Climate Adaptation Plan for New Juaben South Municipal Assembly: Ghana

September 2025

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Written by Foresight Planners and Research Africa Limited

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About the NAP Global Network

The NAP Global Network was created in 2014 to support developing countries in advancing their NAP processes, and help accelerate adaptation efforts around the world. To achieve this, the Network facilitates South-South peer learning and exchange, supports national-level action on NAP formulation and implementation, and generates, synthesizes, and shares knowledge. The Network's members include individual participants from more than 155 countries involved in developing and implementing National Adaptation Plans. Financial support for the Network has been provided by Austria, Canada, Germany, Ireland, the United Kingdom, and the United States. Additional support has been provided by ClimateWorks Foundation. The Secretariat is hosted by the International Institute for Sustainable Development (IISD). For more information, visit www.napglobalnetwork.org.

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Mr. Edward Abazing
Municipal Coordinating Director
Koforidua, Eastern Region

Foreword

Climate change presents growing challenges for communities worldwide, including those in Ghana, making it imperative for local governments to take decisive action. The responsibility to anticipate risks and implement effective responses falls heavily on municipal leadership, requiring well-structured strategies to safeguard lives and livelihoods.

In response, the New Juaben South Municipal Assembly (NJSMA), working in partnership with national agencies, has developed the New Juaben South Adaptation Strategy. This initiative is a critical step in strengthening local capacity, ensuring communities are better prepared to handle both immediate and future climate-related disruptions.

As one of the first municipal-led adaptation strategies under Ghana's National Adaptation Planning (NAP) process, this effort reinforces the importance of integrating climate resilience into local governance. By embedding adaptive measures into planning and policy, the strategy aligns with national objectives while addressing the specific needs of New Juaben South. Throughout this process, my role within the Municipal Assembly has involved engaging diverse stakeholders, gathering perspectives, and refining approaches tailored to address local vulnerabilities. These discussions have been instrumental in shaping a strategy that reflects both expert knowledge and community realities.

The experience of systematically assessing the risks and vulnerabilities of the NJSMA to climate impacts, has reaffirmed the urgency of action and the value of collaboration. The adaptation strategy is not just a document—it is a practical roadmap that will guide New Juaben South toward long-term environmental and social resilience.

Hon. Issac Apaw-Gyasi
Former Municipal Chief Executive
New Juaben South Municipal Assembly

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Abbreviations and Acronyms

AAP	**Annual Action Plan**
AEAs	**Agricultural Extension Agents**
AfES Ghana	**Africa Environmental Sanitation (AfES) Consult**
CA	**conservative agriculture**
CSIR	**Council for Scientific and Industrial Research**
DFID	**Department for International Development**
DRR	**disaster and risk reduction**
DVG	**disaster volunteer group**
EIA	**Environmental Impact Assessment**
EPA	**Environmental Protection Agency**
FM	**Frequency Modulation**
FRI	**Food Research Institute**
GCF	**Green Climate Fund**
GEF	**Global Environment Facility**
GHG	**greenhouse gas**
GIZ	**Deutsche Gesellschaft Für Internationale Zusammenarbeit**
GMet	**Ghana Meteorological Agency**
GNFS	**Ghana National Fire Service**
GSS	**Ghana Statistical Service**
ICT	**Information And Communication Technology**
IISD	**International Institute for Sustainable Development**
ISD	**Information Service Department**
IWRM	**Integrated Water Resource Management**
KNUST	**Kwame Nkrumah University of Science and Technology**
LI	**Legislative Instrument**
M&E	**monitoring and evaluation**
MCA	**multi-criteria analysis**
MDAs	**Ministries Department and Agencies**
MEL	**monitoring, evaluation, and learning**
MESTI	**Ministry of Environment, Science, Technology, and Innovation**

MMDAs	**Metropolitan, Municipal, and District Assemblies**
MOFA	**Ministry of Food and Agriculture**
MPCU	**Municipal Planning Coordination Unit**
MTDP	**Municipal Assembly Medium-Term Development Plan**
NADMO	**National Disaster Management Organization**
NAP	**national adaptation planning**
NCCE	**National Commission on Civic Education**
NDC	**nationally determined contribution**
NDPC	**National Development Planning Commission**
NGO	**non-governmental organization**
NJSMA	**New Juaben South Municipal Assembly**
NJSMAP	**New Juaben South Assembly Adaptation Plan**
PLWD	**persons living with disabilities**
PPPs	**public-private partnerships**
PWD	**persons with disabilities**
SARI	**Savana Agricultural Research Institute**
SDG	**Sustainable Development Goal**
SMS	**short message service**
STEPRI	**Science Technology and Policy Research Institute**
UDS	**University for Development Studies**
UNDP	**United Nations Development Programme**
UNER	**University of Energy and Natural Resources**
UNFCCC	**United Nations Framework Convention on Climate Change**
USAID	**United States Agency for International Development**
USD	**United States dollar**
VA	**vulnerability assessment**

1.0 Introduction

1.1 Background and Context

The impacts of climate change are accelerating, leaving no community untouched. Adapting is not merely about responding to disasters—it is about building resilience before crises strike. Every delay in action deepens vulnerabilities, but proactive adaptation transforms risks into opportunities, safeguarding lives, livelihoods, and the future of our planet. Without bold and coordinated local climate actions that align with both national frameworks and global commitments, communities like the New Juaben South Municipal Assembly will continue to face escalating climate-related challenges.

The undeniable evidence of climate change and its widespread disruptions across Ghana's critical sectors highlight the urgent need for adaptation. Recognizing this urgency, Ghana's national adaptation planning (NAP) process has been established to enhance national and subnational capacities, equipping local governance structures to effectively develop and implement adaptation strategies.

A fundamental step in successful adaptation planning is the thorough assessment of present and future climate risks and vulnerabilities. This process provides a deeper understanding of how climate threats affect various sectors, ensuring that responses are both targeted and effective. The New Juaben South Municipal Assembly's approach to vulnerability assessment aligns with the guidelines set forth in Ghana's NAP Framework (EPA, 2018), enabling the design of adaptation measures rooted in comprehensive, up-to-date data.

The assessment was carried out in three distinct phases. The first phase analyzed socio-economic conditions and the existing impacts of climate change in the municipality. The second phase focused on a qualitative evaluation of vulnerabilities within specific areas and climate-sensitive sectors. The final phase involved a quantitative review, incorporating climate projections specific to the municipality to provide a forward-looking perspective on risks and adaptation needs. These findings formed the basis of the climate change vulnerability assessment (CCVA), offering critical insights into the extent of climate-induced risks within New Juaben South.

Findings from the assessment underscored the agricultural sector as particularly vulnerable. Given the municipality's reliance on rain-fed agriculture for crop and livestock production, climate variability poses a significant threat to food security and livelihoods. Factors such as prolonged dry spells, rising temperatures, and extreme rainfall events contribute to frequent flooding, which damages infrastructure, disrupts economic activities, and exacerbates existing vulnerabilities. This highlights the immediate need for robust adaptation measures to enhance resilience and reduce the municipality's exposure to climate risks.

As a direct response to these challenges, the development of the New Juaben South Adaptation Plan (NJSMAP) marks a pivotal step in advancing adaptation planning efforts within the municipality. This plan builds upon the findings of the vulnerability assessment and serves as a practical guide for fostering resilience while promoting economic and social sustainability. Notably, this initiative is

among the first at the subnational level in Ghana, offering valuable lessons and best practices that can inform adaptation planning in other metropolitan, municipal, and district assemblies (MMDAs).

The NJSMAP was developed through a collaborative process involving key stakeholders who played an active role in translating vulnerability assessment findings into actionable strategies. Its implementation will be overseen by the New Juaben South Municipal Assembly and the Environmental Protection Agency (EPA), with various stakeholders contributing to its execution. Additionally, the adaptation plan provides a framework for broader climate resilience efforts, serving as a model that can guide similar initiatives across Ghana's local governance structures.

Box 1. Climate change vulnerability assessment for the New Juaben South Municipal Assembly

Ghana's EPA, with support from the New Juaben South Municipal Assembly (NJSMA), conducted a climate change vulnerability assessment for the municipality in 2023 to 2024. This comprehensive assessment included an analysis of historical and projected climate patterns, participatory risk mapping to pinpoint vulnerable locations, and an evaluation of community resilience using a matrix-of-functions approach. Additionally, vulnerability scores were derived for six key sectors: agriculture, biodiversity and ecosystems (forests), water resources, health and sanitation, disaster risk reduction and transportation, and mainstreaming gender. The participatory approach to this scoring ensured that all relevant stakeholders were in concord of the most vulnerable sectors of New Juaben South's economy.

The vulnerability assessment reviewed both current climate change impacts and anticipated future scenarios, identifying pathways to inform adaptation strategies. Priority areas for action were established as a foundational step for the NJSMA's adaptive approach: "Building climate resilience to support sustained economic and social development, despite climate changes anticipated by 2050."

Source: EPA, 2023.

1.1.1 Aims and Objectives

This adaptation plan builds upon the insights gained from the climate change vulnerability assessment, equipping the New Juaben South Municipal Assembly (NJSMA) with the capacity to effectively manage climate-related risks both in the present and the future. Aligned with the recommendations of the Least Developed Countries Expert Group (2012) under the United Nations Framework Convention on Climate Change (UNFCCC), the New Juaben South Adaptation Plan is designed to:

- reduce susceptibility to climate change impacts by identifying key actions that enhance adaptive capacity and resilience in a gender-responsive manner, and
- support the integration of climate adaptation strategies into the policies, programs, and development initiatives of the New Juaben South Municipal Assembly.

1.1.2 Expected Outcomes

The adaptation plan will enable New Juaben South Municipal Assembly to

- address critical climate-related risks promptly and effectively by identifying adaptation measures that are balanced, efficient, cost-effective, measurable, gender-responsive and timely,
- develop both short- and long-term business and operational plans based on insights from the vulnerability assessment,
- strengthen the capacity of the New Juaben South Municipal Assembly and its team to manage the complex risks and opportunities of climate change,
- prepare an adaptation plan that presents well-assessed adaptation options with clear steps for implementation, and
- ensure the adaptation plan aligns seamlessly with the priority actions outlined in the Assembly's Medium-Term Development Plans (MTDPs) for both present and future needs.

1.1.3 Time Frame

The time frame for the implementation of the New Juaben South Municipal Assembly Adaptation Plan is from 2024 to 2030, aligning with Ghana's revised Nationally Determined Contribution (NDC) period (2020 to 2030). This period also coincides with the next iteration of the Municipality's MTDP, from 2025 to 2030. This timing presents opportunities to intentionally integrate the adaptation strategy into the municipality's programs, policies, and activities.

1.1.4 Guiding Principles

- **Builds on Ghana's NAP process**: Ghana's National Adaptation Plan (NAP) Framework serves as the overarching roadmap for climate change adaptation planning and implementation. The NAP process has identified key stakeholder institutions and agencies, such as the Ministry of Food and Agriculture (MoFA).
- **Is gender responsive**: Gender is a socially constructed concept, and in Ghana, while normative gender implications are recognized, the term is broadly defined to include women, children, youth, and persons with disabilities. These groups are particularly vulnerable to the impacts of climate change, and their unique needs were carefully considered in the development of this plan.
- **Incorporates nature-based solutions for adaptation**: Nature-based solutions have been increasingly acknowledged for their positive environmental impacts and their role in building resilience to climate change. This plan emphasizes the use of such solutions to strengthen local adaptation efforts.
- **Driven by science**: It is essential that adaptation efforts are guided by a thorough understanding of both current and projected climate impacts, supported by scientific evaluations of climate vulnerabilities and a comprehensive vulnerability assessment process.

- **Applies Traditional and Indigenous Knowledge**: The plan placed a special focus on the knowledge and experiences of local people and made conscious efforts to tap into such knowledge systems to enhance the plan, especially from the perspective of selecting adaptation options.
- **Adopts participatory, inclusive, and local ownership**: Guided by the Ghana NAP framework, processes for both the climate change vulnerability assessment and the development of the plan have been as participatory and inclusive as possible to ensure that the plan is led and owned by local people.
- **Aligns with SDGs and national development goals**: Adaptation projects may provide benefits to or trade-offs with the United Nations Sustainable Development Goals (SDGs) and other national development priorities. As much as possible, the adaptation planning process must aim to reduce the trade-offs, as well as complement efforts to achieve the SDGs and national development goals.

1.2 Methodological Approach

The development of the adaptation plan for the NJSMA followed a structured approach, as illustrated in Figure 1. To ensure its relevance and flexibility, the process incorporated key stages of decision making, beginning with problem identification and scoping, followed by implementation, continuous monitoring, evaluation, and refinement based on lessons learned. A three-stage methodology was employed in formulating the plan, which involved an extensive desk review, consultations with stakeholders, and a final validation process at the municipal level.

Figure 1. Development process of the adaptation plan

Source: Authors

Adaptation Plan Development Process

Phase I: The first phase entailed an extensive review of adaptation priorities and strategies outlined in national and sectoral climate policies, including key documents from the Ministry of Environment, Science, Technology, and Innovation (MESTI) (2013, 2015). Additionally, the New Juaben South Municipal Assembly's Medium-Term Development Plan (MTDP), the 2023 Annual Action Plan, academic research, and findings from the municipal vulnerability assessment were examined. This phase ensured that the adaptation plan was grounded in scientific evidence and aligned with both national and municipal development priorities. Insights from this review contributed to compiling a sector-based catalogue of adaptation measures.

Phase II: In the second phase, preliminary adaptation options developed by consultants underwent evaluation through a participatory multi-criteria analysis. This process took place in structured stakeholder workshops within the municipality, where representatives from five key consultation groups assessed adaptation measures across priority sectors, including:

- agriculture
- biodiversity and forestry (ecosystems)
- water resources
- health and sanitation
- gender and marginalized groups
- disaster risk reduction (DRR) and transportation
- tourism

Participants in these sessions included representatives from various the NJSMA departments, non-governmental organizations (NGOs), the private sector, gender advocacy groups (youth, women, and persons with disabilities), traditional leaders, farmer organizations, and the media. The adaptation options, informed by the vulnerability assessment, were presented during these discussions. The stakeholder consultations aimed to:

- provide clarity on the adaptation planning framework
- introduce and assess proposed adaptation measures through review, screening, and ranking exercises
- collect diverse perspectives and feedback on the suggested adaptation strategies
- deliberate on implementation considerations and approaches

Phase III: The final phase focused on validating the adaptation plan through a dedicated stakeholder validation workshop. This session convened key actors, including many who participated in Phase II, reinforcing a collective sense of responsibility and ownership over the adaptation strategy. Contributions from stakeholders were integrated, culminating in the finalized adaptation plan.

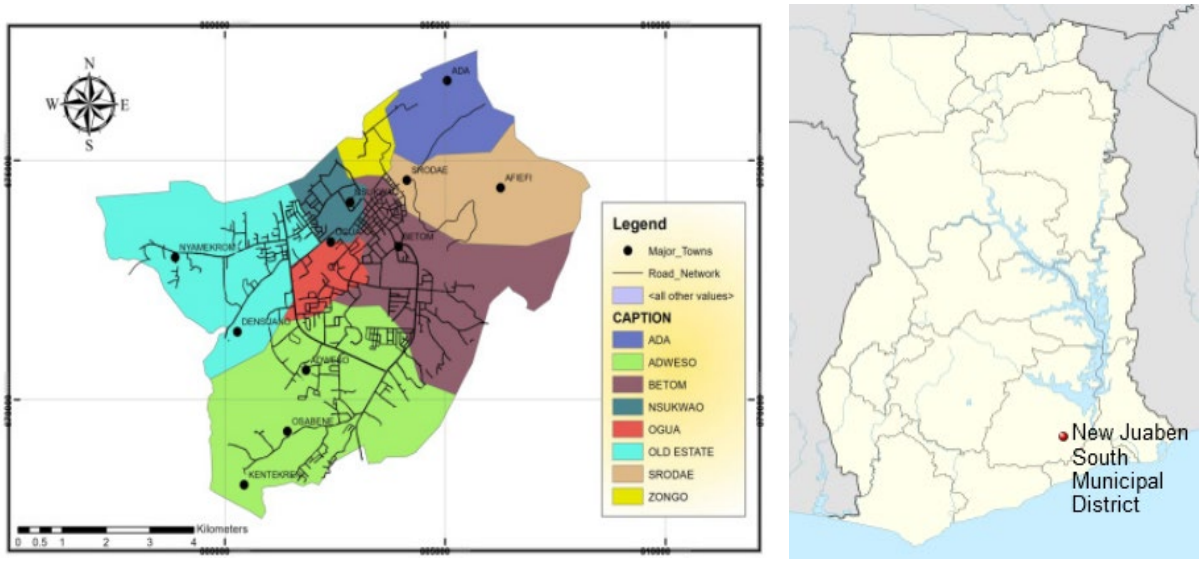
1.3 Overview of the New Juaben South Municipal Assembly

1.3.1 Geographical Location and Size

The New Juaben South Municipal Assembly is one of the thirty-three municipal assemblies in the Eastern Region, with Koforidua as its capital. It covers a land area of 43 square kilometres. The municipality shares boundaries with the following assemblies; New Juaben North Municipal Assembly in the north, Akuapim North Municipal Assembly to the south-east, and Yilo Krobo Municipal Assembly to the east. The land is gently undulating with heights ranging from 152 metres to 198 metres above mean sea level. The highest area is the mountain belt along the eastern boundary of the municipality. The municipality is drained mainly by the Densu River and its tributaries. These are mainly Pompon,

Obopakko, Afena Nsuokwao, and others. The Densu River is dammed at Densuagya, where the water is treated and distributed to the municipality.

Figure 2. Map of Ghana showing the location of the New Juaben South Municipal Assembly



Source: New Juaben South Municipal map from New Juaben South District Constituency Profile (left) and Ghana map from Wikipedia (right).

1.3.2 Topography and Drainage

The municipality's land is characterized by gentle undulations, with elevations ranging from 152 metres to 198 metres above mean sea level. The highest point is found along the mountain belt on the eastern boundary. The municipality is primarily drained by the Densu River and its tributaries. However, human activities, such as estate development and improper waste disposal into streams, have contributed to the near extinction of some of the municipality's water bodies. Additionally, encroachments on natural reserves have further threatened the survival of streams, leading to recurrent flooding issues in many of the towns. The municipality has 596 km of feeder roads, with 260 km in urban areas. Despite the compact area of 110 km², which allows for efficient movement of people, goods, and services, the road network consists of both tarred and untarred roads. While 60% of the roads are in good condition, 20% are fair, and another 20% are in poor condition.

1.3.3 Climate

The New Juaben South Municipal Assembly is situated in one of Ghana's three agro-climatic zones: the semi-deciduous rainforest. The region experiences a bimodal rainy season, with rainfall varying between 1200 mm and 1700 mm annually. The peak rainfall periods occur in May to June and September to October. The dry season is relatively short, lasting from November to February. Temperatures in the municipality range from 20°C to 32°C, with generally high humidity levels. These moderate temperatures contribute to the municipality's appeal as a prime tourist destination.

The vegetation in New Juaben South is dominated by tall trees with evergreen undergrowth, enriched by various economic tree species such as Odum, Onyina, Kyenkyen, and Wawa. These species play a

significant role in supporting lumbering and estate development activities. Additionally, scattered patches of secondary or broken forests are present across the region. The climate of the NJSMA and vegetation interact to provide essential ecosystem services, such as carbon sequestration, watershed preservation, and local climate regulation, which are vital to both the environment and the livelihoods of the residents.

1.3.4 Vegetation

The vegetation of New Juaben South is predominantly composed of tall trees with evergreen undergrowth. The area once had a rich abundance of economic trees, but today, only scattered patches of secondary or fragmented forests remain beneath the larger trees. Some of the once-abundant species include *Triplochiton scleroxylon* (Wawa), *Antiaris Africana* (Kyenkyen), *Chlorophora excelsa* (Odum), and *Ceiba pentandra* (Onyina), but these are now only sporadically found. The municipality's forest ecosystem offers crucial services such as carbon sequestration, climate regulation, and watershed preservation, which help to control water flow, mitigate floods and droughts, and moderate local and regional climates. Additionally, the forest provides a wide array of products, including food, medicine, timber, and non-timber forest goods, supporting the livelihoods of local residents. However, human activities like illegal logging, chainsaw operations, bushfires, and weak enforcement of regulations have led to a rapid decline in the municipality's closed canopy forest cover. Furthermore, climate impacts like droughts exacerbate the risk of forest degradation, making the reserves more vulnerable to fires and further destruction.

1.3.5 Soil Types

The New Juaben South Municipal Assembly is home to three dominant soil types—Nankese-Koforidua/Nta-Ofin compound, Fete-Bediesi Complex, and Adawso-Bawjiasi/Nta-Ofin Compound Association. The most common soil type in the municipality is Nankese-Koforidua/Nta-Ofin compound, which is commonly found in the extreme north of the Densu Basin. While the Adawso-Bawjiasi/Nta-Ofin Compound Association is noted as the smallest of the three main soil types, this association is characterized by grey-brown loamy humus horizon.

These soil types are conducive to the growth of perennial cash crops such as cocoa, coffee, oil palm, and citrus. The soil is also suitable for growing various annual and semi-perennial food crops including vegetables, sweet potatoes, sugar cane, rice, plantain, cocoyam, and bananas. The municipality's soil composition supports the local agricultural economy, providing fertile ground for a variety of crops critical to the region's livelihood.

1.3.6 Demographic Profile

The 2021 population of the municipality is 125,257, constituting 60,567 (48.4%) males and 64,689 (51.6%) females. The population is largely urban with 125,004 living in urban localities and 252 in rural localities. In terms of locality of residence, less than 1 percent of the population in the municipality live in rural areas. The municipality forms 4.3% of the regional population. The household population in the municipality is 120,307, with an average household size of 2.7. The sex ratio is 93.6 implying that for every 100 females there are 93 males (NJSMA, 2021).

The most populous age group within the municipality is 20 to 24 years, accounting for 12% of the population. The municipality has a youthful population, with those aged less than 15 years constituting almost a third (30.8 %) of the population. Residents of the municipality are heterogeneous in terms of ethnicity with a high dominance of Akans and Ga-Adangbes. Ewes and people belonging to other ethnic groups of the north also form significant proportions of the population in the municipality. The Akan tribe constitute is a fair mix of Asantes, Kwahus, and Akims, with a sizeable number of Akwapims. The municipality is predominantly Christian, followed by Muslims and traditional believers, respectively.

Table 1. Summary of New Juaben South Municipality's demographics

	Number	Percentage
Gender		
Male	60,567	48.4%
Female	64,689	51.6%
Urbanization		
Rural	252	0.2%
Urban	125,004	99.8%
Literacy		
Literate	90,898	91%
Illiterate	9,037	9%

Source: Ghana 2021 Population and Housing Census (General Report Volume 3A).

