, streetlights, depots, pump stations and other electricity-using assets. For the community, it includes households, businesses and industry.	consumption; building accounts; pump-station accounts; Eskom or licensed distributor data; electricity use by customer category.	at suitable municipal buildings, efficient pumps, load-management and maintenance of high-consumption assets.
Transport and logistics	The N2, R102, industrial routes, municipal fleet and freight movement support the economy but also create fuel emissions and local air-quality exposure. Traffic emissions are especially relevant near busy corridors and settlements.	Municipal fleet fuel purchases; vehicle register; maintenance records; staff travel; traffic counts; freight routes; public transport and taxi-rank data.	Fleet maintenance, route optimisation, fuel-use tracking, efficient vehicles where feasible, improved traffic flow, public transport coordination and protection of pedestrians from high-exposure corridors.
Waste, landfill and waste burning	Waste is both an adaptation and mitigation issue. Illegal dumping blocks drainage and worsens flood risk, while waste burning and landfill emissions add air-quality and greenhouse-gas concerns. The Sappi landfill and Isithebe waste facilities require clear data linkages.	Waste tonnages collected and disposed; landfill destination; illegal dumping hotspots; clean-up volumes; waste burning complaints; recycling volumes; landfill gas information where available.	Waste minimisation, recycling, improved collection, enforcement against burning and dumping, organic waste diversion where practical, and better records of disposal and clean-up volumes.
Wastewater and sanitation	Wastewater and sanitation systems can produce emissions and can also fail during floods or droughts. Poor sanitation increases public-health risk and can contaminate watercourses during heavy rainfall.	Wastewater treatment volumes; pump-station electricity; sludge management; sanitation backlog data; septic and pit-latrine data; overflow and failure records.	Pump efficiency, maintenance, improved wastewater data, sludge management, sanitation upgrades, reduced overflows and protection of wastewater assets from flood exposure.
Residential energy use	In rural and low-income areas, some households rely on wood, paraffin, candles or other fuels. These may be smaller in total emissions than industry, but they matter because smoke is released close to people and affects health.	Ward-level household energy use; electrification status; informal dwelling or traditional dwelling data recorded separately; fuel-use surveys; fire incidents linked to household energy.	Electrification support, safer household energy, energy-efficient housing measures, awareness and links to public-health and fire-prevention programmes.
Agriculture, forestry and biomass burning	Sugarcane, forestry, veld fires and vegetation management affect both emissions and climate risk. Burning can worsen air quality, while drought and wind can increase fire danger.	Burning permits or records; sugarcane area; forestry and plantation data; fire incident records; land-cover change; farmer engagement data.	Fire management, firebreaks, early warning, alternatives to burning where feasible, soil and erosion control, and climate-smart agriculture support.

Emissions source	What this means for Mandeni	Data needed for the inventory	Mitigation direction
Land use, wetlands, dunes and vegetation	Healthy wetlands, estuaries, riparian corridors, forests and coastal vegetation store carbon and reduce climate risk. Degradation can release carbon and remove natural protection against floods, erosion and heat.	GIS layers for wetlands, forests, dunes and biodiversity corridors; alien invasive areas; rehabilitation sites; land-use change records; protected area and buffer data.	Protect buffers, rehabilitate wetlands and dunes, clear invasive alien plants, avoid development in sensitive areas and treat ecosystems as both adaptation infrastructure and carbon assets.

The screening shows that Mandeni has two mitigation boundaries. The first is the municipal operations boundary: municipal buildings, streetlights, fleet, depots, waste operations and electricity-using infrastructure. These are the sources the municipality can manage most directly. The second is the community-scale boundary: households, industry, freight, agriculture, waste burning, landfills, wastewater and land-use change. These sources are not all under municipal operational control, but municipal planning, by-laws, service delivery, partnerships and land-use decisions influence them. It is recommended that district-owned or privately operated assets be assigned to the appropriate reporting boundary and that overlap be accounted for before municipal and community totals are compared or combined. Carbon-storage or removal benefits from ecosystems require separate site-specific quantification; this screening does not provide measured carbon stocks.

Use of this screening in the Climate Change Strategy is recommended to prepare a practical mitigation inventory. The proposed first steps are to assign responsibility for collecting activity data, confirm which data already exist, identify the largest data gaps, agree on emission factors, separate municipal emissions from wider community emissions, and identify initial measures such as electricity efficiency, fleet fuel tracking, waste burning reduction, recycling, cleaner industrial engagement and ecosystem restoration. This establishes which activities produce emissions, which records are needed, who provides them and which interventions are financially and technically realistic. Future emissions scenarios should use the verified baseline and explicit activity and intervention assumptions; quantified projections cannot be provided without those inputs.

6. Conclusion

Mandeni's climate risk arises through the interaction of rainfall, heat, drought, fire and coastal change with municipal conditions: where people live, how drainage works, whether waste is managed, whether roads remain open, whether water and sanitation services are reliable, whether wetlands and estuaries are protected, and whether vulnerable households can recover after a shock.

The assessment confirms that Mandeni is already exposed to a combination of climate-sensitive risks. Heavy rainfall and flooding are made worse where drains, culverts and watercourses are blocked or poorly maintained. Illegal dumping is therefore not only a cleanliness issue; it is also a flood, water-quality and public-health risk. Coastal and estuary areas are vulnerable because dunes, beaches, estuary mouths and flood-prone lowlands are naturally dynamic. Rural and traditional-authority areas face additional pressure because households may be more dependent on distant water sources, gravel roads, local livelihoods and informal coping systems.

The climate-risk maps are interpreted as screening evidence for planning beyond past conditions, subject to the indicator-specific periods, scenarios and limitations discussed in Chapter 4. Heat stress is expected to become more important for settlements, schools, clinics, workers and public spaces. Drought and fire danger remain important for rural water security, agriculture, forestry, grazing areas and emergency response. More intense rainfall could place additional pressure on stormwater systems, roads, bridges, culverts, settlements and polluted watercourses. Coastal flooding and coastal erosion will require stronger planning controls around Tugela Mouth, Dokodweni, dunes, beach access points and estuary-adjacent land.

The most important conclusion is that Mandeni has enough evidence to act, even though more technical work is still required. Detailed floodline modelling, hydraulic studies, stormwater asset audits, coastal erosion analysis, a verified greenhouse-gas inventory, industrial emissions information and ward-level social vulnerability data are still required. However, these gaps do not delay sensible no-regret actions such as maintaining drainage, enforcing buffers, reducing dumping, protecting ecosystems, preparing for fire and heat, and strengthening early warning.

Incorporating climate change into routine municipal decision-making is recommended. The IDP, SDF, LUMS, Disaster Management Sector Plan, IWMP, Human Settlements Sector Plan, Coastal Management Programme and LED planning should use the same risk logic, with the draft Estuary Management Plan informing context subject to confirmation of its approval status. A development application, housing project, road upgrade, stormwater budget, waste intervention or coastal access decision must be tested against the climate-risk evidence in this report.

It is recommended that the Climate Change Strategy that follows this CRVA convert the evidence into a focused municipal response, with costs confirmed through project scoping and the municipal budget process. The priority is to protect people first, prevent new exposure through better land-use control, maintain the infrastructure that reduces repeated losses, protect ecosystems that provide natural flood and coastal defence, strengthen ward-level preparedness, and build a practical mitigation inventory for Mandeni's emissions-relevant activities.

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