1.3.7 Economic Profile

Ghana's National Adaptation Plan highlights agriculture, water resources, biodiversity and forestry, transport, infrastructure, industry, and human health as critical sectors vulnerable to climate change impacts. Assessing how these sectors are affected by climate hazards is vital. In New Juaben South, key economic sectors include services, industrial manufacturing and processing, agriculture, and other socio-economic activities like business and consumer commerce. The services sector contributes 39.9%, followed by industrial manufacturing at 26.7%, agriculture at 26.1%, and other socio-economic activities at 7.3%. While industrial activities are concentrated in the central business area, agricultural production mainly occurs in smaller settlements and peri-urban regions.

Agriculture in New Juaben South primarily involves crop farming, including yam, grains, cocoa, oil palm, kola nuts, alongside livestock and timber production. The 2010 Population and Housing Census indicates that agriculture comprises roughly a fifth of the municipality's activities and provides employment in both formal and informal sectors. However, Asante and Amuakwa-Mensah (2014) report that changing rainfall patterns and frequent flooding present significant risks to agricultural production. Precipitation, a key source of irrigation for farmers, is increasingly unpredictable, complicating planting schedules and leading to reduced crop yields and heightened food insecurity. As rainfall variability increases, farming becomes riskier, undermining productivity and contributing to lower incomes for farmers. Those dependent on agricultural outputs for their livelihoods are particularly affected (Logah et al., 2013). Additionally, perennial flooding in areas with undulating

terrain exacerbates the vulnerability of farms and plantations, often resulting in runoff that damages crops. The transportation sector and infrastructure also face recurrent damage due to flooding.

Runoff from heavy rainfall also disrupts mining operations in New Juaben South, while improper waste disposal further pollutes local surface water bodies, such as the Densu River and its tributaries. These rivers are crucial water sources for the municipality and surrounding areas. The Ghana Water Company has raised concerns about the contamination of the Densu River, which poses significant risks to water supply quality and availability. To cope with water scarcity, residents often reduce their water consumption or resort to purchasing sachet water and water from private tanker drivers at higher costs, as highlighted in a study by Asibey, Dosu, and Yeboah (2019).

According to Global Forest Watch, New Juaben South had tree cover of 9.44 kha in 2010, representing over 55% of the land area. By 2021, the municipality had lost approximately 152 ha of tree cover, releasing 108 kt of CO_2 emissions. The loss of forest cover due to climate change and variability disrupts critical ecosystem services, including water filtration and aquifer recharge, which in turn affects water demand for human activities. This leads to an increased need for energy to access water, such as through additional pumping and purification. Additionally, the ability of urban trees to regulate temperature and improve eco-energy efficiency is diminished by rising temperatures and rainfall variability (Marful, 2012).

Obuo Tabiri, identified as a potential tourism destination, offers an adventure holiday experience, with its mountain providing a scenic view of Koforidua. However, the growing effects of climate change could influence tourist preferences, with visitors potentially opting for destinations less vulnerable to climate impacts. The municipality also hosts several market centres for commercial activities, particularly in the trade of farm produce. There are two major markets—Juaben Serwaa and Central Market—located within the Central Business District, and three minor markets at Adweso, Zongo, and Agartha. Notably, the municipality is home to one of the few bead markets in the country, located at Gallaway, where beads from around the world are sold.

New Juaben South faces several challenges in promoting its economic development. These include a poor road network, with dilapidated roads hindering economic activities. Tourist sites remain underdeveloped, and the municipality grapples with issues such as flooding and security concerns, including boundary disputes and high crime rates. Despite these challenges, the municipality continues to work toward advancing its economic and infrastructure development.

1.3.8 Observed Gender Gaps

Gender disparities remain a pressing development concern in New Juaben South Municipal Assembly (NJSMA), mirroring broader national trends in Ghana, such as persistent gender gaps in access to economic opportunities, education, political participation, and social protection. Intersecting factors such as urban poverty, socio-cultural norms, and limited institutional mainstreaming of gender issues reinforce these disparities (Theodory & Costantini, 2024; Botwe, 2015; Osei, 2024).

A key area of concern is the gendered division of labour and unequal access to economic resources (NJSMA, 2021). Women in the NJSMA particularly dominate the informal sector in occupations such petty trading, hairdressing, dressmaking, and food vending, yet have limited access to credit, training,

and formal registration that would enable business growth. According to studies such as Owusu, Nursey-Bray, and Rudd (2019) and Addai, Ng'ombe, and Temoso (2022), urban women are more likely to be in vulnerable employment compared to their male counterparts. This structural gap often translates into lower income security for women. Thomas (2018) adds that while there is support for women entrepreneurs, its outreach and effectiveness are often limited by resource constraints and low literacy levels among target beneficiaries.

Also, while there has been improvement in female education and skills development, challenges remain in transitioning female students to higher levels, particularly in technical and vocational education. Additionally, cultural expectations and domestic responsibilities further constrain young women's participation in skills training and labour market programs (Rees, 2022). Moreover, despite some progress, women remain underrepresented in decision-making roles within the Municipal Assembly and in community leadership structures (NJSMA, 2021; Botwe, 2015). Gender gaps in leadership and political participation are also evident.

In the area of access to health and social protection services, women, especially adolescent girls and young mothers, face gaps in access to reproductive health services, safe sanitation, and gender-responsive health care. Nartey et al. (2025) reveal that while antenatal coverage is relatively high, access to adolescent-friendly services and mental health support is low in Ghana. The situation is exacerbated in low-income neighbourhoods and informal settlements within the municipality.

Finally, despite the existence of institutional frameworks like the Gender Desk Unit, mainstreaming gender into municipal planning and financing gender-inclusive activities remains a challenge. A study by Mahama et al. (2023) points out that gender mainstreaming is inconsistently applied at the sub-national level as there is limited disaggregated data to inform evidence-based planning in places like the NJSMA.

2.0 Institutional Arrangements and Municipal-Level Adaptation Governance

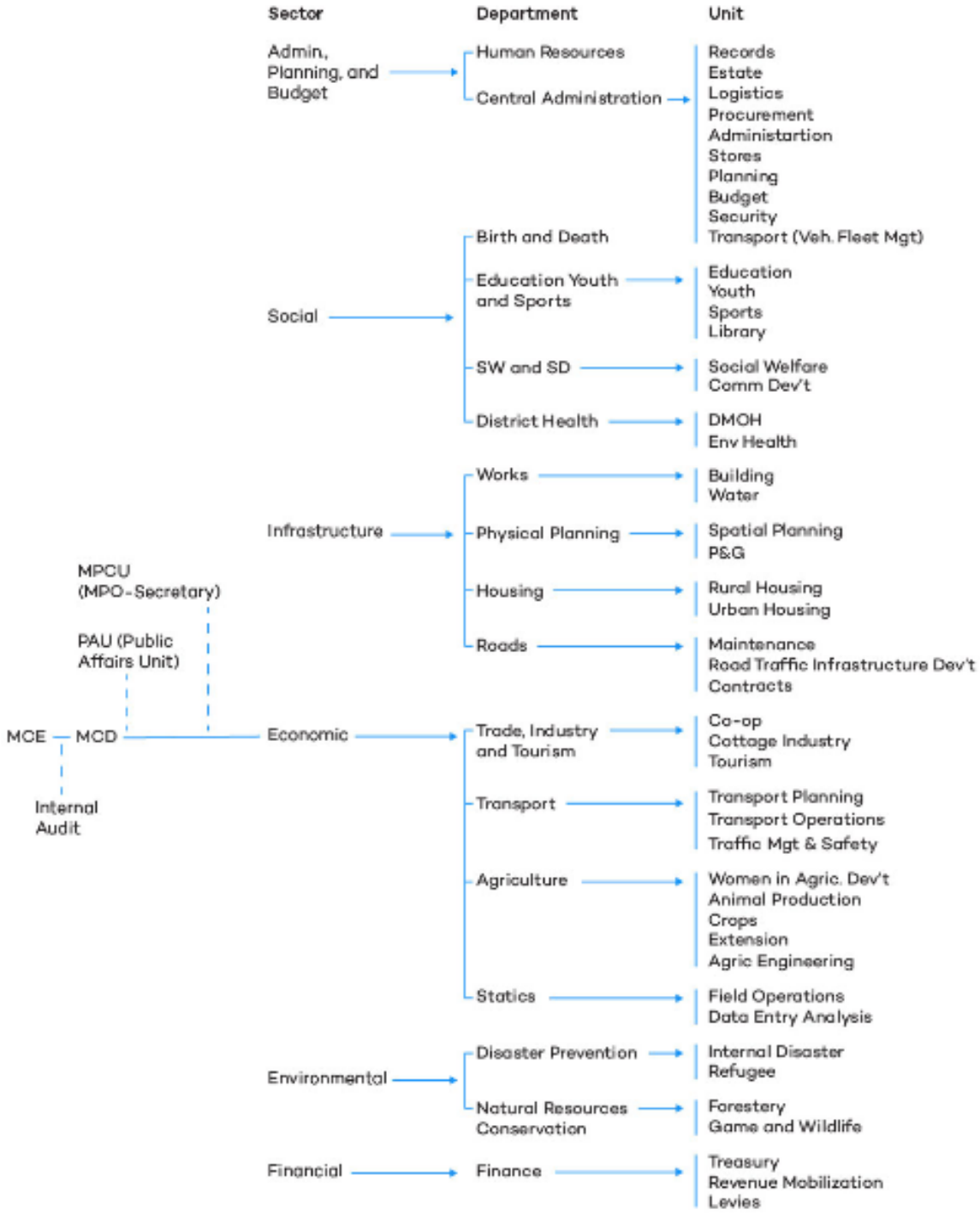
2.1 Current Institutional Arrangements

Since 1988, Ghana has implemented a decentralization policy aimed at shifting development planning to the local level, in alignment with the central government. This approach seeks to address local priorities and mobilize community resources to contribute to national development objectives.

In accordance with Section 12 of the Local Governance Act of 2016, metropolitan, municipal, and district assemblies (MMDAs) are responsible for developing plans that steer local growth. These assemblies serve as the primary political, administrative, and planning authorities within their jurisdictions.

The New Juaben South Municipal Assembly's Medium-Term Development Plans (MTDPs) serve as strategic roadmaps, outlining all the development programs and projects to be carried out in the municipality over a three-year period. These plans integrate the activities of various departments, units, and stakeholders within the Assembly. Figure 3 illustrates the current governance structure of the New Juaben South Municipal Assembly.

Figure 3. Municipal departments organogram



Source: NJSMA MTDP, 2021.

2.2 Relevant National and Municipal-Level Policies

Ghana acknowledges the profound impact of climate change. In response to this global challenge, the Government of Ghana has taken decisive action by establishing regulatory frameworks aimed at addressing climate change effectively. Key frameworks include the National Climate Change

Adaptation Strategy (2011), the National Climate Change Policy (2013), and the National Climate Change Master Plan (2015 to 2020).

The country's Adaptation Strategy is designed to bolster both short- and long-term development, enhancing the resilience of communities and ecosystems to climate impacts. The National Climate Change Policy, which serves as an integrated framework, envisions a "climate-resilient and climate-compatible economy" that promotes sustainable and equitable low-carbon growth (MESTI, 2013, p. ix). The national adaptation plan (NAP) framework further supports this vision by establishing a structured approach to coordinate and implement adaptation plans nationwide, setting clear directives for the adaptation processes (EPA, 2018). As a member of the UNFCCC and a signatory to the Paris Agreement, Ghana updated its Nationally Determined Contributions (NDC) in 2021, reaffirming its commitment to global climate goals (Government of Ghana, 2021a). This updated NDC includes 19 policies, consisting of 13 adaptation and 34 mitigation programs, which integrate climate resilience with economic diversification.

To address the socio-economic challenges posed by climate change, Ghana's National Development Planning Commission (NDPC) works to incorporate climate policies into both the national development framework and local planning efforts. The NDPC ensures that climate adaptation priorities are aligned with national goals and integrated into Medium-Term Development Plans (MTDPs) across all levels of government, including local assemblies such as the New Juaben South Municipal Assembly (NJSMA). The National Medium-Term Development Policy Framework for 2022–2025, influenced by the Paris Agreement, focuses on advancing climate resilience and accelerating the goals of the NAP program (Government of Ghana, 2021b).

The NDPC also plays a crucial role in building the capacity of metropolitan, municipal, and district assemblies (MMDAs), including the NJSMA, to integrate climate policies into their MTDPs. These plans are vital for guiding the development programs and projects implemented at the local level, aiming to foster economic growth, reduce poverty, improve living standards, and raise incomes. Recognizing the risks posed by climate change, the NJSMA's MTDP incorporates several adaptation initiatives, focusing on the vulnerabilities of sectors such as agriculture, which is heavily reliant on rainfall. As part of the adaptation strategy, the MTDP includes farmer education and awareness campaigns to help local communities adapt to changing climatic conditions.

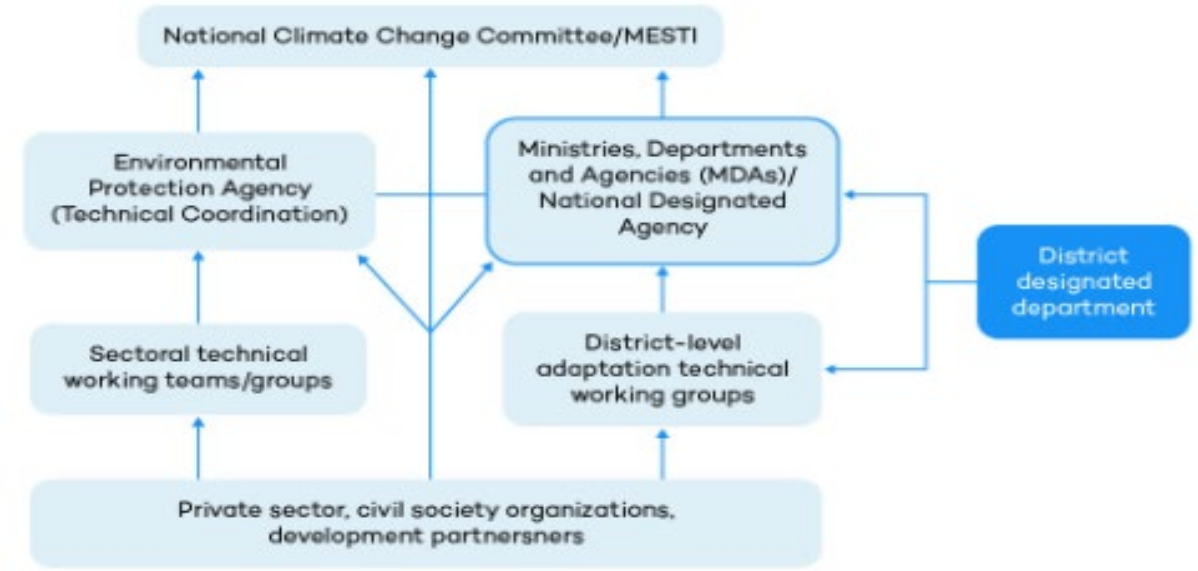
2.3 Proposed Arrangements for Adaptation Governance

For climate change to be effectively incorporated into the development agenda at the local level, the governance framework of the New Juaben South Municipal Assembly must align with the national structures outlined in the national adaptation plan (NAP) (EPA, 2018). This alignment ensures that the Assembly is engaged with national efforts through the relevant ministries, departments, and agencies (MDAs), as depicted in the organogram in Figure 4. As addressing climate change is a relatively new challenge for many municipal governments, there remains some uncertainty about which department will assume the lead role in coordinating climate action. This lack of clarity may undermine leadership and impede the sustainable implementation of adaptation strategies.

The NAP framework designates the Environmental Protection Agency (EPA) as the lead agency for coordinating the development of a comprehensive National Adaptation Plan, which includes

prioritizing adaptation efforts across key sectors like agriculture, forestry, water, energy, gender, and health. The National Development Planning Commission (NDPC) is tasked with overseeing the adaptation planning process at the municipal level, ensuring that these plans are integrated into broader development strategies. To enable effective coordination of climate actions at the local level, it is critical to appoint a specific department within the municipal structure. In New Juaben South, the Municipal Planning Coordination Unit (MPCU) has been assigned this responsibility, and it has taken the important step of establishing a climate change desk within the assembly. This initiative represents the first of its kind at the subnational level in the country.

Figure 4. Proposed institutional arrangement for Ghana's NAP, including the role of the designated municipal lead department



Source: Adapted from Figure 1 in Ghana's NAP Framework (EPA, 2018, p. 18).

2.4 Implementation Roles and Responsibilities

Climate change is increasingly acknowledged as a critical issue that impacts various aspects of society, including economic stability, public health, and social well-being. Uncoordinated actions within and among these sectors can result in duplicated efforts or even maladaptation. To enhance effectiveness and create synergies, it is crucial for the New Juaben South Municipal Assembly to establish a comprehensive system of institutional collaborations.

Addressing the impacts of climate change requires active engagement with multiple stakeholders to ensure that interventions are aligned and complementary. A coordinated approach helps to avoid duplication and fosters a more cohesive response to the challenges posed by climate change. The New Juaben South Municipal Assembly—by building a robust network of institutional relationships—can ensure that adaptation strategies are not only effective but also sustainable across sectors. This framework of collaboration is essential for maximizing the collective impact of climate action at the local level.

Table 2. Relevant stakeholders, their key roles, responsibilities, and expected outcomes from their engagement in the implementation of the NAP

Institution	Role/responsibility	Expected outcome from engagement
Public sector		
Municipal Planning Coordinating Unit, NJSMA	Facilitates the development of climate action plans in NJSMA	Effective integration of climate adaptation in local planning
	Leads monitoring and evaluation of climate initiatives	Enhanced capacity for monitoring climate actions
	Coordinates climate adaptation projects in NJSMA	Increased financing and partnerships for adaptation
Assembly members, town/area councils and unit committees	Advocate and facilitate public participation in adaptation initiatives Be a liaison between the Municipal Assembly and local population in developing and implementing localized climate adaptation plans	Enhanced local awareness and support for climate adaptation Improved climate implementation of community adaptation initiatives
NJSMA departments (agriculture, disaster prevention, health, natural resources, etc.)	Implements adaptation priorities within their sectors	Reduced climate vulnerability within sectors and communities
		Strengthened local resilience through sectoral adaptation initiatives
National Disaster Management Organisation (NADMO)	Promotes disaster risk reduction and climate risk management	Lowered community vulnerability to climate and disaster impacts
	Mobilizes community involvement for disaster prevention	Disaster resilience included in adaptation plans
	Provides relief in times of disaster	
Gender Department	Ensures climate strategies consider women, youth, and vulnerable groups	Increased focus on addressing gender-based climate vulnerabilities
Ghana Health Service	Integrates climate change considerations into health risk management at the municipal level	Strengthened adaptation for climate-sensitive health risks
Forestry Commission	Regulates forest and wildlife resources, provides technical assistance for adaptation measures	Technical expertise to support forest and wildlife-related adaptation activities
National Development Planning Commission (NDPC)	Develops national policy frameworks, coordinating implementation across districts and municipalities	Comprehensive climate change integration in NJSMA development plans
	Integrates climate adaptation in economic, social, and environmental planning	Aligned and coordinated adaptation planning across municipalities
Ghana Meteorological Agency (GMet)	Supplies climate and weather data for decision making at the municipal level	Access to accurate, municipality-specific climate data

Institution	Role/responsibility	Expected outcome from engagement
Environmental Protection Agency (EPA)	Leads on the NAP process, overseeing pollution control, sanitation, and environmental protection	Clear adaptation priorities for NJSMA sectors
	Develops sector-specific vulnerability reports	Support for vulnerability assessments
Ministry of Food and Agriculture (MoFA)	Oversees agricultural policies in NJSMA	Improved climate resilience in agriculture
	Trains extension staff to integrate climate considerations into agricultural practices	Effective climate messaging by extension staff
	Facilitates technology transfer	Improve adaptation of climate smart agriculture
Information Service Department (ISD) and National Commission on Civic Education (NCCE)	Educates the public on climate change and adaptation measures	Increased community understanding and engagement in climate resilience efforts
Regional Coordinating Council	Oversees NJSMA's Climate Change Adaptation Strategy through monitoring and evaluation	Enhanced support for smooth implementation of adaptation initiatives
	Coordinates regional planning	
Ministry of Finance	Manages financing for climate vulnerability assessments and adaptation strategies	Financial support for vulnerability assessments and adaptation implementation
Private sector		
Farm input dealers	Promote climate-resilient farm inputs and technologies	Improved access to climate-adaptive farming technologies
Financial institutions	Provide credit facilities for climate-related initiatives	Increased financial support for climate adaptation among farmers and businesses
Farmer-based organizations	Advocate for farmers, enhance bargaining power, and influence policy on adaptation	Improved resilience and adaptive capacity among farmers
Development partners		
Green Climate Fund, bilateral organizations (e.g., GIZ, USAID)	Mobilize resources, offer capacity development, and facilitate technology transfer for adaptation	Financial and technical support for NJSMA's adaptation projects
UN agencies (UNDP, UNICEF, NAP Global Network)	Provide support for planning, advocacy, research, and monitoring of climate adaptation	Improved capacity building, effective planning, and implementation of adaptation actions
NGOs/civil society organizations		
Africa Environmental Sanitation (AfES) Consult, New Juaben South Youth Parliament, etc.	Engage in planning, advocacy, education, research, and monitoring of adaptation programs	Enhanced community awareness and resilience through supported adaptation projects
	Initiate and fund local adaptation efforts	

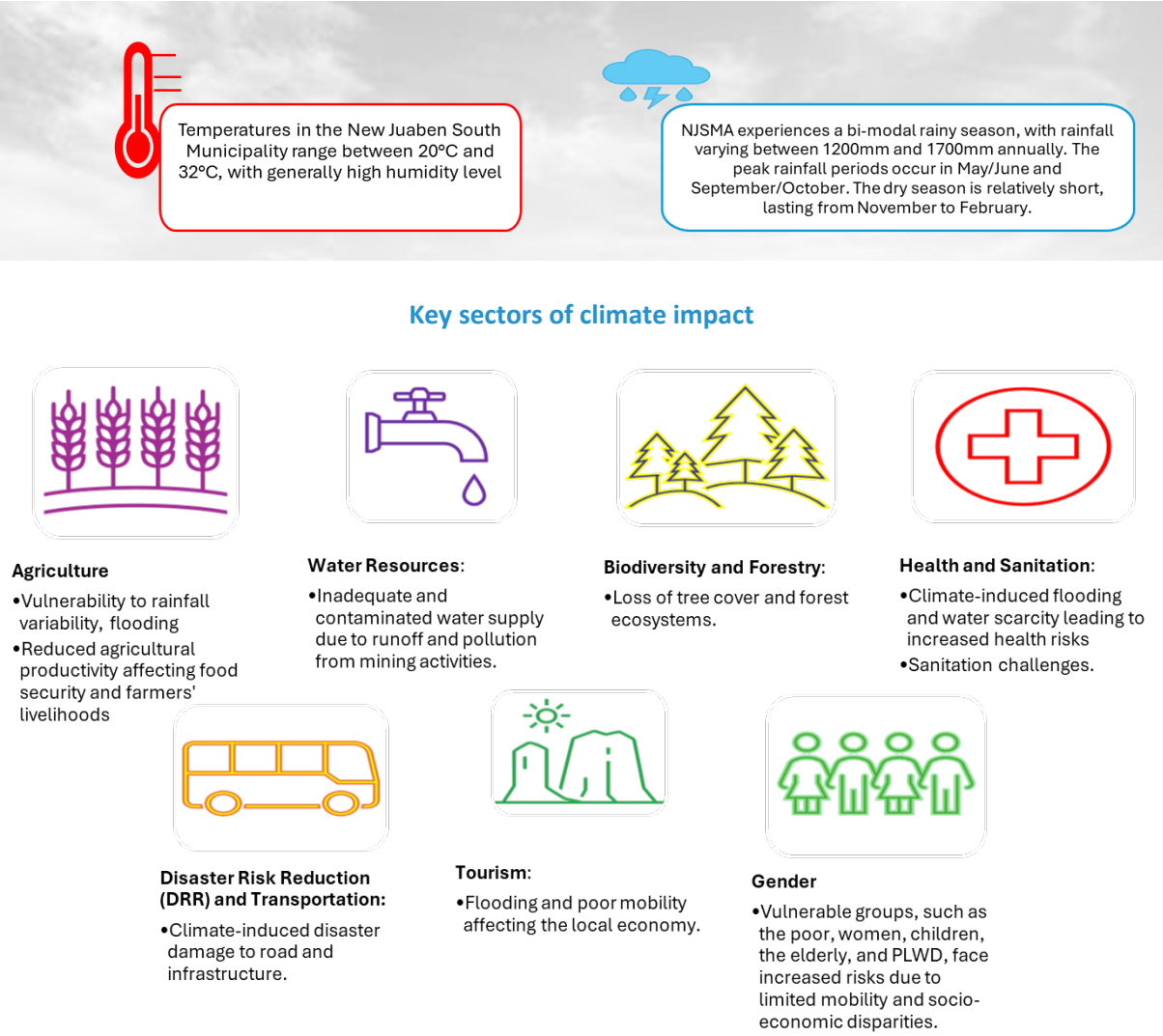
Institution	Role/responsibility	Expected outcome from engagement
Traditional councils	Mobilize communities, support engagement for adaptation activities	Strong community involvement in climate adaptation practices
Faith-based organizations	Mobilize communities and raise awareness on climate issues	Strong community commitment to climate adaptation practices
Opinion leaders	Champion climate awareness and engage communities	Increased local engagement in climate resilience efforts
Local media (GBC Sunrise FM, community information centres, other local radio and television stations, etc.)	Educate and inform the public on NJSMA's climate adaptation plan and strategies	Greater community awareness and support for climate adaptation
Vulnerable groups		
Women, youth, and PWDs	Participate in the design and execution of adaptation initiatives	Greater visibility of climate impacts on vulnerable groups
	Engage in public awareness on climate impacts and adaptation	Increased advocacy and support for these groups in adaptation measures

Source: Adapted from New Juaben South vulnerability assessment report.

3.0 Current Climate and Future Scenarios

This section outlines both the current climate conditions and future climate projections for the New Juaben South Municipal Assembly, with further details available in the Phase III vulnerability assessment report. The report provides a comprehensive analysis of climate change impacts and their relevance to the municipality. It is recommended that this adaptation plan be used alongside the vulnerability assessment, particularly in relation to the climate data it contains. The adaptation plan is grounded in observed climate trends and future projections specific to the region, designed to inform climate-sensitive decision making. Therefore, the climate projections have been customized to meet the distinct needs and characteristics of the New Juaben South Municipal Assembly.

Figure 5. Current overview and impacts



Source: NJSMA vulnerability assessment.

Summary of Climate Hazards, Vulnerabilities, Risks, and Impacts in the New Juaben South Municipal Assembly

Table 4 provides an overview of the climate hazards, key vulnerability factors, and climate impacts and risks across seven priority sectors, summarizing the information presented in the climate change vulnerability assessment for the New Juaben South Municipal Assembly. This table reviews the six priority sectors and highlights particularly vulnerable groups and areas. Collectively, the identified climate vulnerabilities—including those affecting specific groups, communities, and regions—along with the expected impacts and risks for each sector, help determine priority adaptation actions. The information in the table is based on EPA, 2023. The framework is adapted from and informed by Dazé and Echeverria (2016) and the Government of Nepal (2021).

Table 3. Current versus future climate scenarios

Current climate	Future climate
New Juaben South is observed to have experienced a significant reduction in rainfall since 1995, with the amount of rainfall recorded over the years decreasing drastically (Ampaw et al., 2013).	An increasing annual rainfall trend is projected with high variability. The projections expect annual rainfall to increase steadily from a current mean of 1,250 mm, reaching a mean of 1,550 mm by mid-century (2050).
Population growth coupled with increasing economic, housing, and environmental demands have significantly contributed to accelerated land use change. These factors have caused destruction of natural habitat and increased natural hazards such as flooding in the municipality (Nyamekye et al., 2020).	Koforidua is increasingly prone to floods and droughts in the future. The variation in rainfall will likely reveal itself at the start of the wet seasons with either an early or late occurrence of rainfall events. Some years may have an early onset of the dry season, while others may delay.
The mean annual temperature in Ghana increased by 1.0°C from 1961 to 2000, implying a decadal mean increase of temperature of 0.25°C.	Studies predict that if carbon emissions go unchecked under the business-as-usual RCP85 scenario, nighttime temperatures could reach 24.3°C by 2050. By 2050, the mean temperature would also rise to 33.4°C from the current average of 32.3°C.

Source: The NJSMA vulnerability assessment.

Table 4. Summary of climate hazards, climate vulnerability, and climate risks in the New Juaben South Municipality Assembly

Climate hazards	Key vulnerability factors
Acute: Increased rainfall variability and likelihood of heavy rainfall events Increased frequency and severity of extreme weather events and floods **Chronic/slow onset**: Increased intensity of rainfall Changes in precipitation patterns	• High exposure to flooding due to poor drainage and infrastructure • Limited access to economic opportunities and production facilities • Increased frequency of extreme weather events like windstorms and heatwaves • Poor road networks affecting mobility and emergency response • Inadequate access to safe sanitation and health services • Settlements in low-lying areas and valleys prone to recurrent flooding • Unequal distribution of climate adaptation infrastructure • High dependence on small-scale agriculture, with most farms less than 5 acres • High reliance on natural rainfall, limited irrigation infrastructure • Reliance on groundwater for domestic and commercial use with low water storage capacity • Frequent community water shortages, causing long queues at water points

Climate hazards	Key vulnerability factors
	• Illegal mining (galamsey) upstream of the Nsukwao River in neighbouring districts, water pollution at Densuano where water is treated for the NJSMA • High deforestation from activities • Insufficient gender equality, with restricted financial access for women **Particularly vulnerable areas**: Climate-vulnerable communities: Kantudu, Anlo Town, Nsukwao, and Densuano Flooding: Communities along and downstream of the Nsukwao River: Nsukwaosu, Densuano, Srodae, Anlo Town, and Kantudu Deforestation and changes in forest ecosystem due to urbanisation: Adweso, residential areas, Sempoamiensa, and parts of Oguaa **Particularly vulnerable groups**: women, youth, children, senior citizens, persons with disabilities, pregnant women, and incapacitated or disadvantaged persons or groups; farmers with small landholdings dependent on rain-fed agriculture; unemployed youth **Particularly vulnerable assets**: houses, transport infrastructure, schools, Koforidua Water Treatment Plant, farms, hospitals, etc.
Priority sector	**Climate impact/risk**
Agriculture and food security	• Erratic rainfall patterns disrupt planting and harvesting seasons • Increased temperatures and droughts reduce crop yields and food availability • Pests and diseases spread more widely due to changing climatic conditions • Unpredictable weather events damage crops and reduce productivity • Soil degradation and desertification reduce arable land for farming • Flooding and excessive rainfall lead to crop failure and post-harvest losses • Reduced water availability affects irrigation and overall food production • Rising temperatures impact livestock health, reproduction, and productivity • Changing climate patterns increase the cost of inputs like fertilizers and pesticides
Biodiversity and ecosystems	• Habitat loss and ecosystem degradation threaten species survival • Rising temperatures and changing rainfall patterns alter ecological balance • Increased frequency of wildfires and invasive species disrupt biodiversity • Deforestation and land-use changes accelerate biodiversity loss • Migration of species due to climate change disrupts local food chains • Overexploitation of natural resources intensifies due to environmental pressures
Water resources	• Increased competition for water among agriculture, industry, and households • Higher risks of flooding and contamination affecting water quality • Rising temperatures increase evaporation rates, reducing freshwater availability • Pollution and sedimentation from extreme illegal gold mining in neighbouring districts degrade water bodies • Inadequate water supply hinders sanitation and hygiene efforts
Health and sanitation	• Increased spread of vector-borne diseases due to temperature and humidity shifts • Water scarcity and contamination heighten risks of waterborne diseases • Extreme weather events strain health infrastructure and service delivery
Disaster risk reduction and transport	• Lack of public education on disaster preparedness • Increased vulnerability to extreme climate events

Climate hazards	Key vulnerability factors
	• Inadequate disaster response systems • Property loss due to insufficient DRR measures • Loss of lives from poor disaster preparedness • Flooded roads and disrupted transportation systems • Flooding and landslides increase risks for road and transport systems
Gender	• Climate-related stressors disproportionately impact vulnerable groups • Women and marginalized communities face increased economic and social burdens • Limited access to resources and decision making exacerbates climate risks • Increased dependency on others • Socio-economic status disparities • Risks for persons with disabilities (PLWD)
Tourism	• Extreme weather events disrupt tourism seasons and activities • Damage to tourism infrastructure increases costs and reduces investor confidence

Source: Authors

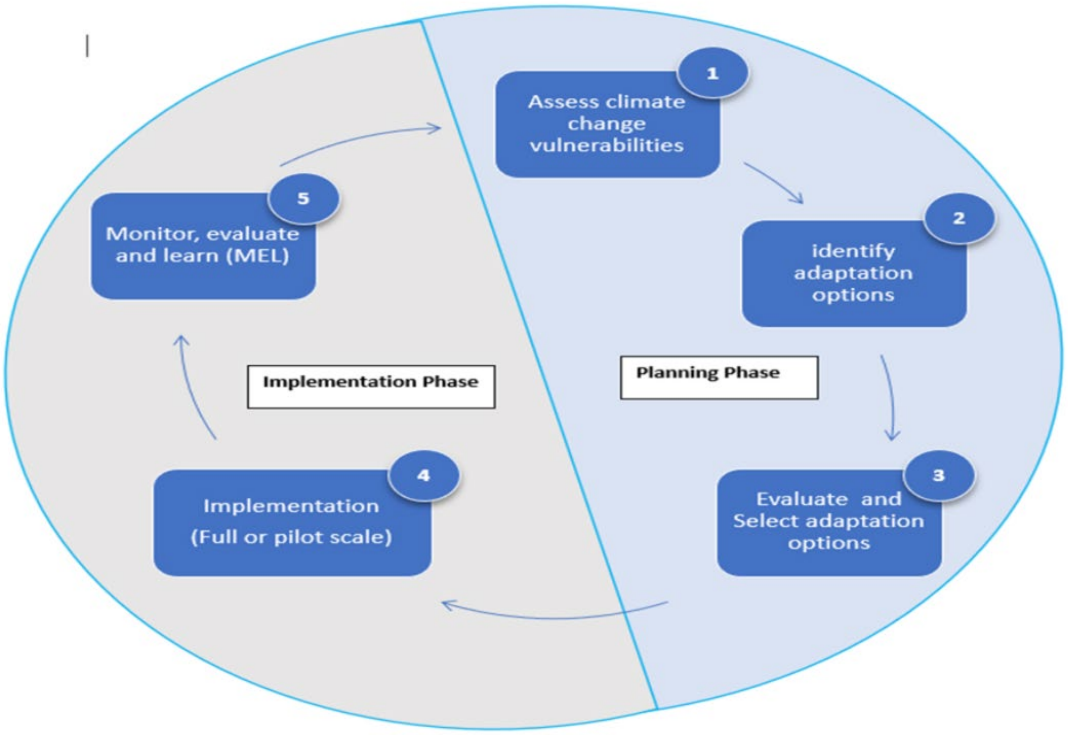
4.0 Adaptation Actions Planning

4.1 Introduction

To effectively manage limited resources while addressing diverse development needs, the NJSMA must adopt a strategic approach in selecting and prioritizing climate adaptation measures. These measures are designed to mitigate climate-related risks while also harnessing any potential advantages that shifting environmental conditions may offer. Adaptation efforts may include initiatives such as increasing community awareness, strengthening institutional support, and implementing management tools like land-use policies and insurance mechanisms.

The process of choosing adaptation strategies is guided by an evaluation of both current and future vulnerabilities, incorporating historical climate data, projected trends, and socio-economic factors. This section outlines the approach for identifying, assessing, and ranking adaptation options, along with the necessary steps for implementation and potential avenues for resource mobilization. The NJSMA's adaptation planning framework is structured to facilitate a systematic and effective response to climate challenges.

Figure 6. Approach to the NJSMA adaptation planning



Source: Gkika et al., 2024.

4.2 Identification and Compilation of Sector-Specific Adaptation Actions

The detailed action plan for climate change adaptation in the New Juaben South Municipal Assembly identified and compiled municipality-specific adaptation options. This process facilitated the exploration of potential adaptation strategies and helped in identifying relevant actions. The adaptation planning team used the methods outlined in Table 5 to determine these adaptation options.

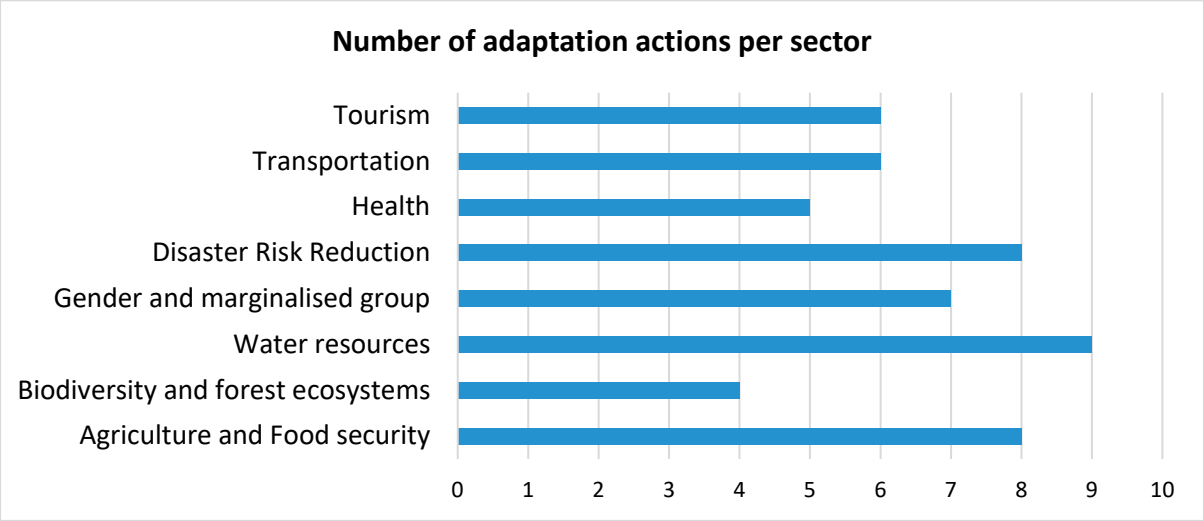
Table 5. Methodology to identify adaptation options

Input source	Description
 Vulnerability assessment report recommendations	The climate change vulnerability assessment for the New Juaben South Municipal Assembly provided specific recommendations on adaptation measures. These suggestions aim to strengthen resilience, boost adaptive capacity, and lower vulnerabilities. They were thoroughly integrated into the planning process.
 Literature review	A comprehensive review of effective solutions and practices was conducted. This included a desk review of government reports, scientific studies, grey literature, and municipal documents to pinpoint adaptation strategies that address similar climate impacts and vulnerabilities.
 Stakeholder consultation	Identified stakeholders were actively engaged through participatory workshops, allowing open, inclusive discussions on adaptation options based on climate scenarios and current and projected impacts.

Source: Author, based on the NJSMA Adaptation Plan.

The measures discussed in Figure 6 were used to create a catalogue of relevant adaptation options presented in the tables in Appendix B. Overall, 53 adaptation options were identified across eight sectors: agriculture, biodiversity, water resources, health, DRR, transport, gender, and tourism. The distribution of the identified actions is illustrated in Figure 7.

Figure 7. Distribution of adaptation actions by sector



Source: Author, based on the NJSMA Adaptation Plan.

4.3 Methodology to Assess and Select Adaptation Options

4.3.1 Adaptation Assessment Criteria

After identifying and compiling a list of 53 potential adaptation options, the next step for the New Juaben South Municipal Assembly was to evaluate and prioritize them based on clearly defined information and criteria. This process involved assessing the suitability of the options within the context of the New Juaben South Municipal Assembly, their potential to enhance resilience and reduce the vulnerabilities identified in the vulnerability assessment report, and their overall impact on sustainable development. The objective of the prioritization process was to make informed decisions that facilitate effective adaptation and avoid maladaptation. To achieve this, relevant actors and stakeholders were engaged in the assessment process to ensure that the selected adaptation options are appropriate and do not result in potentially negative outcomes.

The stakeholders were divided into four groups (agriculture and biodiversity; water resources, health, and sanitation; disaster risk reduction and transportation; and gender and tourism) which screened the proposed adaptation options using a multicriteria analysis (MCA) (see Appendix A). This approach is crucial because each adaptation measure may perform differently across multiple criteria and may involve trade-offs. Therefore, these options must be closely and critically evaluated, with the results of the analysis integrated into decision making regarding priority options.

MCA, also known as multi-objective decision making, is a tool designed for scenarios where single-criterion methods, such as cost-benefit analysis, fail to address all relevant factors. This is especially true when environmental and social impacts are significant but cannot be quantified monetarily. MCA offers a framework for evaluating a comprehensive range of criteria, encompassing social, environmental, technical, economic, and financial aspects (Ngara, 2011). In this method, desired outcomes are clearly defined, and relevant attributes or indicators are established. The evaluation of these indicators is not solely monetary; it often incorporates a quantitative approach involving scoring,

ranking, and weighting a variety of qualitative impacts and criteria. The criteria for assessing adaptation options are outlined in Table 6.

Table 6. Criteria for assessment of adaptation actions

Criteria	Description
Adaptation type	Assesses the risk reduction or risk transfer potential of an adaptation option. For instance, an irrigation system reduces drought risk, while crop insurance transfers it
Implementation level	Identifies the implementation scale of an adaptation, which could be community, municipal/government, or autonomous
Risk gradient	Determines if the adaptation option is "risk-specific" (only effective if a particular risk occurs) or has broader applicability. Risk-specific options, like crop insurance, are beneficial only when certain impacts materialize, while others, such as post-harvest loss technology, are useful continuously
SDGs and development co-benefit	Evaluates alignment of municipal development programs with SDGs for additional benefits
Risk mitigation potential	Assesses the option's effectiveness in reducing specific climate risks
Upscaling and replicability potential	Examines the potential to expand or replicate an adaptation intervention
Cost-effectiveness	Evaluates cost-effectiveness for planning and implementing the adaptation measure
Social and cultural acceptance	Ensures local buy-in by assessing the social and cultural acceptance of the project
Cross-sectoral maladaptation	Evaluates if an adaptation option might unintentionally harm other sectors
Deliverability and feasibility	Assesses the overall practicality and feasibility of the adaptation option
Technical feasibility	Determines if the necessary technical knowledge and capacity for implementing the adaptation measure are available
Governance implications	Evaluates if the adaptation aligns with current governance structures or if it requires modifications or new governance frameworks
Social considerations	Considers the impact of the adaptation measure on social inclusion and community cohesion
Environmental considerations	Assesses potential benefits for GHG reduction, biodiversity, human health, soil and water quality, air quality, climate, and landscapes
Stakeholder interest	Gauges the level of stakeholder support for the adaptation measure
Potential negative outcomes	Identifies possible adverse effects from implementing the adaptation option
Barriers to implementation	Highlights potential institutional, economic, or social obstacles to implementing the adaptation option

Source: Author, based on the NJSMA Adaptation Plan.

As outlined in Appendix B, indicators were derived for each criterion and applied through scoring, ranking, and weighting. The stakeholder groups ranked the criteria for each of the 54 adaptation options identified during the sector group consultations. The results of the comprehensive assessment

are presented in Appendix A. The outcomes of the multicriteria analysis (MCA) were used as inputs to identify adaptation options for further development into concrete actions, based on their aggregated scores from the sum of the variables for each indicator. Additionally, expert judgment, findings from the literature review, and consultations with authorities from the New Juaben South Municipal Assembly and the Environmental Protection Agency (EPA) informed the selection of priority adaptation options.

In each sector, approximately half of the proposed actions were prioritized and selected for further development and implementation considerations. The identification of priority adaptation actions was based on the vulnerability and relative importance of each sector within the New Juaben South Municipal Assembly, as well as the alignment of the actions with the assembly's developmental priorities outlined in the MTDP 2022–2025.

4.4 Adaptation Options

This section outlines the prioritized adaptation options, detailing the adaptation objectives, justifications, and key considerations for each action. It also includes the estimated annual costs for these actions from 2024 to 2030. These cost estimates were calculated based on the budgeting procedures of the New Juaben South Municipal Assembly, which account for year-on-year inflationary factors.

Group discussion session. Credit: Authors

4.4.1 Agriculture and Food Safety

According to the New Juaben South Municipal Assembly vulnerability assessment, agriculture is identified as the most vulnerable sector and requires significant attention. The eight adaptation actions that were identified and assessed through the multicriteria analysis (Table A2, p. 98) are

discussed below. These actions target small-scale farmers who currently depend on rain-fed agriculture and are designed to enhance or maintain agricultural productivity in the face of climate change.

In the NJSMA, the adaptation options for agriculture and food security focused on livelihood resilience and sustainable practices. Animal husbandry and aquaculture are the top-ranked strategies, indicating a strong focus on improving alternative food sources and income through livestock and fish farming. Diversification and conservative agriculture, ranked joint third, underscoring intentions to manage climate risks through varied livelihoods and soil-friendly farming methods. Medium-ranked priorities such as sensitization and training and irrigation systems highlight the importance of farmer awareness and water management. Meanwhile afforestation and agroforestry alongside early warning mechanisms reflect an integrated approach that combines environmental conservation with risk preparedness.

Table 7. Ranking of adaptation options for the agriculture sector

Agriculture and food security	Total	Rank
Animal husbandry	46	1
Aquaculture	45	2
Diversification	39	3
Conservative agriculture	39	3
Sensitization and training	37	5
Irrigation systems	33	6
Afforestation and agroforestry	32	7
Early warning and response mechanisms	32	7

Source: Authors

The adaptation objectives, justifications, and estimated implementation costs for each of these actions are further elaborated upon.

4.4.1.1 Afforestation and Agroforestry

Objective

Afforestation and agroforestry in the agriculture sector aim to enhance climate resilience in the New Juaben South Municipal Assembly (NJSMA) by integrating tree planting into farmlands to improve soil fertility, conserve water, and protect crops from extreme weather conditions. This adaptation strategy reduces soil degradation, enhances biodiversity, and provides farmers with diversified income sources through timber, fruits, and other forest products. By promoting tree-based farming systems, afforestation and agroforestry contribute to long-term agricultural sustainability, improved livelihoods, and enhanced food security.

Justification

Climate change in the NJSMA has led to erratic rainfall patterns, rising temperatures, and increasing soil degradation, which negatively impact agricultural productivity. Traditional farming practices, such as monocropping and extensive land clearing, have exacerbated land degradation, reducing soil

fertility and increasing vulnerability to droughts and floods. Afforestation and agroforestry present a sustainable alternative by incorporating trees into agricultural landscapes to enhance ecosystem services. Trees help stabilize soils, increase organic matter, and regulate microclimates, making farming systems more resilient. Additionally, agroforestry practices—such as alley cropping, silvopasture, and windbreaks—offer farmers economic benefits by providing timber, fodder, and non-timber forest products. These systems not only improve farm productivity but also contribute to carbon sequestration, aligning with broader climate adaptation and mitigation goals.

Key Considerations

Sustainable land management: The integration of trees into agricultural systems must be carefully planned to optimize land use and ensure complementarity between crops and trees. Agroforestry systems such as alley cropping, where trees are planted between rows of crops, can enhance soil fertility and protect against erosion. Similarly, silvopasture systems, which combine trees with livestock grazing, provide shade, fodder, and improved pasture conditions. These approaches promote sustainable land management by reducing the need for synthetic fertilizers and improving long-term farm productivity.

Farmer participation and capacity building: The successful adoption of afforestation and agroforestry depends on farmers' willingness and capacity to integrate trees into their farming practices. Awareness campaigns, training sessions, and demonstration farms can help farmers understand the benefits and best practices of agroforestry. Providing incentives such as access to high-quality seedlings, extension services, and financial support will encourage widespread adoption. Strengthening farmer cooperatives and local organizations can also enhance knowledge sharing and collective action for sustainable land management.

Tree species selection for agricultural benefits: Selecting appropriate tree species is crucial for ensuring that afforestation and agroforestry systems are beneficial to both farmers and the environment. Multipurpose tree species that improve soil fertility (such as nitrogen-fixing trees), provide fodder, or yield fruits and nuts should be prioritized. Drought-resistant species will be essential to ensure resilience in the face of changing rainfall patterns. A mix of fast-growing and long-lived trees can balance short-term economic gains with long-term ecological sustainability.

Land tenure and policy support: Secure land tenure arrangements and supportive policies are necessary to encourage farmers to invest in tree planting. Land ownership uncertainties can discourage long-term investment in agroforestry, so clear policies on land use rights must be established. Municipal incentives, such as the provision of farm inputs for afforestation, agroforestry, and climate-smart agriculture can further promote adoption. Strengthening enforcement of land use regulations to prevent illegal deforestation and land degradation will also support the sustainability of these practices.

Monitoring and long-term sustainability: Sustaining afforestation and agroforestry efforts requires regular monitoring to assess tree survival rates, soil health improvements, and overall farm productivity. Community-based monitoring initiatives can enhance local ownership and accountability. Establishing agroforestry research and development programs can help improve best practices and adapt systems to local climatic and soil conditions. Additionally, integrating afforestation

and agroforestry into municipal and national climate adaptation plans will ensure long-term policy support and funding for these initiatives.

4.4.1.2 Sensitization and Training

Objective

Sensitization and training programs in the agriculture sector aim to enhance climate resilience in the New Juaben South Municipal Assembly (NJSMA) by equipping farmers with knowledge, skills, and best practices for climate-smart agriculture. These programs focus on increasing awareness of climate change impacts, promoting sustainable land management techniques, and strengthening farmers' adaptive capacities to improve productivity and food security. By fostering behavioural change and encouraging the adoption of innovative farming methods, sensitization and training initiatives help ensure long-term agricultural sustainability in the face of climate variability.

Justification

Farmers in the NJSMA face significant challenges due to climate change, including erratic rainfall patterns, soil degradation, and increased pest infestations. Many farmers rely on traditional farming methods that may not be well suited to changing climatic conditions, leading to lower yields and increased vulnerability to extreme weather events. Sensitization and training programs play a crucial role in bridging the knowledge gap by providing farmers with information on climate-resilient practices such as conservation agriculture, crop diversification, agroforestry, and efficient water use. Training also enhances farmers' access to and understanding of modern technologies, such as weather forecasting tools and precision farming techniques. When combined with extension services and participatory approaches, these programs can drive widespread adoption of adaptive measures, thereby reducing climate-related risks and ensuring food security

Key Considerations

Continuous education and training for farmers: Providing continuous comprehensive education and training programs for farmers is crucial to the successful adoption of conservation agriculture. Workshops and field demonstrations by AEAs should focus on techniques such as counter ploughing, minimum tillage, crop rotation, cover cropping, and education against bush burning to prepare farms.

Climate-smart agricultural practices: Training should focus on equipping farmers with practical skills and knowledge on climate-smart agricultural techniques that enhance resilience and productivity. Topics such as soil conservation, crop rotation, integrated pest management, water harvesting, and organic farming should be covered. Demonstration farms and hands-on training sessions will be essential in ensuring that farmers can effectively apply these techniques on their own farms.

Access to extension services and farmer support: Strengthening agricultural extension services is critical for ensuring that farmers receive continuous technical guidance and support. Training programs should be complemented with regular farm visits, advisory services, and access to information on improved farming techniques. Digital extension platforms, such as SMS alerts and mobile applications, can also enhance farmers' access to real-time climate information and best practices.

Community-based training and peer-to-peer learning: Farmer-led training initiatives and community-based learning approaches can improve knowledge dissemination and ensure sustainability. Establishing farmer field schools and peer exchange programs will enable farmers to share experiences and adopt best practices more effectively. Community champions and lead farmers can be trained to serve as resource persons for knowledge sharing within their communities.

Gender and social inclusion: Sensitization and training programs must be inclusive and accessible to all farmers, including women, youth, and marginalized groups. Tailoring training sessions to address the specific needs and challenges faced by different farmer demographics will enhance participation and impact. Providing training in local languages and using visual aids can also improve understanding and engagement among diverse groups.

Sustainability and institutional support: Ensuring the long-term sustainability of sensitization and training initiatives requires institutional backing and integration into existing agricultural development programs. Partnerships with government agencies, research institutions, and non-governmental organizations can enhance the reach and effectiveness of training programs. Additionally, securing funding and policy support for continuous farmer education will be crucial for maintaining the momentum of adaptation efforts.

4.4.1.3 Conservative Agriculture

Objective

Conservation agriculture (CA) aims to enhance climate resilience in the New Juaben South Municipal Assembly (NJSMA) by promoting sustainable farming practices that improve soil health, increase water retention, and reduce vulnerability to climate change. This adaptation strategy focuses on minimizing soil disturbance, maintaining permanent soil cover, and diversifying crops to enhance productivity while protecting the environment. By adopting CA, farmers can mitigate the negative effects of erratic rainfall, drought, and soil degradation, ensuring long-term food security and agricultural sustainability.

Justification

Climate change has led to declining soil fertility, increased erosion, and unpredictable weather patterns in the NJSMA, threatening agricultural productivity. Traditional farming practices, such as excessive tillage, burning crop residues, and monocropping have further degraded soil structure and depleted essential nutrients. Conservation agriculture offers a viable alternative by reducing soil disturbance, improving organic matter content, and enhancing soil moisture retention. The combination of minimal tillage, cover cropping, and crop rotation promotes soil biodiversity, reduces reliance on chemical fertilizers, and enhances ecosystem resilience. Additionally, CA reduces greenhouse gas emissions by sequestering carbon in the soil, contributing to both climate adaptation and mitigation.

Key Considerations

Minimum soil disturbance (no-till farming): Reducing or eliminating ploughing and tillage preserves soil structure, enhances water infiltration, and prevents erosion. No-till farming allows organic matter to accumulate, improving soil fertility and reducing the need for synthetic fertilizers. However,

transitioning to no-till practices requires initial investments in specialized equipment and training for farmers to understand proper soil management techniques.

Permanent soil cover (mulching and cover crops): Keeping the soil covered year-round with crop residues or cover crops helps reduce evaporation, suppress weeds, and prevent erosion. Mulching with organic materials, such as crop residues or grass, improves soil moisture retention and reduces temperature fluctuations. Cover crops, such as legumes, further enrich the soil by fixing nitrogen, enhancing long-term productivity and resilience to climate stressors.

Crop diversification and rotation: Planting a variety of crops in rotation helps break pest and disease cycles, improves soil nutrient balance, and enhances food security. Intercropping and agroforestry approaches can be integrated to provide additional benefits, such as shade, improved biodiversity, and alternative income sources for farmers. Choosing drought-resistant and climate-adaptive crop varieties will further strengthen agricultural resilience in the NJSMA.

Farmer awareness and capacity building: The successful implementation of conservation agriculture requires farmer training and capacity building. Many farmers may be unfamiliar with CA principles, so extensive sensitization and demonstration farms are necessary to showcase its benefits. Training programs should focus on practical implementation, best practices, and long-term benefits to encourage widespread adoption.

Policy support and incentives: Government and institutional support are critical for scaling up conservation agriculture. Policies that provide incentives such as subsidies for cover crop seeds, reduced taxes on conservation-friendly equipment, and grants for soil restoration projects will encourage farmers to transition to CA practices. Additionally, integrating CA into national agricultural policies and extension programs will ensure its sustainability and long-term impact.

Monitoring and research for continuous improvement: Continuous monitoring and research on conservation agriculture practices in the NJSMA will help assess their effectiveness and inform improvements. Establishing farmer-led research initiatives and partnerships with agricultural institutions will provide valuable insights into soil health, yield performance, and climate adaptation benefits. Regular assessments will also help refine best practices and ensure that CA remains a viable adaptation strategy for farmers in the municipality.

4.4.1.4 Early Warning and Response Mechanisms

Objective

Early warning and response mechanisms in the agriculture sector aim to strengthen the resilience of farmers in the New Juaben South Municipal Assembly (NJSMA) by providing timely and accurate climate-related information. These systems help predict and monitor extreme weather events, pest outbreaks, and other climate risks, enabling farmers to take proactive measures to minimize losses. By improving preparedness and response capacity, early warning mechanisms contribute to safeguarding livelihoods, ensuring food security, and reducing the negative impacts of climate change on agricultural production.

Justification

Climate change has increased the frequency and intensity of extreme weather events such as droughts, floods, and storms, posing a significant threat to agricultural activities in the NJSMA. Unpredictable rainfall patterns and rising temperatures also contribute to pest and disease outbreaks that can devastate crops and livestock. Many farmers lack access to real-time climate information, making it difficult to prepare for or respond effectively to these threats. Implementing early warning systems will bridge this gap by providing localized and actionable information through meteorological forecasts, digital alerts, and community-based monitoring. Timely dissemination of warnings will enable farmers to make informed decisions on planting times, irrigation schedules, pest control, and other adaptive strategies to mitigate risks and enhance productivity.

Key Considerations

Data collection and monitoring systems: Establishing robust weather monitoring infrastructure and agricultural surveillance systems is essential for effective early warning mechanisms. This includes installing automated weather stations, deploying satellite-based climate monitoring tools, and integrating traditional knowledge systems. Continuous data collection on temperature, rainfall, soil moisture, and pest activity will improve the accuracy of forecasts and alerts.

Timely and accessible information dissemination: Ensuring that climate and disaster alerts reach farmers in real-time is critical for response effectiveness. A multi-channel communication strategy, including SMS alerts, community radio broadcasts, mobile apps, and extension services, should be adopted. Information should be delivered in local languages and tailored to the literacy levels of different farmer groups to ensure widespread accessibility and comprehension.

Capacity building and training: Farmers and agricultural extension officers need training on how to interpret early warning information and implement appropriate response actions. Sensitization programs should focus on risk assessment, disaster preparedness, and climate-smart farming techniques. Building the capacity of local communities to develop and use simple early warning indicators, such as changes in wind patterns or pest migration, will also enhance resilience.

Community engagement and participatory approaches: Involving farmers, local authorities, and traditional leaders in the design and implementation of early warning systems will improve their effectiveness and acceptance. Establishing community-based disaster risk reduction committees can enhance coordination and ensure that response measures are context-specific. Peer-to-peer learning networks and farmer cooperatives can also facilitate the dissemination of climate risk information.

Integration with national and local policies: For sustainability, early warning and response mechanisms should be integrated into existing national climate adaptation and disaster risk management frameworks. Collaboration with government agencies, meteorological services, and research institutions will help align local efforts with broader climate resilience strategies. Institutionalizing early warning systems within municipal agricultural programs will ensure long-term implementation and impact.

Sustainability and funding: Sustaining early warning systems requires continuous investment in technology, training, and infrastructure. Public-private partnerships, donor support, and government

funding should be leveraged to finance system upgrades and expansion. Encouraging private sector involvement, such as mobile network operators providing weather alert services, can enhance sustainability while reducing costs for farmers.

Gender dimensions: Women play a crucial role in agricultural production in the NJSMA, yet they often face challenges in accessing early warning systems due to limited access to mobile technology, lower literacy levels, and exclusion from decision-making processes. Gender-sensitive data collection should ensure that women farmers' experiences and vulnerabilities are adequately captured, recognizing that they often face unique climate risks due to land tenure insecurity and limited access to resources. Gender-responsive early warning mechanisms should ensure that information reaches PWDs, the aged, women, and children through channels they can easily access, such as community-based groups, women's cooperatives, and radio programs in local dialects. Training programs should consider the unique schedules and responsibilities of women, including household and caregiving duties, to enhance their participation. Additionally, gender-inclusive disaster response plans should recognize the different vulnerabilities men and women face, ensuring that adaptation measures address the specific needs of women farmers, particularly those heading households or engaged in subsistence agriculture.

4.4.1.5 Diversification of Livelihoods

Objective

To promote the diversification of livelihoods as a climate adaptation strategy that reduces vulnerability to climate shocks, enhances economic resilience, and provides inclusive opportunities for sustainable growth beyond traditional agricultural practices. By focusing on these key contextual considerations, livelihood diversification can significantly contribute to building climate resilience in New Juaben South, fostering economic empowerment, and reducing the risks associated with climate-dependent farming.

Justification

Diversification of livelihoods is essential in New Juaben South due to the district's heavy reliance on climate-sensitive sectors, which is increasingly threatened by droughts, floods, erratic rainfall and other climate-related shocks. By expanding income-generating activities to include agro-processing, small-scale businesses, and eco-friendly ventures such as beekeeping and agroforestry, the community can mitigate the risks posed by fluctuating agricultural yields. This strategy not only builds economic resilience but also ensures more sustainable land use and environmental conservation. Diversification aligns with municipal priorities of improving community resilience and creates new opportunities for women, youth, and marginalized groups, fostering social equity. Despite challenges related to affordability and institutional feasibility, promoting a diverse range of livelihoods will reduce dependence on single sectors and enhance adaptive capacity across the municipality.

Key Considerations

Access to start-up capital and credit facilities: Access to financial resources is a major challenge for individuals looking to diversify their livelihoods. In New Juaben South, promoting access to affordable credit through local savings schemes, microfinance institutions, or government-supported grants is

key. Financial literacy training can also empower individuals to manage and expand their new ventures effectively.

Promotion of value-added agricultural products: One of the most feasible options for livelihood diversification is to focus on value addition in agriculture, such as agro-processing. Encouraging farmers to move beyond raw crop production to processing and packaging agricultural products can open up new markets and income streams. Investment in local processing facilities and training in value-chain management will be crucial to making this shift viable. Drawing upon indigenous knowledge and existing natural resources, such as shea nut processing, artisanal crafts, or community tourism, can provide livelihood options that are culturally accepted and sustainable. Local knowledge should be integrated into diversification initiatives to ensure they align with community norms and practices.

Training skills for non-farming livelihoods: Training programs should be developed to equip community members—especially women and youth—with the skills necessary for non-farming livelihoods. Skills such as entrepreneurship, vocational training in trades like carpentry or tailoring, and digital literacy for e-commerce will allow individuals to pursue diverse income sources and thrive in different sectors beyond agriculture.

Creating market linkages for new livelihoods: For diversified livelihoods to be sustainable, access to markets is critical. The New Juaben South Municipal Assembly must establish stronger market linkages for non-traditional products. This can be achieved through partnerships with regional buyers, participation in trade fairs, and the development of local cooperative groups that can pool resources to reach larger markets.

Gender, social, and culturally sensitive livelihood strategies: Women often face distinct barriers to accessing new livelihood opportunities. Livelihood diversification strategies in New Juaben South should actively target these barriers, ensuring that women have equal access to resources, training, and markets. Supporting women's cooperatives and creating mentorship opportunities for female entrepreneurs can help overcome gender-specific challenges.

Moreover, new livelihood activities must be accepted by the community. This means considering traditional practices and local social structures when introducing new ventures. Engaging community leaders in the design and promotion of diversification strategies ensures that new livelihoods are socially accepted and that local customs are respected.

Environmental sustainability: New livelihood activities should be environmentally sustainable and climate resilient. Diversification into eco-friendly practices such as organic farming, reuse of rice factory waste as biochar, or renewable energy projects like solar-powered water pumps can ensure that economic activities do not exacerbate environmental degradation but instead contribute to long-term climate resilience.

Institutional support and policy alignment: For diversification to succeed, strong institutional support from local governments and NGOs is essential. Policies that incentivize diversification—such as tax breaks for small businesses or subsidies for eco-friendly technologies—should be aligned with the municipality's climate resilience goals. Institutional partnerships with development organizations can

also provide technical support and seed funding for innovative projects. To ensure the success of livelihood diversification, ongoing monitoring and evaluation systems must be established. This will allow for the assessment of which diversification strategies are most effective and what adjustments are needed. By incorporating feedback from participants, the municipality can continuously refine its approach to ensure long-term sustainability and community support.

4.4.1.6 Irrigation Systems

Objective

To enhance the adoption and effectiveness of irrigation systems in the New Juaben South Municipal Assembly, the Densu and Nsukwakwao rivers, along with other rivers and waterbodies in the municipality should be used as natural resources to support increased irrigation uptake as a climate adaptation strategy. This will improve agricultural productivity, ensure water resource efficiency, and build resilience against droughts and erratic rainfall patterns. By focusing on these key considerations, the New Juaben South Municipal Assembly can foster the successful adoption and scaling of irrigation systems, helping to enhance food security, promote sustainable water management, and build resilience to climate change in the region.

Justification

In New Juaben South, climate variability and water scarcity are significant challenges for farmers who rely on rainfall for crop production. The introduction and scaling of efficient irrigation systems can provide a reliable water supply, reducing farmers' dependence on increasingly unpredictable weather patterns. By allowing for year-round farming and improved crop yields, irrigation systems directly enhance food security and economic resilience. Moreover, water-efficient irrigation technologies contribute to sustainable water management, preserving limited water resources while boosting productivity. Although challenges related to affordability and institutional feasibility exist, prioritizing the adoption of irrigation systems aligns with the municipality's goal of fostering agricultural resilience and reducing the risks posed by climate change. Additionally, improving gender responsiveness within irrigation projects will ensure that women, who play a vital role in farming, have equitable access to these resources.

Key Considerations

Affordability and financing models: One of the primary barriers to adopting irrigation systems in New Juaben South is affordability. Developing innovative financing models, such as government subsidies, pay-as-you-go systems, or low-interest loans, can make irrigation technologies more accessible to smallholder farmers. These schemes should also consider marginalized groups like women and youth, ensuring their ability to invest in irrigation solutions. Also, potential sources of funding need to be identified, and a financial plan developed that is sustainable over the long term.

Water availability and water-efficient technologies: Irrigation development in the NJSMA must be implemented with caution, taking into consideration limited water availability and the dependence on underground water resources which may not be available all year round. Implementing technologies that capture and store water efficiently will ensure that irrigation remains viable even in times of drought or water scarcity. The success of irrigation systems in the NJSMA can be achieved by

promoting efficient water use, reducing runoff and evaporation, and encouraging farmers to adopt conservation farming techniques that complement irrigation efforts.

Promoting the use of solar-powered irrigation pumps can also reduce reliance on electricity or fuel, making irrigation more sustainable and cost-effective. Also, water-efficient irrigation technologies, such as drip or sprinkler systems, should be prioritized in New Juaben South due to the region's water scarcity issues. These systems optimize water usage, reducing waste and ensuring that crops receive adequate water without depleting local resources.

Capacity building and training for farmers: The success of irrigation systems depends on farmers' ability to use and maintain them effectively. Training programs that focus on the technical skills required to operate, repair, and optimize irrigation systems should be provided to farmers. Capacity building efforts should also include water management techniques to ensure that farmers understand the importance of sustainable water use in a changing climate. Currently, farmers have indigenous ways of irrigating, such as using plastic bottles as sprinklers and carting water from rivers and other water bodies. Such traditional technologies should be considered during implementation

Community-based water management and sustainability: Effective irrigation systems require collective management of water resources. Community-based water management committees can be established to oversee the equitable distribution of water, resolve conflicts, and ensure that water resources are shared fairly across different groups. These committees should have representation from all key stakeholders, including women and marginalized farmers, to ensure inclusivity and transparency in decision making.

Information collected through these systems can inform adjustments and improvements, ensuring that irrigation systems remain sustainable, equitable, and responsive to the needs of farmers over time.

Gender inclusion: Women in New Juaben South play a significant role in agriculture, yet they often have less access to irrigation systems due to social and economic barriers. Gender-sensitive approaches should be incorporated into irrigation projects to ensure that women have equal access to these resources. This includes providing targeted financial support, training, and leadership opportunities for women in water management roles.

Collaboration with local institutions and NGOs: Institutional support is essential for the successful implementation of irrigation systems. Partnerships with local governments, agricultural extension services, and NGOs can provide farmers with the technical expertise, funding, and resources they need to adopt and maintain irrigation technologies. Collaborative efforts can also ensure that irrigation systems are aligned with broader climate adaptation and water management strategies.

4.4.1.7 Aquaculture

Objective

Aquaculture serves as a climate adaptation strategy in the New Juaben South Municipal Assembly (NJSMA) by enhancing food security, diversifying income sources, and reducing reliance on climate-vulnerable land-based agriculture. With increasing climate variability affecting rainfall patterns and

crop yields, integrating aquaculture into local food systems provides a stable and sustainable source of protein and livelihood for farmers. By optimizing water use and promoting climate-resilient fish farming practices, aquaculture enhances overall agricultural resilience in the face of climate change.

Justification

Agricultural productivity in the NJSMA is increasingly threatened by erratic weather conditions, soil degradation, and water shortages, leading to reduced crop yields and food insecurity. Traditional farming systems face difficulties in adapting to shifting climate patterns, making it necessary to explore alternative or complementary livelihood options such as aquaculture. Fish farming requires less land than traditional crop farming and can be practiced in diverse environments, including ponds, tanks, and integrated rice-fish systems. Additionally, aquaculture contributes to nutritional security by providing an affordable source of protein and essential micronutrients. Properly managed aquaculture can also enhance water conservation and utilization, making it a viable climate adaptation measure for smallholder farmers.

Key Considerations

Gender dimensions: Aquaculture presents opportunities for the youth, women, and men as an alternative to traditional crop farming. The adaptation option provides a livelihood alternative to economically marginalized groups. These groups often face challenges in accessing land, water resources, and credit for agriculture investment.

Gender-sensitive policies should be implemented to enhance women's ownership and decision-making roles in aquaculture enterprises. Additionally, training programs should consider women's time constraints and provide flexible learning formats to encourage their participation. Supporting women-led aquaculture cooperatives and providing financial incentives can enhance their involvement in climate-resilient food production.

Capacity building and extension services: Building the technical capacity of farmers through training in fish farming best practices, disease management, and climate-smart aquaculture techniques is essential for long-term success. Extension services should be strengthened to provide continuous technical support, especially for smallholder farmers new to aquaculture. Demonstration farms and farmer-to-farmer learning approaches can be effective in knowledge transfer and adoption of best practices.

Site selection and water resource management: Effective aquaculture requires suitable site selection, particularly in areas with reliable water sources and proper drainage. Farmers must assess water availability, quality, and sustainability to prevent depletion of local resources. Climate-smart water management techniques, such as rainwater harvesting and recirculating aquaculture systems, should be promoted to optimize water use. Proper site selection should also minimize environmental impacts such as water pollution and habitat destruction.

Species selection and climate resilience: The choice of fish species plays a critical role in the success of aquaculture under changing climate conditions. Farmers should prioritize climate-resilient species that can tolerate temperature fluctuations, variable water quality, and disease pressures. Indigenous and fast-growing species such as tilapia and catfish are well-suited for local conditions in the NJSMA.

Additionally, breeding programs for heat- and disease-resistant strains should be encouraged to enhance productivity and reduce losses.

Sustainable feed and inputs: Ensuring the availability of affordable, high-quality fish feed is crucial for the long-term viability of aquaculture. Climate change can affect the availability of traditional fish feed ingredients, making it necessary to explore alternative, locally available feed sources such as insect-based proteins, agricultural by-products, and plant-based feeds. Encouraging the development of sustainable feed supply chains will reduce dependency on imported feed and enhance the financial sustainability of aquaculture enterprises.

Integration with existing farming systems: Aquaculture can be effectively integrated with other agricultural practices to maximize productivity and resource efficiency. Integrated aquaculture-agriculture systems, such as rice-fish farming or livestock-fish farming, allow for nutrient recycling and improved farm resilience. For instance, fish waste can be used as organic fertilizer for crops, while farm runoff can provide nutrients for fishponds. Promoting these integrated systems will enhance overall agricultural sustainability and resilience to climate shocks.

Market access and value chain development: For aquaculture to be a viable adaptation strategy, farmers need reliable market access and value chain support. Establishing fish processing and preservation facilities, improving transportation networks, and linking farmers to urban markets will enhance profitability. Additionally, cooperative models and farmer associations can strengthen bargaining power, reduce transaction costs, and facilitate access to credit and technical assistance. Strengthening the entire aquaculture value chain will ensure long-term benefits for farmers in the NJSMA.

Policy and institutional support: A supportive policy environment is necessary to promote aquaculture as a climate adaptation strategy. Policies should address regulatory frameworks for water use, land access, and environmental sustainability. Government and private sector collaboration should focus on providing incentives, financial support, and infrastructure development to scale up aquaculture in the NJSMA. Institutional support through research partnerships, technology transfer, and climate risk assessments will further enhance the resilience and productivity of the sector.

Sustainability and environmental considerations: While aquaculture offers climate adaptation benefits, it must be managed sustainably to prevent negative environmental impacts such as water pollution, habitat destruction, and overuse of antibiotics. Farmers should adopt environmentally friendly practices such as integrated multi-trophic aquaculture, proper waste management, and the use of natural water filtration systems. Policy-makers should also enforce sustainable aquaculture guidelines to balance productivity with environmental conservation.

4.4.1.8 Animal Husbandry

Objective

The general objective of promoting animal husbandry as an adaptation strategy in the NJSMA is to provide farmers with a resilient, alternative livelihood option that complements traditional crop farming, diversifying income sources, and ensuring food security in the face of climate change. Similar to aquaculture, animal husbandry offers a means of reducing vulnerability to climate impacts, such as

droughts and unpredictable rainfall, which disproportionately affect crop production. By improving livestock management practices, breed selection, and feed systems, animal husbandry enhances agricultural resilience, offering a robust system that is less dependent on climate-sensitive crops.

Justification

In the NJSMA, climate change is significantly impacting crop farming, making it harder to predict harvests and sustain food production. As an alternative to traditional crop farming, animal husbandry, like aquaculture, can reduce the risk of food insecurity by providing a reliable source of nutrition and income. Both sectors allow farmers to diversify their livelihoods and decrease their reliance on unpredictable crop yields. Livestock, particularly when integrated with sustainable feed practices and climate-resilient breeds, can act as a buffer during times of crop failure, offering both a source of protein for communities and a means to maintain economic stability. Furthermore, as with aquaculture, animal husbandry systems can be adapted to local environmental conditions and are often more resilient to extreme weather events, ensuring that farming systems remain functional under changing climatic conditions.

Key Considerations

Financial support and access to credit: Access to financial resources is critical for expanding and improving animal husbandry practices in response to climate change. As with aquaculture, livestock farmers in the NJSMA need affordable credit options and insurance products tailored to livestock risks, such as droughts and diseases. Financial institutions should offer low-interest loans to enable farmers to invest in animal health, feed, and infrastructure. Access to credit ensures that farmers can implement improved practices, acquire necessary resources, and scale up their operations, contributing to more climate-resilient livelihoods.

Market access and value chain development: Just as aquaculture benefits from improved market access and value chain development, animal husbandry requires a well-developed infrastructure to ensure farmers can access profitable markets. This includes developing processing facilities for meat, dairy, and other animal products, and enhancing transport networks to reach regional and national markets. By integrating value chains and offering more diverse products, farmers can increase their income, improve the sustainability of their operations, and create more climate-resilient agricultural systems. Strengthening market access can also create economic opportunities, similar to how aquaculture helps generate employment and income in rural areas.

Gender dimensions: Women are heavily involved in both animal husbandry and aquaculture, often in small-scale operations. However, they face barriers to accessing resources, credit, and decision-making power. In the NJSMA, it is important to ensure that women have equal access to livestock ownership, training in husbandry practices, and resources such as feed and water. Gender-sensitive policies should encourage women's participation in livestock value chains, from breeding and care to marketing and processing. As with aquaculture, promoting gender equity in livestock farming can empower women economically and help improve overall household resilience to climate change impacts.

Breed selection and genetic improvement: Similar to aquaculture, breed selection plays a crucial role in making animal husbandry more resilient to climate change. Climate-resilient breeds, such as

drought-tolerant or heat-resistant livestock, should be prioritized to ensure that animals can thrive in the NJSMA's changing climate. Just as aquaculture benefits from the selection of hardy fish species, livestock farmers must focus on improving animal genetics to enhance disease resistance, productivity, and adaptation to the local environment. This can be achieved through selective breeding and crossbreeding techniques.

Water management and access: Water is a critical resource for both livestock and fish farming, and its availability is increasingly threatened by climate change. For animal husbandry, ensuring access to clean, reliable water sources is key to sustaining healthy livestock populations. Water management strategies such as the construction of water storage systems, rainwater harvesting, and the provision of drinking troughs can significantly improve the resilience of livestock farming. Just like aquaculture systems that require controlled water sources, livestock farms in the NJSMA need efficient water management practices to mitigate the impact of droughts or floods on animal health and productivity.

Animal nutrition and feed management: As with aquaculture, where feeding practices must adapt to changing environmental conditions, animal husbandry in the NJSMA requires improved feed management to cope with the impacts of climate change. Climate-induced changes to pasture availability and quality necessitate the use of supplemental feed or agro-industrial by-products. Livestock farmers should be trained in sustainable forage production and efficient feed management techniques, much like how aquaculture farmers are encouraged to diversify fish feeds. This ensures that animals receive consistent nutrition, regardless of the variability in natural pasture.

Livestock health and disease control: Climate change can lead to increased disease outbreaks in both livestock and fish, making health management a priority. Animal husbandry practices, like aquaculture, must address the risk of climate-related diseases by investing in better veterinary services, vaccination programs, and pest control measures. Farmers should adopt practices such as regular health checks, disease-resistant breeds, and biosecurity measures to protect their herds from climate-induced health threats. Effective surveillance and response systems for disease outbreaks can also reduce livestock mortality and improve overall farm productivity.

Livestock housing and shelter: Providing adequate shelter for livestock is essential, particularly in light of the increased frequency of extreme weather events linked to climate change. As aquaculture systems are designed to protect fish from adverse weather conditions, animal husbandry requires proper housing to shield livestock from excessive heat, rain, and cold. Climate-resilient housing structures, including shade for cattle or poultry and well-ventilated barns, are critical to ensuring animal well-being. Proper housing helps prevent the spread of diseases and reduces exposure to environmental stresses, just as controlled environments are essential for maintaining fish health in aquaculture.

Climate-smart practices and sustainable management: Animal husbandry, like aquaculture, benefits from the adoption of climate-smart practices that reduce environmental impacts. These include rotational grazing, silvopastoral systems (integrating trees with livestock), and efficient manure management to enhance soil fertility. Climate-smart practices ensure the sustainability of livestock farming by reducing overgrazing, maintaining biodiversity, and increasing carbon sequestration. Educating farmers on these practices will improve long-term productivity and contribute to a more

sustainable and resilient agricultural system, much like the environmental benefits of integrated multi-trophic aquaculture systems.

Policy and institutional support: Supportive policies and institutional frameworks are necessary for scaling up animal husbandry as an adaptation strategy. As with aquaculture, national and local policies should promote sustainable livestock farming, provide incentives for best practices, and support the development of infrastructure. Extension services, research institutions, and local governments must collaborate to deliver the knowledge, technology, and resources needed to improve livestock productivity and resilience. By fostering a favourable policy environment, both animal husbandry and aquaculture can thrive as effective climate adaptation strategies.

Table 8. Adaptation actions for the agriculture and food safety sector

Objectives	Indicators of success	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	Lead institution	Implementing partners
Action step: Afforestation and agroforestry					
Restore flood degraded lands and reduce erosion Promote sustainable land management and enhance biodiversity Provides farmers with diversified income sources through timber, fruits, and other forest products	Number of hectares afforested Survival rate of planted trees	Medium to long term	Human, financial, technological	Municipal Department of Agriculture, Forestry Commission	NGOs, traditional authorities, MoFA, EPA, NADMO, Municipal Assembly Development Planning, FBOs, CSIR and farmer cooperatives, international development partners
Action step: Sensitization and training					
Increasing awareness of climate change impacts Foster behavioural change and encourage the adoption of innovative farming methods	Number of training sessions held Adoption rate of new practices	Short term	Human, financial, technological	NADMO and Municipal Department of Agriculture	MoFA, local radio stations and information centres, FBOs, Ministry of Education, Ministry of Health, traditional authorities, academia, international development partners
Action step: Conservative agriculture					
Promote sustainable farming practices that improve soil health, increase water retention, and reduce vulnerability to climate change Minimize soil disturbance, maintaining permanent soil cover	Area under conservation practices Reduction in erosion Increase in yield per acre	Short to medium term	Human, financial	Municipal Department of Agriculture	MoFA, CSIR, academia, NGOs, FBOs and farmer cooperatives, international development partners

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Action step: Early warning and response mechanisms					
Predict and monitor extreme weather events, pest outbreaks, and other climate risks Strengthen preparedness for climate-related risks Enable farmers to take proactive measures to minimize losses	Functional early warning system in place Community awareness and responsiveness Reduction in loss from climate-related events	Short term	Human, financial, technological	NADMO, Ghana Meteorological Agency, Municipal Department of Agriculture	Municipal Assembly, MoFA, media, local radio stations, FBOs, research and academia, Water Resources Commission, international development partners
Action step: Diversification of livelihoods					
Reduce dependence on single crop or income source Provide inclusive opportunities for sustainable growth Promote fish farming as an alternative livelihood	Number of farmers with alternative income Household income growth Adoption of non-farm enterprises	Medium term	Human, financial, technological	Municipal Department of Agriculture	BAC, NBSSI/GEA, NGOs, women's groups, international development partners
Action step: Irrigation systems					
Using the Densu and Nsukwakwao rivers and other rivers and waterbodies in the municipality for enhanced irrigation uptake Ensure water resource efficiency, and build resilience against droughts and erratic rainfall patterns	Number of functional irrigation systems Area under irrigation Increase in off-season farming activity	Medium term	Veterinary services, feed, housing materials, training	Veterinary Services Department, Department of Agriculture	MoFA, NGOs, livestock farmers associations

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Action step: Aquaculture					
Diversifying income sources and reducing reliance on climate-vulnerable land-based agriculture Integrating aquaculture into local food systems to provide a stable and sustainable source of protein and livelihood for farmers Optimizing water use and promoting climate-resilient fish farming practices	Number of fishponds constructed Quantity of fish harvested Increase in household protein consumption/income	Short term	Technological, human, financial	Municipal Department of Agriculture	Ministry of Fisheries and Aquaculture Development, NGOs, Water Resources Commission, farmers' groups, SMEs
Action step: Animal husbandry					
Alternative livelihood option that complements traditional crop farming Ensuring food security in the face of climate change Improve livestock production	Number of improved breeds introduced Increase in livestock productivity Access to veterinary services	Medium term	Human, technological, financial	Municipal Department of Agriculture	MoFA, NGOs, CSOs, livestock farmers associations

Source: Authors

4.4.2 Biodiversity and Ecosystems

New Juaben South's biodiversity is highly vulnerable to climate change, primarily due to deforestation, bush burning, and changing weather patterns that threaten local ecosystems. These activities disrupt biodiversity and ecosystems, reduce carbon sequestration, and accelerate soil erosion, making the region more susceptible to climate-related impacts. The New Juaben South Municipal Assembly prioritizes community-led and conservation-driven adaptation strategies (Table A3, p. 101). The key adaptation options identified focus on restoring biodiversity, community participation, and alternative livelihoods for persons who depend on the ecosystems for income and sustenance. Formation of disaster volunteer groups and creation of protected areas share the top rank, emphasizing both proactive disaster response and ecosystem preservation. Afforestation and sustainable land use follow closely, reflecting the Assembly's commitment to restoring degraded areas and promoting responsible land management to enhance ecological resilience.

Table 9. Ranking of adaptation options for the biodiversity and ecosystems sector

Biodiversity and ecosystems	Total	Rank
Formation of disaster volunteer groups	40	1
Create protected areas	40	1
Afforestation	36	3
Sustainable land use	35	4

Source: Authors

The adaptation objectives, justifications, and estimated implementation costs for each of these actions are further elaborated.

4.4.2.1 Afforestation

Objective

The general objective of afforestation in the NJSMA as an adaptation strategy is to enhance ecosystem resilience and mitigate the adverse impacts of climate change on biodiversity and livelihoods. By planting trees in areas where forests have been degraded or where new forest areas can be established, afforestation aims to restore ecological balance, sequester carbon, and regulate local climate conditions. This initiative will also contribute to improving water availability, preventing soil erosion, and supporting biodiversity conservation. Afforestation is particularly vital as an alternative to deforestation, which exacerbates climate change impacts.

Justification

Afforestation is a critical strategy for climate adaptation in the NJSMA, where the loss of forest cover, soil degradation, and reduced biodiversity have made the environment more vulnerable to climate extremes, such as droughts and floods. Planting trees helps reverse deforestation, restores habitats, and enhances carbon sequestration, thereby reducing the amount of greenhouse gases in the atmosphere. Moreover, afforestation promotes climate regulation, stabilizes local temperatures, improves water cycles, and enhances biodiversity. This multi-dimensional approach offers both

environmental and socio-economic benefits, including improved livelihoods through sustainable forestry and non-timber forest products, making it a key adaptation strategy in the face of climate challenges.

Key Considerations

Selection of indigenous tree species: To ensure the success of afforestation efforts, it is vital to prioritize the planting of indigenous tree species that are well-suited to the local climate and ecosystems. Indigenous species are more resilient to local environmental conditions, require less maintenance, and support the biodiversity of the region by providing habitats for native wildlife. This approach also helps maintain the ecological balance and contributes to long-term forest sustainability.

Community engagement and ownership: Local communities play a central role in afforestation projects. Their active involvement from the planning to the implementation phase is key to ensuring the success of these efforts. Community members should be encouraged to take ownership of forest management, with the provision of training and resources to maintain newly planted trees. Such community-based models of afforestation foster traditional acceptance and long-term commitment to protecting restored forest areas.

Sustainable livelihoods linked to afforestation: Afforestation projects should be designed to create economic opportunities for local communities, such as the development of forest-based enterprises, ecotourism, or agroforestry. By linking forest restoration to income-generating activities, afforestation can reduce the economic dependence on deforestation and charcoal production, making it easier for communities to adopt sustainable practices. Providing alternative livelihoods ensures that afforestation efforts are both economically viable and environmentally sustainable.

Incorporation of gender-sensitive approaches: Afforestation projects must consider gender inclusiveness to ensure equitable participation and benefits for all members of the community. Women, who often play key roles in land use and natural resource management, should be empowered through targeted training and access to resources. Gender-sensitive strategies not only enhance the social acceptance of afforestation initiatives but also improve the overall equity of the project by addressing the needs of both men and women.

Institutional support and policy framework: The success of afforestation efforts depends on strong institutional support and the existence of enabling policies. The New Juaben South Municipal Assembly should develop clear policies that prioritize afforestation within broader environmental protection goals. Coordination with governmental bodies, NGOs, and international partners can provide the necessary technical expertise, financial resources, and long-term support to scale afforestation projects.

Monitoring and maintenance of forests: Newly planted forests require continuous monitoring and maintenance to ensure their survival and growth. Local communities and municipal authorities should establish mechanisms for regular forest monitoring, which includes protecting trees from pests, diseases, and illegal logging. Long-term sustainability also depends on maintenance efforts, such as periodic replanting and the introduction of mixed species to increase forest diversity and resilience.

Integration with land use planning: Afforestation efforts must be integrated with local land use planning to ensure they align with agricultural practices and other development goals. Zoning laws should designate areas specifically for afforestation, ensuring that forests are not later cleared for agricultural or industrial use. Strategic land use planning can enhance the replicability of afforestation projects across different regions within New Juaben South.

Educational campaigns and public awareness: Raising awareness about the environmental and social benefits of afforestation is essential for gaining broader community support. Public education campaigns that emphasize the role of forests in biodiversity protection, climate resilience, and economic development can encourage widespread community participation. Educational initiatives should target schools, local farmers, and community leaders to foster a culture of environmental stewardship.

4.4.2.2 Create Protected Areas

Objective

The general objective of creating protected areas in the NJSMA is to preserve biodiversity, protect vital ecosystems, and safeguard local species from the adverse impacts of climate change. By establishing designated protected areas, the municipal assembly aims to conserve critical habitats, enhance ecosystem resilience, and improve biodiversity management. These areas will serve as sanctuaries for endangered species, provide buffer zones against climate impacts, and promote the long-term sustainability of ecosystems that are essential for local livelihoods, water resources, and climate regulation.

Justification

Creating protected areas is a fundamental strategy for adapting to climate change impacts in the NJSMA, where ecosystems are increasingly threatened by human activities, climate-induced stresses, and the loss of biodiversity. Protected areas play a vital role in providing refuges for species and ecosystems that may be vulnerable to temperature fluctuations, altered rainfall patterns, and land-use changes. They help mitigate biodiversity loss by reducing habitat degradation and providing spaces for species to adapt to changing environmental conditions. By conserving these natural areas, the NJSMA can also enhance local livelihoods through ecotourism, sustainable harvesting of non-timber products, and the provision of vital ecosystem services such as water purification, flood control, and carbon sequestration.

Key Considerations

Legal framework and enforcement: For protected areas to be effective, strong legal frameworks must be established and enforced. This involves clear delineation of boundaries, drafting of protective regulations, and ensuring the local enforcement of conservation laws. Without proper legal backing and enforcement mechanisms, protected areas risk being encroached upon by illegal activities such as logging and poaching, which undermine their ecological integrity.

Community engagement and local stewardship: The success of protected areas depends on the support and involvement of local communities. It is essential to create participatory management

frameworks where communities play an active role in managing and conserving these areas. Engaging local stakeholders through education, awareness campaigns, and the creation of alternative livelihood programs can foster a sense of ownership and reduce reliance on environmentally harmful practices like charcoal production and unsustainable agriculture.

Sustainable livelihood alternatives: To alleviate the pressure on protected areas from local populations, promoting sustainable livelihood alternatives is crucial. Programs that provide income through eco-friendly activities, such as agroforestry, ecotourism, or sustainable agriculture, help reduce the dependence on resources within protected areas. These alternatives can also help communities benefit economically from the conservation of biodiversity, ensuring long-term social acceptance and support.

Zoning and land-use planning: Strategic zoning is critical when creating protected areas to ensure that they are established in regions of high biodiversity value. This includes integrating protected areas into broader land-use planning frameworks and ensuring that they are connected with ecological corridors to prevent habitat fragmentation. Effective zoning ensures that human development activities do not infringe upon critical ecosystems and biodiversity hotspots.

Institutional coordination and capacity building: Effective management of protected areas requires coordination between local, municipal, and national environmental agencies. Building institutional capacity is necessary to ensure that local authorities and conservation groups have the skills, resources, and knowledge required to manage these areas. Regular training programs and funding support are essential for enhancing the technical feasibility and institutional capacity to maintain protected areas.

Long-term financial sustainability: Establishing a sustainable financial model is key to ensuring that protected areas remain functional over time. This may include setting up conservation trust funds, developing public-private partnerships, or accessing international conservation grants. Financial sustainability ensures that protected areas have the resources necessary for ongoing management, enforcement, and restoration activities.

Ecological monitoring and research: To maintain the health of protected areas, regular ecological monitoring and research are essential. These efforts help track biodiversity changes, detect early signs of ecosystem degradation, and assess the effectiveness of conservation measures. Research initiatives can also inform adaptive management strategies that ensure protected areas remain resilient in the face of climate change and other environmental challenges.

4.4.2.3 Formation of Disaster Volunteer Groups

Objective

Forming disaster volunteer groups (DVG) in the NJSMA aims to build local capacity for disaster preparedness, response, and resilience, particularly in the context of biodiversity and forestry conservation. These groups will serve as first responders to natural disasters, working to mitigate the impacts of climate change on ecosystems, protect vital biodiversity, and restore affected landscapes. DVGs will play a crucial role in enhancing community awareness, conducting environmental

monitoring, and supporting restoration efforts, contributing to the overall climate adaptation strategy.

Justification

The formation of disaster volunteer groups is critical for biodiversity protection in New Juaben South, where natural and human-induced disasters like bushfires, deforestation, and charcoal production pose significant threats to local ecosystems. Volunteers can act as first responders and quickly mobilize to provide essential services during and after disasters, including emergency response, reforestation efforts, and protecting wildlife. Furthermore, DVGs can raise awareness about climate risks, teach communities about sustainable land and forest management practices, and help safeguard vital natural resources. Their presence will empower local communities to take an active role in disaster risk reduction and climate resilience, ensuring that both human and ecological systems can recover and thrive post-disaster.

Key Considerations

Community ownership and participation: The success of disaster volunteer groups depends on strong community ownership. Involving local leaders and residents in the formation and management of these groups ensures higher levels of participation and traditional acceptance. This bottom-up approach fosters long-term commitment to protecting biodiversity and reduces reliance on external interventions.

Training and capacity building: To ensure the effectiveness of disaster volunteer groups, members must receive regular training on disaster management, forest fire prevention, and biodiversity conservation practices. This training should include first aid, communication during emergencies, and sustainable land management techniques. Equipping volunteers with the necessary skills and knowledge is essential for building a capable and responsive team.

Rapid response and coordination: Disaster volunteer groups must be trained to act quickly and efficiently during climate-related disasters. This requires establishing clear communication networks and ensuring that DVG members are familiar with disaster response protocols. Effective coordination among local authorities, environmental organizations, and volunteers is crucial for timely interventions, such as protecting endangered species, managing forest fires, or conducting emergency soil erosion control. Additionally, developing standardized response plans tailored to the unique challenges of the NJSMA, such as the conservation of water resources and biodiversity, will enhance the effectiveness of DVGs during disasters.

Post-disaster restoration and recovery: After a climate disaster, DVGs will play a central role in the recovery and restoration of affected ecosystems. This includes reforestation, soil stabilization, and the restoration of wetlands, which are essential for maintaining the biodiversity and ecosystem services of the NJSMA. Volunteers will work with environmental scientists and local stakeholders to plant native species, repair damaged infrastructure, and help ecosystems recover from disaster impacts.

Integration with local and national disaster response frameworks: For disaster volunteer groups to be effective, they must be integrated into the broader local and national disaster management frameworks. Coordination with municipal authorities, the National Disaster Management

Organization (NADMO), and environmental agencies ensures that volunteers have access to resources, early warning systems, and logistical support during emergencies. Therefore, disaster volunteer groups should be linked to early warning systems and other environmental emergencies that threaten biodiversity. Also, the physical infrastructure required to support disaster response, such as communication tools, transport, and protective gear is essential for the effectiveness of volunteer groups.

Gender inclusiveness: The formation of disaster volunteer groups must prioritize gender inclusiveness, ensuring that both men and women are equally represented and involved. Gender-responsive strategies also promote equity and increase the social acceptance of these volunteer groups.

Financial mobilization and sustainability: Sustaining disaster volunteer groups requires consistent funding and resource mobilization. Support from municipal budgets, donor agencies, and NGOs can provide essential tools and protective equipment for volunteers. Creating local fundraising mechanisms, such as community-based initiatives, helps ensure that the groups remain functional even during periods of limited external support.

Environmental education and public awareness: Raising public awareness about the importance of disaster prevention for biodiversity protection is critical. Disaster volunteer groups can engage in environmental education campaigns, teaching community members about the risks of unsustainable land use practices like bush burning and deforestation. Public education efforts help foster a culture of environmental stewardship and reduce the occurrence of preventable environmental disasters.

Monitoring and evaluation mechanisms: To ensure continuous improvement, disaster volunteer groups must be part of a robust monitoring and evaluation framework. This allows for the regular assessment of their performance in biodiversity protection, response times, and the outcomes of their interventions. Feedback loops between the groups and municipal authorities can identify areas for improvement and ensure that lessons learned are applied in future disasters.

4.4.2.4 Sustainable Land Use

Objective

The general objective of sustainable land use in the NJSMA is to manage land resources in a way that enhances climate resilience, preserves biodiversity, and supports both ecological health and human livelihoods. Through sustainable agriculture, agroforestry, and proper land management techniques, the region will be better equipped to adapt to climate change while safeguarding its biodiversity and improving the long-term viability of its ecosystems.

Justification

Sustainable land use is a critical adaptation strategy for the NJSMA where climate change is exacerbating issues such as soil erosion, land degradation, and the loss of biodiversity. The region's agricultural land is increasingly under threat from erratic rainfall patterns, deforestation, and unsustainable farming practices. By promoting sustainable land use practices, the NJSMA can mitigate these impacts by maintaining healthy soils, conserving water resources, and protecting natural

habitats. This strategy offers a dual benefit: enhancing local climate resilience and ensuring that natural ecosystems continue to provide vital services such as carbon sequestration, water filtration, and habitat for wildlife. Sustainable land use will also improve food security and the economic well-being of local communities by promoting long-term agricultural productivity without compromising the region's biodiversity.

Key Considerations

Soil conservation and erosion control: A fundamental consideration for sustainable land use is soil conservation, which is vital for maintaining soil fertility and preventing erosion, particularly in the face of climate change-induced heavy rainfall and droughts. Practices such as contour farming, terracing, cover cropping, and agroforestry can significantly reduce soil erosion, enhance soil structure, and increase water retention. These practices also help mitigate the risk of desertification and land degradation, which are serious threats to both agricultural productivity and biodiversity. Ensuring that these methods are integrated into local farming systems will help communities in the NJSMA adapt to changing climate conditions while sustaining healthy, productive land for future generations.

Agroforestry and biodiversity enhancement: Agroforestry, which integrates trees with agricultural crops, is a key strategy for enhancing both land productivity and biodiversity in the NJSMA. By planting native trees alongside crops, agroforestry helps to improve soil fertility, conserve water, and provide habitats for wildlife, thus promoting ecological balance. This approach not only mitigates the impacts of climate change but also creates an additional income stream for local farmers through the sale of timber, fruits, and other non-timber forest products. The careful selection of tree species is essential to ensure that they are well-suited to local conditions and contribute to the conservation of native biodiversity. Agroforestry can serve as a sustainable alternative to traditional monoculture farming, which often leads to soil depletion and loss of habitat.

Water management and conservation: Sustainable land use also requires efficient water management practices, especially in a region like the NJSMA, which may experience fluctuating rainfall patterns and droughts due to climate change. Techniques such as rainwater harvesting, drip irrigation, and the use of drought-resistant crop varieties can help optimize water use on farms while conserving this precious resource. Additionally, protecting wetlands, restoring watersheds, and conserving riparian zones can improve the region's water retention capacity and reduce the risk of flooding during heavy rains. Sustainable water management practices ensure that agricultural systems can adapt to the challenges posed by climate variability while protecting aquatic ecosystems and ensuring reliable access to water for farming and domestic use.

Community involvement and capacity building: For sustainable land use practices to be successful, it is essential to engage local communities in the decision-making process and ensure that they have the necessary skills and knowledge to implement these practices effectively. This requires capacity-building programs that educate farmers on sustainable agricultural techniques, soil conservation methods, and the benefits of biodiversity protection. Local knowledge should be incorporated into land-use planning, as it can provide valuable insights into the region's environmental conditions and the most effective ways to adapt to climate change. Promoting community ownership of land-use initiatives helps to ensure long-term commitment and fosters a sense of responsibility toward preserving the environment.

Policy support and legal frameworks: Support from local and national governments is essential for the successful implementation of sustainable land use practices. Policies that incentivize sustainable agriculture, provide technical support to farmers, and enforce land-use regulations are key to ensuring that land resources are managed effectively. This includes creating policies that promote agroforestry, soil conservation, and sustainable water use. Additionally, legal frameworks should protect communal lands and prevent encroachment on protected areas, ensuring that biodiversity is maintained. Encouraging private-public partnerships and securing funding for sustainable land use initiatives can also help scale these practices across the NJSMA, ensuring that climate adaptation efforts are both effective and sustainable.

Monitoring and adaptive management: Effective monitoring and adaptive management are critical to ensuring that sustainable land use practices continue to meet climate adaptation goals. Regular assessments of land health, biodiversity levels, and water availability will help identify areas that require intervention or adjustment. Adaptive management allows for flexibility, enabling land-use strategies to evolve as climate conditions change and new challenges emerge. Involving local communities in monitoring efforts enhances the resilience of these practices, as they provide valuable insights and can help adjust strategies based on local conditions and needs.

Table 10. Adaptation actions for the biodiversity and ecosystems sector

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Action step: Afforestation					
Enhance ecosystem resilience and mitigate the adverse impacts of climate change on biodiversity and livelihoods Restore ecological balance Sequester carbon and regulate local climate conditions	Number of trees planted and survival rate Hectares of degraded land restored Measurable reduction in soil erosion and temperature in targeted areas	Medium to long term	Human, financial, technological	Forestry Commission and Municipal Department of Agriculture	NGOs, traditional authorities, MoFA, EPA, NADMO, Municipal Assembly Development Planning, FBOs, CSIR, farmer cooperatives, international development partners, community groups
Action step: Create protected areas					
Preserve biodiversity Safeguard local species from the adverse impacts of climate change	Area legally designated as protected Reduced rate of habitat loss Improved population trends for key species	Long term	Human, financial, technological	Forestry Commission	Lands Commission, Land Use and Spatial Planning Authority, traditional authorities, local community, Municipal Assembly Development Planning Unit, EPA
Action step: Formation of disaster volunteer groups					
Build local capacity for disaster preparedness, response and resilience, particularly in the context of biodiversity and forestry conservation Quickly mobilize to provide essential services during and after disasters, including emergency response, reforestation efforts, and protecting wildlife	Number of active volunteer groups trained Response time during biodiversity-related events Frequency of participation in reforestation or monitoring	Short to medium term	Human, financial	NADMO	Municipal Department of Agriculture, Forestry Commission, youth groups, civil society, traditional authority, assembly persons

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Action step: Sustainable land use					
To adapt to climate change while safeguarding its biodiversity and improving the long-term viability of its ecosystems Maintain healthy soils, conserving water resources and protecting natural habitats	Increase in land under sustainable management Reduced bushfires and soil degradation Adoption of conservation agriculture practices	Medium term	Human, technological, financial	Municipal Physical Planning and Development Planning Units, Forestry Commission	Land Use and Spatial Planning Authority, EPA, NGOs, farmer groups, Municipal Department of Agriculture

Source: Authors

4.4.3 Water Resources

According to the New Juaben South Municipal Assembly vulnerability assessment, water resources management is identified as the most vulnerable sector and requires significant attention. Nine adaptation actions were identified and assessed through the multicriteria analysis (Table A4, p. 106) due to their cross-cutting nature of the adaption option and its discussion in previous sectors. These actions target water scarcity for household and agricultural use and pollution disasters caused by the flooding of water bodies.

Municipal water treatment dam at Densuano. Credit: GWCL risks shutdown over turbidity of water due to illegal mining.

The results show that the New Juaben South Municipal Assembly (NJSMA) places the highest priority on enforcement of permit laws against building in waterways, as well as community education and involvement. This reflects a recognition that strong regulation and active citizen participation are key to protecting water sources. Equally prioritized are increasing access to potable water and communal water storage, which aim to ensure water security amidst growing demand. Supporting strategies like water quality monitoring, afforestation, and infrastructure improvements reflect a balanced focus on both supply and ecosystem integrity. Although enforcing illegal gold mining laws ranks lowest, this is not due to lack of concern. Illegal mining largely occurs upstream in other districts, outside the NJSMA's direct jurisdiction, but significantly impacts water quality at the Densuano treatment plant. As such, the NJSMA advocates for stronger enforcement at the national level to address these external threats and protect downstream water resources.

Table 11. Ranking of adaptation options for the water resources sector

Water resources	Total	Rank
Enforcement of permit laws	47	1
Community education and involvement	47	1
Increase access to potable water supply	46	3
Communal water storage	46	3

Water resources	Total	Rank
Water quality monitoring program	45	5
Construct and improve water management infrastructure	44	6
Practice afforestation	44	6
Early warning and response mechanisms	40	8
Enforce illegal gold mining laws	39	9

Source: Authors

The adaptation objectives, justifications, and estimated implementation costs for each of these actions are further elaborated.

4.4.3.1 Afforestation

Objective

To promote afforestation practices that enhance water retention and soil stability in the New Juaben South Municipal Assembly, contributing to sustainable water management and increased resilience to water scarcity.

Justification

Afforestation serves as a vital tool in adapting to the climate impacts faced by the NJSMA, where erratic rainfall and flooding frequently threaten water availability and quality. By planting trees in strategic areas, particularly around water catchments and flood-prone regions, the adaptation measure enhances water retention, reducing the risk of water scarcity for both household and agricultural purposes. By creating a buffer of vegetation, afforestation efforts can improve water quality and quantity while mitigating the impacts of climate change on municipal and regional water supply.

Key Considerations

Strategic site selection: To ensure the success of afforestation efforts in the water resources sector, it is crucial to select appropriate sites for tree planting. These sites should be near water catchments, flood-prone areas, and regions where soil erosion is prevalent. Proper site selection helps optimize the benefits of afforestation by enhancing water retention and preventing erosion. Local knowledge and participatory approaches should guide the identification of these sites, ensuring that the right areas are targeted for planting.

Involvement of local communities: The active participation of local communities is essential for the success of afforestation projects. Communities living near water catchments or flood-prone areas should be engaged in afforestation efforts from the planning phase to implementation and monitoring. This involvement ensures that the projects are tailored to local needs and conditions, and community members are more likely to take ownership and care of the newly planted trees. Furthermore, afforestation can provide economic opportunities for locals, such as employment in tree planting and maintenance and access to forest products.

Selection of suitable tree species: For afforestation to be effective, it is vital to select tree species that are well-suited to local environmental conditions and the specific goals of the project. Trees should be chosen for their ability to thrive in the region's climate, provide effective soil stabilization, and contribute to water retention. Native species that are adapted to the local ecosystem should be prioritized to enhance biodiversity and ensure that the trees do not disrupt existing ecological balances. Additionally, the growth rates and root structures of tree species should be considered to ensure they provide the desired benefits over time.

Monitoring and maintenance: Ongoing monitoring and maintenance are essential to the success and sustainability of afforestation initiatives. Regular checks should be conducted to assess the health of the planted trees and the effectiveness of the afforestation efforts in enhancing water retention and reducing soil erosion. Maintenance activities, such as watering young trees, controlling invasive species, and replacing dead or damaged trees, should be carried out to ensure the long-term survival and success of the project. Furthermore, adaptive management practices should be implemented to adjust strategies based on monitoring outcomes.

Integration with broader water resource management plans: Afforestation efforts should be integrated into broader water resource management and climate adaptation plans. By incorporating afforestation into integrated water resources management (IWRM) strategies, it becomes part of a holistic approach to water security. Policies should support afforestation initiatives through incentives, technical assistance, and financial resources. Collaboration between government agencies, NGOs, and local communities is essential to ensure that afforestation projects align with other water management strategies, such as improving water quality and protecting vulnerable ecosystems.

Climate change and long-term resilience: As climate change continues to impact water availability and quality, afforestation projects should be designed to enhance the long-term resilience of water resources in the NJSMA. Tree planting efforts should consider the potential impacts of future climate scenarios, including changes in rainfall patterns and temperatures, to ensure that the selected tree species and afforestation practices remain effective. Additionally, afforestation projects should aim to create diverse, resilient ecosystems that can adapt to these changing conditions, providing continued benefits for water resources and local communities.

Capacity building and knowledge sharing: Building the capacity of local authorities, communities, and stakeholders to implement and manage afforestation projects is crucial. Training programs, workshops, and knowledge-sharing initiatives should be organized to enhance understanding of the benefits of afforestation, best practices, and the role of trees in water resource management. By equipping local communities and institutions with the necessary skills and knowledge, afforestation projects can be more effectively implemented and maintained over time.

4.4.3.2 Enforce Illegal Mining Laws

Objective

The general objective of enforcing illegal mining laws as an adaptation option in the water resources sector of the NJSMA is to safeguard water quality and ensure the sustainable supply of clean water for both household and agricultural use.

Given the NJSMA's downstream position, illegal mining (galamsey) activities in surrounding areas directly affect the water quality that flows into the municipal water treatment plant at Densuano. Although the NJSMA may not have direct jurisdiction over mining activities in surrounding districts, it can work to reduce the downstream impacts on water quality by advocating for stronger enforcement and regulation at the central government level. This strategy aims to protect water sources from contamination and ensure the sustainability of water resources for domestic and agricultural use.

Justification

Illegal mining, particularly galamsey, in neighbouring districts severely impacts the water quality in the NJSMA. Activities such as unregulated gold mining often led to water bodies being contaminated with toxic chemicals, sedimentation, and heavy metals, which flow downstream into the NJSMA. This contamination directly affects the water treatment processes at the municipal water treatment plant, resulting in increased costs and challenges in producing potable water for households and agriculture. While the NJSMA lacks the authority to enforce laws in neighbouring areas, advocating for the central government to take stronger action against illegal mining activities is crucial. By addressing these upstream pollution sources, the water resources in the NJSMA can be safeguarded, ensuring a more reliable and sustainable water supply for the region.

Key Considerations

Advocacy for central government action: Given that the NJSMA does not have jurisdiction over illegal mining in neighbouring districts, a key consideration is the need for strong advocacy at the national level to enforce mining laws. The NJSMA can work with other districts, regional authorities, and national agencies to pressure the central government to allocate more resources for monitoring and curbing illegal mining. Engaging policy-makers and advocating for stricter regulations, such as increasing penalties for illegal mining or improving law enforcement capacity, can help reduce the downstream pollution affecting the NJSMA. Central government involvement is crucial in addressing the root causes of water contamination in the region and ensuring that proper legal measures are taken.

Regional collaboration for cross-district solutions: To effectively mitigate the impacts of illegal mining on water quality in the NJSMA, regional cooperation between neighbouring districts and the NJSMA itself is essential. While the NJSMA cannot directly enforce mining laws in other districts, it can collaborate with local authorities from affected districts to share data, coordinate response efforts, and jointly advocate for stronger enforcement at the national level. This collaboration can include joint public awareness campaigns, shared monitoring of mining activities, and coordinated enforcement strategies that ensure all districts are working toward a common goal of protecting water resources. Working together will increase the political weight and influence needed to secure government action.

Community engagement and local reporting: The NJSMA can engage local communities to participate in monitoring and reporting illegal mining activities. Communities often have valuable insights into illegal mining operations and can assist in identifying and reporting such activities to the authorities. Establishing local reporting systems, where individuals can confidentially report illegal mining activities, could strengthen the NJSMA’s advocacy efforts and provide more accurate data on the

extent of contamination. By empowering communities to take an active role in protecting water resources, the NJSMA can promote greater public involvement and accountability in the fight against illegal mining.

Strengthening water treatment systems: While advocacy for stronger enforcement is underway, it is essential that the NJSMA continues to invest in improving its water treatment infrastructure to handle the effects of water pollution caused by illegal mining in neighbouring districts. Upgrading the municipal water treatment plant with more advanced filtration systems, chemical treatment methods, and sedimentation management techniques will ensure that the plant can handle varying levels of contamination. This will help minimize the impact of upstream pollution on water quality, providing a buffer while the longer-term solution of stricter enforcement takes effect. Investing in water infrastructure ensures that the NJSMA remains resilient in the face of water quality challenges.

Public awareness and education: Raising public awareness about the connection between illegal mining activities and water pollution is vital for garnering support for stronger enforcement. The NJSMA should initiate public education campaigns aimed at local communities, stakeholders, and local government officials to highlight the impacts of illegal mining on water bodies. Such campaigns can emphasize the importance of preserving water quality and advocate for the enforcement of laws at the national level. By fostering a deeper understanding of the issue, the NJSMA can build greater community support for regulatory measures and encourage more sustainable practices among local residents.

Monitoring and data collection: Regular monitoring of water quality in rivers and streams, especially those feeding into the municipal water treatment plant, is necessary to assess the level of pollution and the effectiveness of any mitigation efforts. The NJSMA can invest in water quality testing and establish a baseline for contamination levels. This data will be critical for identifying pollution sources and tracking changes over time. Additionally, collecting and sharing this data with the public and policy-makers will help strengthen the advocacy for enforcement and demonstrate the need for immediate action.

Policy integration and alignment: For long-term success, enforcing illegal mining laws must be aligned with broader environmental and water resource policies. The NJSMA should advocate for the integration of stricter illegal mining laws into national water and environmental policies. Coordinating these efforts will ensure that the challenges posed by illegal mining are addressed comprehensively within the context of sustainable water management. By aligning the objectives of water protection with broader environmental goals, the NJSMA can contribute to a unified national approach to tackling the issue of water contamination from illegal mining.

4.4.3.3 Community Education and Involvement

Objective

To enhance community education and involvement as an adaptation option in the water resources sector in the NJSMA is to enhance local understanding and active participation in sustainable water management practices. By increasing awareness of the impacts of climate change on water availability, quality, and distribution, the NJSMA aims to foster community-driven solutions for water

conservation, pollution control, and disaster preparedness, ensuring a more resilient water system for both agricultural and household use.

Justification

Climate change is causing increased variability in rainfall, leading to both water scarcity and more frequent flooding, which in turn affect local water resources. These challenges are compounded by inadequate water management practices and lack of public awareness on the importance of protecting water bodies and conserving water. Community education can play a crucial role in addressing these issues by changing attitudes toward water usage and waste, promoting sustainable practices, and encouraging active involvement in monitoring and preserving water resources. Engaging communities in water management also ensures that adaptation efforts are more locally relevant, culturally acceptable, and sustainable over time.

Key Considerations

Local knowledge integration: Building on existing traditional knowledge of water conservation ensures that educational programs are relatable and practical for the community.

Accessibility of educational resources: Ensuring materials are available in local languages and formats that are accessible to all community members, including those with limited literacy.

Economic incentives and benefits: Highlighting the economic benefits of water conservation, such as reduced water costs and enhanced agricultural productivity, to promote community investment.

Partnerships with local institutions: Collaborating with local schools, NGOs, and government agencies to reinforce the reach and impact of educational campaigns.

Gender-sensitive approaches: Incorporating gender-responsive strategies, as women often play key roles in water collection and use, which can enhance community buy-in and equitable access to resources.

Scalability of projects: Developing pilot projects that can be scaled up to other parts of the district or region if successful, providing a model for sustainable water management practices

Long-term monitoring and support: Establishing mechanisms to periodically assess the effectiveness of education initiatives and the adoption of water-saving practices, and to provide ongoing support where needed.

4.4.3.4 Water Quality Monitoring

Objective

A water quality monitoring program as an adaptation option in the water resources sector in the NJSMA is to ensure the protection and improvement of local water bodies by systematically tracking water quality parameters. This will help address the challenges posed by climate change, including increased pollution from flooding, rising temperatures, and other climate-induced factors that affect

water quality. Regular monitoring will enable the early detection of water contamination and ensure that water resources are safe for both agricultural and domestic use.

Justification

Climate change exacerbates threats to water quality in the NJSMA, particularly due to increased rainfall variability, flooding, and agricultural runoff that can degrade water bodies. Polluted water from these sources can have serious consequences for human health, agriculture, and ecosystem stability. A water quality monitoring program is essential to assess these risks and allow for timely responses to protect public health and ensure water quality standards are maintained. Monitoring will also help identify trends in water contamination, enabling the NJSMA to adapt to climate challenges and manage its water resources more effectively. Furthermore, it supports the development of targeted interventions, such as pollution control measures and flood management strategies, ensuring the sustainability of local water systems.

Key Considerations

Establishing monitoring frameworks and protocols: One of the first considerations for a water quality monitoring program is the establishment of clear monitoring frameworks and protocols. The NJSMA must define what water quality parameters (such as pH, turbidity, dissolved oxygen, and contaminant levels) will be monitored, and at which locations. Standardizing methods for sample collection, testing, and data recording is crucial for consistency and reliability. The program should align with national or international water quality standards to ensure that it is scientifically credible and useful for guiding policy decisions.

Building local capacity for data collection and analysis: To effectively implement a water quality monitoring program, local capacity building is essential. The NJSMA must train community members, local water management authorities, and technicians in proper sampling techniques, water quality analysis, and data interpretation. Building local expertise will enhance the sustainability of the program and ensure that water quality data is accurately collected and interpreted. This approach will also foster community ownership of water quality issues and improve local understanding of the implications of climate change on water resources.

Integration with existing water management systems: The water quality monitoring program should be integrated into existing water management systems and policies within the NJSMA. Coordination with municipal water treatment plants, agricultural stakeholders, and environmental monitoring bodies is necessary for a comprehensive understanding of water quality across the district. This integration will also facilitate more effective responses to contamination, as monitoring data can be used in conjunction with flood mitigation, water conservation, and pollution control strategies.

Ensuring timely reporting and communication: An important consideration for a successful water quality monitoring program is ensuring that findings are reported in a timely and transparent manner. Effective communication of water quality data to the public, local authorities, and stakeholders is essential for swift action. Regularly updated reports should be made available, especially during and after flooding events when water quality is most vulnerable to contamination. Community members

should be educated on how to interpret water quality reports and respond accordingly to potential health risks, ensuring that water sources are safe for consumption.

Funding and resource allocation: Sufficient funding and resource allocation are critical to the success of a water quality monitoring program. The NJSMA must secure funding for equipment, laboratory testing, staff, and transportation to monitor water bodies effectively. Resources will also be needed for training and capacity-building initiatives. This financial commitment ensures that the program can be sustained in the long term and that monitoring efforts are not hindered by budgetary constraints. Collaboration with national agencies and international partners may be necessary to secure adequate funding and technical support.

Collaboration with research and educational institutions: Collaboration with universities, research institutions, and NGOs can enhance the effectiveness of the water quality monitoring program. These institutions can provide technical expertise, assist with data analysis, and support the development of innovative monitoring techniques. They can also play a key role in disseminating findings and conducting further research on the impacts of climate change on local water quality. By fostering these partnerships, the NJSMA can ensure that its water quality monitoring efforts are backed by scientific rigor and the latest technological advances.

Adapting to climate change impacts: The monitoring program should be adaptive to the changing impacts of climate change. Water quality monitoring must not only focus on current contamination levels but also anticipate future risks, such as those associated with increased flooding, shifting agricultural practices, and altered rainfall patterns. For example, monitoring flood-prone areas during the rainy season may be crucial for detecting contamination caused by runoffs from mining activities or agricultural land. By anticipating climate-related risks, the monitoring program will remain relevant and effective in addressing emerging challenges.

Community engagement and participation: Engaging the community in the monitoring process can improve the accuracy of data and foster a sense of shared responsibility in protecting water resources. The NJSMA can involve local residents in citizen science initiatives, where they help collect water samples or report signs of contamination. Community members can also be involved in interpreting results and taking actions such as reporting pollution incidents. By ensuring that the program is inclusive, the NJSMA can increase public awareness of water quality issues and promote sustainable practices at the grassroots level.

4.4.3.5 Construct and Improve Water Resource Infrastructure

Objective

The general objective of constructing and improving water management infrastructure in the water resources sector in the NJSMA is to enhance the district's capacity to manage water resources efficiently, ensuring access to clean water for household and agricultural use while mitigating the adverse impacts of climate change. This includes the development of sustainable water storage systems, improving the resilience of existing water infrastructure, and upgrading water treatment facilities to better handle climate-induced stresses such as variable rainfall, flooding, and increased demand.

Justification

Climate change has exacerbated water scarcity and contamination issues in the NJSMA, impacting both domestic water supply and agricultural production. Seasonal droughts, erratic rainfall, and flooding have strained existing water management systems. Improving infrastructure such as reservoirs, water storage tanks, and treatment plants is critical for ensuring that water resources are effectively conserved, stored, and distributed. Upgrading existing facilities will increase resilience to climate-induced water scarcity and pollution, ensuring a sustainable water supply for the NJSMA's growing population and agricultural activities. Enhanced water management infrastructure is key to reducing waterborne diseases, supporting food security, and promoting economic growth in the face of a changing climate.

Key Considerations

Assessing current infrastructure and identifying gaps: A comprehensive assessment of the existing water management infrastructure is necessary to identify gaps and weaknesses that could be exacerbated by climate change. The NJSMA must evaluate current water storage facilities, treatment plants, and distribution systems to understand their capacity, condition, and potential vulnerabilities. This evaluation will inform which areas need urgent upgrading, such as increasing storage capacity for drought periods, improving treatment processes to handle increased sedimentation from floods, or ensuring that distribution networks can withstand the impacts of extreme weather events. Addressing these gaps early will build resilience against future climate challenges.

Designing infrastructure to withstand climate stressors: When constructing and improving water management infrastructure, it is essential to incorporate climate resilience into the design. For example, reservoirs should be built or retrofitted to capture and store water during rainy seasons for use during droughts. Water treatment plants should be upgraded to handle the increased load caused by flooding, such as higher levels of sediment and pollutants. Infrastructure must be designed with the ability to cope with both extreme weather events and gradual climate changes, ensuring that the NJSMA’s water supply remains stable regardless of climate variability.

Integration with flood management systems: Given the NJSMA's vulnerability to floods and the potential contamination of water sources, integrating water management infrastructure improvements with flood management systems is critical. Upgrading drainage systems, flood barriers, and improving floodplain management can help protect water storage and treatment facilities from being overwhelmed or contaminated by floodwaters. Additionally, flood risk assessments should be incorporated into the planning of new infrastructure to avoid building in flood-prone areas. A combined focus on water and flood management will safeguard both water quality and availability during extreme weather events.

Community engagement and local involvement: Incorporating community involvement is key to ensuring the sustainability of water management infrastructure improvements. Local communities should be engaged in the planning, design, and maintenance of water systems. This engagement can include consultations on infrastructure needs, involvement in the construction process, and training on how to maintain water storage and treatment systems. When communities are invested in the

success of the infrastructure, they are more likely to support and care for it, enhancing the long-term effectiveness of adaptation efforts.

Sustainable resource management and maintenance: For water infrastructure to remain effective in the long term, the NJSMA must establish plans for sustainable resource management and regular maintenance. Upgrading infrastructure without a solid maintenance plan can lead to rapid deterioration, negating the benefits of the investment. Regular maintenance schedules should be developed for water treatment plants, reservoirs, and distribution systems, and these efforts should be supported with sufficient funding and technical expertise. Additionally, the long-term financial sustainability of these improvements needs to be ensured, whether through public-private partnerships, community-based management models, or government support.

Capacity building for local authorities and stakeholders: Building local capacity is essential to ensure that improved water management infrastructure is effectively operated and maintained. The NJSMA should invest in training local water authorities and technicians in the operation of advanced systems and technologies, as well as in climate resilience practices. Capacity building will ensure that personnel have the skills to handle the increased demands on water systems and respond to emergencies such as floods or droughts. It will also promote local innovation in adapting water systems to emerging climate challenges.

Leveraging technology and innovation: Technological innovations, such as smart water meters, automated leak detection systems, and advanced water treatment technologies, should be integrated into the new and upgraded water management infrastructure. These technologies can optimize water use, improve monitoring, and reduce waste. They can also provide real-time data on water quality and availability, enabling the NJSMA to respond more effectively to changes in water conditions. By leveraging technology, the NJSMA can enhance the efficiency of its water systems and make better-informed decisions about water distribution, usage, and conservation.

Funding and financial sustainability: Securing adequate funding is crucial to ensure the successful construction and improvement of water management infrastructure in the NJSMA. Financial resources should be sourced from a combination of local government budgets, national funding, international climate adaptation funds, and private investments. Additionally, the NJSMA should explore innovative funding mechanisms, such as public-private partnerships or donor-funded projects, to support large-scale infrastructure development. Long-term financial sustainability should be ensured through cost-recovery mechanisms, such as tariff adjustments or community-based water management models, to maintain and expand the infrastructure over time.

4.4.3.6 Enforce Building Permit Laws

Objective

The general objective of enforcing building permit laws in the NJSMA as an adaptation option in the water resources sector is to ensure that new developments are located and constructed in ways that do not exacerbate climate-induced water scarcity or pollution. By regulating urban expansion and construction in flood-prone or water-sensitive areas, the NJSMA can safeguard its water resources and reduce the risk of damage to water infrastructure caused by unplanned or poorly managed

developments. Effective enforcement of building permits will protect existing water bodies, reduce runoff, and minimize pollution, all of which are essential for adapting to climate impacts.

Justification

Urbanization and unregulated construction in the NJSMA can increase runoff, water pollution, and sedimentation of water bodies, all of which negatively impact water quality and availability. Unplanned developments often occur in flood-prone or ecologically sensitive areas, leading to increased risks of flooding, contamination of water supplies, and the destruction of natural water filtration systems such as wetlands and forests. Enforcing building permit laws ensures that developments comply with zoning laws that protect water resources, reducing the negative environmental impacts of rapid urban growth and enhancing the resilience of the district's water resources to climate change.

Key Considerations

Assessing vulnerability of proposed sites: A critical consideration when enforcing building permits is to assess the vulnerability of proposed construction sites to climate impacts, such as flooding and water scarcity. Developments should be directed away from flood-prone areas, wetlands, and regions with fragile water ecosystems. Site assessments should incorporate climate projections to identify areas most at risk of flooding or other water-related challenges due to climate change. Zoning regulations must be updated to reflect this information and guide development toward safer, more sustainable locations, ensuring that urban expansion does not exacerbate existing water resource issues.

Building standards for water efficiency and flood protection: Building standards should be adapted to include water-efficient technologies and flood protection measures to mitigate the climate-related risks associated with new constructions. This includes implementing rainwater harvesting systems, efficient wastewater management, and permeable paving materials that reduce runoff. Additionally, developments in flood-prone areas should include elevated structures, flood barriers, and stormwater management systems to reduce the risk of property damage and water contamination during extreme weather events. Such standards will enhance the resilience of buildings to climate impacts while reducing their strain on local water resources.

Community awareness and engagement: For the enforcement of building permit laws to be effective, the NJSMA must prioritize community education and involvement. Developers and the local population must understand the importance of building regulations in protecting water resources and mitigating climate risks. Engaging the community through awareness campaigns, public consultations, and collaboration with local organizations can foster support for regulatory enforcement and ensure compliance with water protection measures. By making the benefits of these laws clear to residents and developers, the NJSMA can ensure that new developments contribute positively to the district's overall water management strategy.

Monitoring and enforcement mechanisms: Enforcement of building permit laws requires strong monitoring systems and enforcement mechanisms. Local authorities must be adequately equipped with the resources and manpower to monitor new developments and ensure they comply with water

protection regulations. This can include regular site inspections, the use of satellite imagery to track construction in sensitive areas, and penalties for non-compliance. Effective enforcement will help deter illegal construction activities and ensure that developments are in line with the NJSMA's water resource management and climate adaptation goals.

Integrating building permits with broader urban planning policies: The enforcement of building permit laws should be part of a broader urban planning strategy that integrates climate resilience and water resource management. The NJSMA should align its building permit policies with broader land use and environmental regulations to create a cohesive approach to urban development. This includes ensuring that urban expansion is in harmony with sustainable water management practices, such as protecting natural water catchment areas, minimizing impermeable surfaces, and promoting the restoration of ecosystems that provide water filtration and flood regulation services. Coordination between building permits and broader urban planning policies will ensure that the NJSMA's growth is both climate-resilient and water-sustainable.

Stakeholder coordination: Successful enforcement of building permit laws requires coordination between various stakeholders, including local government authorities, environmental agencies, developers, and community organizations. The NJSMA should establish clear communication channels and collaborative frameworks to ensure that all stakeholders are aligned with water resource management objectives. This could involve regular consultations between planning departments, water authorities, and local community leaders to ensure that new developments are consistent with climate adaptation strategies. Working together with stakeholders will enhance the overall effectiveness of the enforcement process and foster a collective effort to protect the NJSMA's water resources.

Incentives for compliance: To support the enforcement of building permit laws, the NJSMA could consider providing incentives for developers who comply with water-resilient building practices. These incentives could include tax breaks, faster approval processes, or reduced permit fees for developers who incorporate water-saving technologies, flood mitigation measures, and sustainable construction practices into their projects. Such incentives can encourage voluntary compliance with water protection standards, ultimately contributing to a more sustainable and water-resilient urban environment in the NJSMA.

Resource allocation for enforcement and compliance: Adequate funding and resource allocation are essential for the successful enforcement of building permit laws in the NJSMA. Local authorities need to ensure that sufficient resources are available for the implementation of monitoring, inspection, and enforcement activities. This includes budgeting for personnel training, the acquisition of technology for site monitoring, and ensuring that penalties for non-compliance are appropriately enforced. Effective use of resources will ensure that building permits are properly enforced and that the adaptation benefits of the regulations are realized.

4.4.3.7 Increase Access to Potable Water Supply

Objective

Increasing access to potable water supply in the NJSMA as an adaptation option is to enhance the availability of clean and safe drinking water for households and agriculture, thereby reducing vulnerability to climate-induced water scarcity. This strategy aims to ensure a sustainable and equitable distribution of water resources, which is crucial for improving resilience to climate impacts, particularly in the face of changing precipitation patterns and population growth. By increasing access to potable water, the NJSMA can mitigate the adverse effects of water shortages, improve public health, and support agricultural productivity.

Justification

Water scarcity is a growing concern in the NJSMA, exacerbated by climate change, rapid urbanization, and population growth. Many areas within the municipality experience limited access to reliable and safe water sources, leading to health issues, increased economic burdens, and a reduced capacity for agricultural productivity. Increasing access to potable water through improved infrastructure and distribution networks is essential to address these challenges. By ensuring a steady and safe water supply, the NJSMA can enhance the quality of life for its residents, support economic activities, and reduce dependency on vulnerable water sources, particularly during periods of drought or flooding caused by climate change.

Key Considerations

Infrastructure development and maintenance: A key consideration in increasing access to potable water is the development and maintenance of robust water supply infrastructure. This includes building new water treatment plants, expanding the distribution network, and ensuring that existing infrastructure is well-maintained and resilient to climate impacts. Investments in infrastructure should prioritize underserved areas and communities with limited access to clean water. Additionally, maintenance programs should be implemented to regularly assess the condition of infrastructure and address issues promptly, ensuring continuous and uninterrupted access to potable water.

Sustainable water sourcing: The sourcing of water must be sustainable to ensure that the increased access does not lead to over-extraction of water resources, which can further exacerbate water scarcity. Sustainable practices such as rainwater harvesting, the reuse of treated wastewater, and the management of groundwater sources should be integrated into the water supply strategy. The NJSMA should also explore alternative water sources such as desalination or the restoration of wetlands for water purification. This will help diversify the water supply and reduce dependence on a single, vulnerable water source, ensuring long-term water security.

Equity and accessibility: Ensuring equitable access to potable water across different socio-economic groups, including marginalized communities, is crucial for the success of this adaptation option. Water supply projects should be designed to ensure that both urban and rural populations, as well as vulnerable groups such as women, children, and the elderly, have reliable access to clean drinking water. The NJSMA should prioritize water access in informal settlements, rural areas, and low-income neighbourhoods, where access to water is often limited. Policies should also ensure that water tariffs are affordable for all residents, with subsidies or support for the most vulnerable populations.

Climate resilience and water storage: In light of the unpredictability of climate patterns, especially prolonged dry spells or extreme rainfall events, the NJSMA must incorporate climate resilience into water supply systems. This includes the construction of additional water storage facilities such as reservoirs, dams, or underground tanks to buffer against periods of scarcity. Climate-resilient water systems should be designed to store excess water during rainy seasons and release it during dry spells. Additionally, systems should be capable of handling floods or storm surges, ensuring that infrastructure can withstand the impacts of extreme weather events linked to climate change.

Community participation and awareness: Community participation is essential for the successful implementation and sustainability of water supply projects. The NJSMA should involve local communities in the planning and decision-making processes, ensuring that the design and operation of water supply systems meet local needs and are culturally appropriate. Public awareness campaigns should be conducted to educate residents about water conservation, the importance of maintaining clean water sources, and proper water management practices. Empowering communities with the knowledge to manage their water resources sustainably will lead to greater community ownership and reduce the risk of water wastage.

Financial investment and funding: Increasing access to potable water requires substantial financial investment, not only for infrastructure development but also for maintenance and expansion of existing systems. The NJSMA should seek funding from both national and international sources, including government budgets, climate adaptation funds, development partners, and private sector investments. Public-private partnerships could also play a role in financing large-scale water supply projects. Additionally, financial resources should be allocated for capacity building, community involvement, and ongoing monitoring of water systems. Proper budgeting and financial management will ensure that water supply projects are adequately funded and sustainable in the long term.

Technological innovation and smart water management: Technological innovation can enhance the efficiency and effectiveness of water supply systems. The NJSMA should explore the use of smart water management technologies such as remote monitoring, leak detection systems, and automated controls to optimize water usage and reduce wastage. Digital tools can also be used to monitor water quality and track supply levels in real-time, ensuring that any issues are identified and addressed promptly. By integrating modern technologies into water supply systems, the NJSMA can enhance the resilience of water infrastructure and improve service delivery to residents.

Policy coordination and governance: Effective governance is essential for the successful implementation of water supply projects. The NJSMA should ensure coordination between different levels of government, including the municipal, regional, and national authorities, to create policies that support water access and sustainability. This may involve aligning local water management practices with national climate change adaptation plans, ensuring that water resources are managed in a way that supports both local needs and national goals. Additionally, the NJSMA should strengthen the regulatory framework for water supply, ensuring that private sector players, local water utilities, and community-based organizations comply with water quality standards and provide reliable services to residents.

Table 12. Adaptation options of water resources sector

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Action step: Practice afforestation					
Improve water retention in catchment areas Reduce sedimentation and runoff into water bodies Restore degraded watersheds	Area of land reforested near water sources Improved water table levels Reduced siltation in reservoirs and rivers	Medium to long term	Human, financial, technological	Forestry Commission	EPA, Municipal Department of Agriculture, NGOs, community groups, private sector, international development partners
Action step: Early warning and response mechanisms					
Provide timely alerts on flood and drought risks Minimize water-related disasters and health outbreaks	Installation of early warning systems Number of trainings and public alerts issued Community response rate to alerts	Short to medium term	Human, technological, financial	NADMO	Ghana Meteorological Agency, EPA, assembly units, research and academia, local community, local media and information centres
Action step: Enforce illegal mining laws					
Protect downstream water sources from contamination caused by illegal mining in upstream districts Advocate for stronger enforcement of mining regulations by central government and relevant authorities	Reduction in heavy metal and sedimentation levels at Densuano Water Treatment Plant Number of advocacy engagements with central authorities on illegal mining Improvement in raw water quality test results	Medium term	Human, financial	Ministry of Lands and Natural Resources, NJSMA	WRC, EPA, district assemblies upstream, Regional Security Council (REGSEC), neighbouring district assemblies, CSOs, Forestry Commission, traditional authorities

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Action step: Community education and involvement					
Promote behavioural change on water conservation and sanitation Enhance local ownership of water resources protection	Number of sensitization programs held Community participation rates Reduction in improper waste disposal	Short term	Human, financial	Ghana Education Service	NGOs, EPA, CWSA, traditional authorities, research and academia, local community, local media and information centres
Action step: Water quality monitoring program					
Regularly assess the quality of water sources Inform decision making and treatment needs	Number of sites monitored regularly Water testing reports generated Action taken based on findings	Medium term	Human, technological	Water Resources Commission	Ghana Water Company Ltd, EPA, NJSMA, CSIR, research and academia, international development partners
Action step: Increase access to potable water supply					
Enhance storage, distribution, and drainage systems to ensure reliable water supply	Infrastructure projects completed Reduction in water losses or flood incidents Increase in water access coverage	Medium to long term	Financial, technological, human	Ghana Water Company Ltd	Department of Urban Roads, NJSMA, Public Works Department
Action step: Increase access to potable water supply					
Ensure availability of safe drinking water	Number of new water points installed Decrease in water-borne diseases % of households with access to potable water	Short to medium term	Financial, human	Community Water and Sanitation Agency (CWSA)	Ghana Water Company Ltd, NJSMA, NGOs

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Action step: Communal water storage					
Improve community resilience during water shortages	Number of communal storage systems built Community usage and maintenance reports Reduced water scarcity reports	Medium term	Financial, technological, human	NJSMA, Ghana Water Company Ltd	CWSA, NGOs, community groups, local authorities
Action step: Enforcement of permit laws					
Regulate and manage sustainable water extraction and use	Number of permits issued and monitored Number of enforcement actions taken Reduced illegal water abstraction	Medium to long term	Human, financial, technological	Water Resources Commission	EPA, NJSMA, CWSA, traditional authorities, Regional Security Council (REGSEC), security authorities (police, army, immigration, national security)

Source: Authors

4.4.4 Health and Sanitation Sector

The adaptation strategies for the health and sanitation sector in the New Juaben South Municipal Assembly (NJSMA) focus on addressing the challenges posed by climate change to public health and sanitation systems. The adaptation options proposed for the district mainly focused on improving infrastructure and preventive measures to enhance community well-being. Construction and improvement of health infrastructure ranks highest, reflecting a clear commitment to expanding access to quality health care. Jointly ranked second are the expansion of potable water and sanitation facilities and afforestation/agroforestry and early warning systems, indicating a holistic approach that links environmental health, disaster preparedness, and hygiene. Public health education and sensitization follows closely, underscoring the importance of awareness and behaviour change in promoting long-term health resilience (Table A5, p. 109).

Table 13. Ranking of adaptation options for the health and sanitation sector

Health and sanitation	Total	Rank
Construct and improve health infrastructure	45	1
Afforestation/agroforestry	44	2
Early warning signs	44	2
Construction and extension of potable water and sanitation facilities	44	2
Public health education campaign and sensitization	42	5

Source: Authors

The adaptation objectives, justifications, and estimated implementation costs for each of these actions are further elaborated. Two out of the five identified adaptation actions have been selected and expanded on due on the interlinkages and discussions in other related sectors.

4.4.4.1 Construct and Improve Health Infrastructure

Objective

The general objective of constructing and improving health infrastructure in the NJSMA is to enhance the capacity of local health care facilities to effectively respond to the health challenges posed by climate change. This includes upgrading existing health centres, building new facilities, improving sanitation infrastructure, and ensuring these facilities are resilient to climate impacts such as floods, heatwaves, and the spread of climate-sensitive diseases.

Justification

As climate change continues to exacerbate public health risks, it is crucial to ensure that health infrastructure in the NJSMA is prepared to handle increased demand for services. Extreme weather events such as floods and heatwaves, combined with an increase in vector-borne diseases, pose significant health threats to the community. Constructing and improving health infrastructure will enable local health facilities to provide timely medical care and improve disease prevention strategies.

Enhanced infrastructure will also strengthen the overall health system's capacity to respond to climate-induced health emergencies, thus ensuring the resilience of the population.

Key Considerations

Climate-resilient design: To effectively adapt to the impacts of climate change, health infrastructure should be designed with resilience in mind. This includes the construction of flood-resistant buildings, installation of renewable energy sources like solar panels, and the use of materials that can withstand extreme temperatures and weather conditions. Health facilities must be equipped to maintain operational continuity during climate-related disasters, ensuring uninterrupted service delivery during emergencies.

Access and coverage: Improving access to health care services is a key consideration in constructing and upgrading health infrastructure. Health facilities should be strategically located to serve both urban and rural communities, especially those in remote or underserved areas of the NJSMA. This will ensure that all residents, regardless of their location, can access necessary health services, particularly during climate-induced emergencies when timely medical care is crucial.

Integration of sanitation facilities: Health infrastructure must go hand-in-hand with sanitation improvements. Constructing and upgrading health facilities should incorporate clean water, waste management systems, and hygiene facilities to prevent the spread of waterborne diseases, especially in flood-prone areas. Safe and reliable sanitation infrastructure is essential for maintaining public health and preventing the exacerbation of climate-related health issues such as diarrhea and cholera.

Capacity building and training: Investing in the capacity of health care workers is vital to the success of health infrastructure improvements. Training health care providers on climate change-related health risks, disaster preparedness, and response techniques will enhance their ability to handle climate-induced health emergencies. Additionally, equipping health workers with the skills needed to manage the increasing burden of climate-sensitive diseases will ensure that the community can effectively address the public health challenges posed by climate change.

Funding and resource allocation: Securing adequate funding is essential for the construction and improvement of health infrastructure. Local governments must work with national and international partners to mobilize financial resources for infrastructure projects. This includes allocating funds for both initial construction and long-term maintenance to ensure that facilities remain functional and capable of withstanding future climate impacts. Effective financial planning and investment are necessary to guarantee the sustainability and effectiveness of health infrastructure improvements.

4.4.4.2 Construction and Extension of Potable Water and Sanitation Facilities

Objective

Constructing and extending potable water and sanitation facilities, including public toilets in the NJSMA is to ensure improved access to clean water and proper sanitation for all residents. This adaptation option seeks to address the challenges of water scarcity and sanitation-related diseases exacerbated by climate change by providing reliable water supply systems and sanitary facilities that can withstand climate stressors.

Justification

Access to clean water and sanitation is a fundamental aspect of public health and climate resilience. In the NJSMA, the impacts of climate change, such as more frequent floods and droughts, have affected water availability and sanitation infrastructure. By constructing and extending potable water and sanitation facilities, including public toilets, the district can reduce the risks of waterborne diseases, mitigate the effects of water scarcity, and enhance community resilience. These interventions will improve the overall quality of life, reduce climate-induced health risks, and contribute to the well-being of the population by ensuring access to safe drinking water and hygienic waste disposal.

Key Considerations

Climate-resilient infrastructure: Water and sanitation facilities must be designed to withstand the increasing frequency of extreme weather events such as floods and droughts. This includes constructing water storage systems that are durable and able to store water during periods of abundance, as well as installing flood-resistant sanitation infrastructure. Public toilets and water facilities should be designed with materials and technologies that are durable and can function under varying climate conditions, ensuring their long-term sustainability.

Equity and accessibility: Ensuring that potable water and sanitation facilities are accessible to all residents, including marginalized and underserved communities, is essential for the success of this adaptation option. The design and location of water and sanitation facilities must consider the needs of vulnerable populations, such as women, children, the elderly, and persons with disabilities. Public toilets should be strategically located in high-density areas to ensure equitable access and reduce the burden on residents, especially in informal settlements.

Community engagement and participation: Community involvement is crucial in the planning, construction, and maintenance of water and sanitation facilities. Local residents should be actively engaged in decision-making processes to ensure that facilities meet their needs and preferences. Additionally, communities should be involved in maintaining the facilities to ensure their long-term functionality. This participatory approach will foster ownership and ensure that facilities remain in use and are well-maintained over time.

Hygiene education and awareness: In addition to building water and sanitation infrastructure, it is essential to complement these efforts with hygiene education and awareness campaigns. Residents need to be educated on the importance of safe water handling, proper sanitation practices, and the health risks of poor hygiene. Public health campaigns can help reduce the transmission of waterborne diseases and promote a culture of cleanliness and responsible water use, ensuring that the new infrastructure has a positive impact on public health.

Sustainable financing and maintenance: Long-term sustainability of water and sanitation facilities depends on securing funding for both construction and ongoing maintenance. This includes establishing financial mechanisms that ensure funds are available for regular maintenance, repairs, and the eventual expansion of facilities as the population grows. Public-private partnerships, donor funding, and local government investments should be explored to ensure that the infrastructure

remains operational and able to meet future demand. Sustainable financing is key to ensuring that these essential services continue to benefit the population over the long term.

4.4.4.3 Public Health Education Campaigns

Objective

The general objective of implementing a public health education campaign and sensitization in the NJSMA is to enhance community awareness and preparedness for the health risks associated with climate change. This initiative aims to educate residents on proactive health measures, including prevention of climate-related diseases, and the importance of sanitation and hygiene practices to build resilience in the face of changing environmental conditions.

Justification

Public health education is critical in reducing the health impacts of climate change in the NJSMA. With the increasing frequency of extreme weather events, such as floods and heatwaves, communities need to be informed about the potential health risks and how to protect themselves. Educating the public on proper sanitation practices, hygiene, and how to mitigate climate-related health challenges (e.g., vector-borne diseases) can significantly reduce the burden on health systems and improve overall public health outcomes. The sensitization campaign also promotes behaviour change, encouraging residents to adopt climate-resilient health practices.

Key Considerations

Funding and resources: Ensuring adequate funding and resources is vital for the sustainability of the public health education campaign. Financial support is required for the development of educational materials, the implementation of outreach programs, and the training of local health workers and community leaders. Securing long-term funding will ensure that the campaign can be sustained and adapted over time, providing continuous education and support to the community as climate change-related health risks evolve. Proper allocation of resources will guarantee the campaign's success and long-term impact.

Community engagement: Community engagement is an essential element for the success of the public health education campaign. Local leaders, community-based organizations, and health workers must play a central role in ensuring that the campaign's messages are effectively communicated and understood by all members of the community. Involving the community in the design and delivery of health education materials helps build trust and ensures the relevance of the messages. Ensuring that the campaign reaches all demographics, including marginalized groups, is critical for widespread participation and engagement.

Cultural sensitivity: Cultural sensitivity is key to the success of the public health education campaign. Public health messages should be aligned with local values, customs, and practices to resonate with the population. Tailoring content to reflect the community's beliefs, language, and health practices will improve comprehension and foster greater acceptance of the proposed health initiatives. This cultural approach ensures that the information is not only heard but also acted upon, promoting lasting behavioural change.

Collaboration and partnerships: Collaboration with government agencies, non-governmental organizations, and international bodies is essential for amplifying the impact of the public health education campaign. Building partnerships enables the pooling of resources, expertise, and outreach capacity. These collaborations provide the necessary tools to extend the reach of the campaign, increase awareness, and ensure that the messages are consistent and effective across various platforms. A coordinated approach enhances the overall effectiveness of the health education program.

Monitoring and evaluation: Monitoring and evaluation are necessary components for assessing the effectiveness of the public health education campaign. Continuous feedback allows for adjustments in messaging and delivery methods to improve understanding and address gaps in knowledge. Regular assessment of the campaign's impact can identify strengths and areas of improvement, enabling the design of targeted interventions that respond to evolving community needs. Evaluation also helps ensure that the campaign meets its objectives and leads to measurable changes in health-related behaviours.

Table 14. Adaptation options for the health and sanitation sector

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Action step: Construct and improve health infrastructure					
Expand access to quality health care services Strengthen capacity to respond to climate-related health risks Improve resilience of health systems to climate-induced shocks	Number of new or rehabilitated health facilities Increase in population accessing health services Reduction in climate-sensitive disease outbreaks	Medium to long term	Financial, human, technological	MoH and NJSMA	GHS, international development partners, NJSMA Environment and Health Unit, NGOs, CSOs, NJSMA Health Directorate, traditional leaders
Action step: Afforestation/agroforestry					
Improve air quality and reduce heat-related illnesses Enhance ecosystem services that benefit human health Reduce risk of vector-borne diseases through improved habitat control	Number of trees planted in health-sensitive zones Measurable improvement in air quality indices Reduction in reported cases of heat stroke or related illnesses	Medium term	Human, technological, environmental	Forestry Commission, NJSMA	EPA, MoH, local NGOs, international development partners, traditional leaders, NAMO, Municipal Development Planning Unit, community
Action step: Early warning signs					
Strengthen capacity for early detection of disease outbreaks Improve community preparedness and response to health emergencies Minimize health risks from climate-related disasters	Establishment of local health surveillance systems Frequency of public alerts issued Time taken to respond to detected outbreaks	Short to medium-term	Human, technological	GHS	NADMO, Municipal Environment and Health Unit, local health facilities, community, traditional and religious authorities, local media and information centres

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Action step: Construction and extension of potable water and sanitation facilities					
Improve public health through increased access to safe water and sanitation Reduce incidence of waterborne diseases Promote hygiene and disease prevention	Number of new water and sanitation facilities Increase in households with access to potable water Decrease in reported cases of cholera and diarrhea	Medium term	Financial, human, technological	Ghana Water Company, NJSMA	CWSA, NGOs, WASH-focused CSOs, traditional leaders, international development partners, Water Resource Commission
Action step: Public health education campaign and sensitization					
Raise awareness about climate-related health risks Promote adoption of hygiene and health protection practices Empower communities to act during health emergencies	Number of campaigns and outreach events held Increase in knowledge and behavioural change indicators Community feedback and participation rates	Short term	Human, technological	NJSMA Health Directorate	Information Services Department, NGOs, community leaders, local media and information centres, international development partners

Source: Authors

4.4.5 Disaster and Risk Reduction

The adaptation strategies for disaster risk reduction (DRR) in New Juaben South focus on enhancing community resilience and reducing vulnerability to climate-related hazards. These strategies emphasize proactive measures such as improving infrastructure, promoting community engagement, and enforcing regulations that ensure safe land use and disaster preparedness. Additionally, the strategies prioritize enhancing early warning systems, effective response mechanisms, and safety measures in urban planning, ultimately aiming to build a more resilient and disaster-ready community in the face of climate impacts. (Table A6, p. 111)

The DRR sector prioritized structural and regulatory interventions to reduce urban vulnerability. Construction of improved drainage systems ranks highest, reflecting the urgency of addressing flood risks, followed by road markings and pedestrian walkways, which aim to enhance safety and urban mobility. Mid-level priorities such as community engagement and awareness, strict enforcement of bylaws and early warning and response mechanisms highlight the value of preparedness and community involvement. Although afforestation and zoning laws rank lower, they remain important for sustainable land use and long-term resilience. Notably, all adaptation options in this sector received the lowest equity rankings, likely because they are infrastructure- or regulation-heavy, which may disproportionately affect vulnerable populations. For example, the eviction of informal roadside settlers or demolition of structures obstructing drainage systems without adequate provisions for resettlement or support.

Consultations with planning group. Credit: Authors

Table 15. Ranking of adaptation options for the DRR sector

DRR	Total	Rank
Construction of improved drainage systems	45	1
Road markings	43	2
Pedestrian walkways	43	2
Community engagement and awareness	41	4
Strict enforcement of by-laws	40	5
Early warning and response mechanisms	40	5
Afforestation	39	7
Implementing zoning laws	38	8

Source: Authors

Four of the eight adaptation actions that were identified are not discussed due to their cross-cutting nature and because they were addressed in previous sectors.

4.4.5.1 Implementing Zoning Laws

Objective

The general objective of implementing zoning laws as an adaptation option in the DRR sector of New Juaben South is to regulate land use in a way that minimizes exposure to climate hazards, particularly flooding, landslides, and other natural disasters. This strategy aims to ensure that land is developed in safer areas, reducing the risk of damage to infrastructure and communities, and promoting sustainable urban growth.

Justification

The impacts of climate change, such as increased flooding and unpredictable weather patterns, have underscored the importance of land use planning in disaster risk reduction. In New Juaben South, implementing zoning laws can help prevent the construction of buildings in flood-prone or vulnerable areas, thereby safeguarding lives and property. Zoning laws can also help guide the development of essential infrastructure in safer, less vulnerable locations. By aligning land use with climate resilience goals, zoning can significantly reduce the costs of disaster response and recovery, while fostering sustainable urban development and enhancing the safety of the population.

Key Considerations

Enforcement and compliance: For zoning laws to be effective in adapting to climate impacts, strict enforcement is critical. Local authorities need to ensure that all developments comply with zoning regulations to prevent risky constructions in hazard-prone areas. This requires the establishment of clear monitoring mechanisms, regular inspections, and penalties for non-compliance to discourage illegal building activities and ensure that the zoning laws are respected.

Stakeholder involvement: Successful implementation of zoning laws requires the involvement of all relevant stakeholders, including local authorities, urban planners, developers, and community

members. Engaging the community in the zoning process is essential to ensure that zoning decisions reflect the needs and realities of those directly affected by them. Stakeholder participation fosters a sense of ownership, increases awareness of disaster risks, and ensures that zoning laws are more effectively integrated into local development practices.

Integration with DRR plans: Zoning laws must be integrated into broader disaster risk reduction and climate adaptation strategies. This involves aligning land use planning with the district's DRR policies, including identifying vulnerable zones, developing disaster response plans, and ensuring that zoning regulations consider future climate scenarios. Effective integration helps ensure that zoning laws support and enhance the district's overall resilience to climate hazards.

Public awareness and education: For zoning laws to be effective, public awareness and education campaigns are essential. Community members, developers, and landowners need to be informed about the risks associated with certain land uses and the benefits of following zoning laws. Awareness efforts can encourage voluntary compliance, support community-driven enforcement, and help residents understand how zoning decisions are made with their safety and well-being in mind.

Monitoring and review: Given the evolving nature of climate change, zoning laws must be regularly reviewed and updated to reflect new climate risks and urban development patterns. A dynamic monitoring and review system should be established to assess the effectiveness of existing zoning regulations and make adjustments as necessary. This ensures that zoning laws remain relevant and continue to contribute to disaster risk reduction in the long term.

4.4.5.2 Construct and Improve Infrastructure and Drainage System

Objective

The general objective of constructing improved drainage systems in New Juaben South is to reduce the risk of flooding and manage stormwater more effectively. By enhancing the capacity of existing drainage infrastructure and introducing new systems in vulnerable areas, this strategy seeks to protect communities and infrastructure from flood-related damage, thus improving overall disaster resilience in the face of climate change.

Justification

Flooding, exacerbated by climate change, poses a significant threat to both urban and rural areas in New Juaben South. With increasing rainfall intensity and rapid urbanization, many areas suffer from poor drainage, leading to frequent flooding, property damage, and health risks. The construction of improved drainage systems is essential for mitigating these impacts by channeling stormwater efficiently, reducing floodwater accumulation, and preventing damage to buildings, roads, and public infrastructure. A well-designed drainage system can also improve water quality by reducing the spread of contaminants and preventing waterlogging that disrupts livelihoods, particularly in agriculture.

Key Considerations

Design and capacity: The design of drainage systems should account for the increased intensity and frequency of rainfall due to climate change. Systems must be capable of handling larger volumes of water to prevent overflows. The design should also consider local topography, water flow patterns,

and the need for both stormwater and wastewater management. Incorporating green infrastructure such as permeable pavements, vegetated swales, and retention ponds into the drainage system can help absorb excess water and reduce strain on traditional stormwater management systems.

Maintenance and sustainability: A major consideration for the success of improved drainage systems is ongoing maintenance. Without regular inspection, cleaning, and repairs, drainage systems can quickly become clogged and inefficient. Local governments must allocate resources for routine maintenance and establish clear responsibility for upkeep, ensuring that drainage infrastructure remains functional throughout the year, especially during rainy seasons. Sustainable design and the use of local materials can also reduce maintenance costs and improve the long-term viability of the drainage systems.

Community involvement: Engaging the community in the planning and implementation of improved drainage systems is crucial. Public education on the importance of proper waste disposal, the dangers of blocking drainage channels, and how to report drainage issues can contribute to the system's effectiveness. Community involvement ensures that drainage solutions meet the local needs and helps to cultivate a sense of ownership and responsibility among residents, encouraging greater public cooperation in maintaining the system.

Funding and resource allocation: Constructing improved drainage systems requires significant financial investment. Securing funding from local, regional, and national sources, as well as potential international donors, is essential to the success of such infrastructure projects. Budget allocation must prioritize the construction of drainage systems in high-risk areas, and partnerships with private sector organizations or NGOs could help mobilize additional resources. Cost-benefit analysis should guide decision making, ensuring that the most vulnerable areas receive adequate attention.

Integration with urban planning: Improved drainage systems must be integrated into broader urban planning and climate adaptation strategies. This includes ensuring that new developments adhere to sustainable water management practices and that urban expansion does not undermine drainage infrastructure. Coordinating drainage system construction with other urban development projects, such as road and housing construction, can optimize the effectiveness of the infrastructure and avoid costly future adjustments.

4.4.5.3 Road Markings and Creating Pedestrian Walkways

Objective

The general objective of implementing road markings and creating pedestrian walkways in New Juaben South is to enhance public safety and resilience to climate impacts, particularly in urban areas prone to flooding and traffic-related accidents. These adaptations aim to improve pedestrian mobility, reduce accidents, and ensure safer movement during extreme weather events.

Justification

Increased rainfall and climate change contribute to higher risks of accidents, particularly in areas with poorly defined or overcrowded road infrastructure. During heavy rainfall, visibility often decreases, leading to traffic accidents. Additionally, pedestrians are at risk of accidents due to the absence of

designated walkways, especially in urbanized areas with limited infrastructure. By introducing clear road markings and creating pedestrian walkways, the safety of commuters—especially vulnerable groups like children and the elderly—can be significantly improved. In the context of climate change, these measures help mitigate traffic-related injuries and fatalities while promoting sustainable and safe mobility for the population.

Key Considerations

Funding and resource mobilization: Implementing road markings and pedestrian walkways requires financial resources, which must be factored into the municipality's budget. Funding opportunities from central government, donor organizations, or climate resilience programs can help offset costs. Additionally, public-private partnerships may be explored to share the financial burden of large-scale infrastructure projects. Prioritizing funding for high-risk areas ensures that resources are allocated effectively, benefiting the most vulnerable populations.

Maintenance and upkeep: Once the infrastructure is in place, a robust maintenance plan must be established to ensure its longevity. This includes regular inspections of road markings and pedestrian walkways, ensuring that they remain clear and effective, particularly after heavy storms or other climate events. Repair schedules should be put in place, and funding should be allocated to ensure that maintenance is carried out promptly and consistently. Communities should be encouraged to report any damage or issues to relevant authorities to keep the infrastructure in good condition.

Integration with DRR plans: The development of pedestrian infrastructure and road markings must align with the municipality's broader disaster risk reduction (DRR) strategies. These infrastructure improvements should be planned in high-risk areas, such as flood zones or regions with frequent accidents. Strategic placement of pedestrian walkways near key facilities like hospitals, schools, and marketplaces can ensure that vulnerable populations are better protected during adverse weather events.

Inclusivity and accessibility: When creating pedestrian walkways, it is essential to consider the needs of all segments of the population, including those with mobility challenges. The design should include features like ramps, smooth surfaces, and proper signage that make the walkways accessible to everyone, regardless of age or physical ability. In addition, clear road markings should ensure that drivers yield to pedestrians, creating a safer environment for people of all abilities.

Public engagement and education: For the successful implementation and use of pedestrian walkways and road markings, public education is key. Local communities should be informed about the benefits of these infrastructure improvements and how to safely use pedestrian spaces. Public campaigns can raise awareness about the importance of following road markings and respecting pedestrian zones. Collaboration with schools, local organizations, and media outlets can ensure that messages reach a wide audience, particularly in areas with heavy foot traffic.

Climate-resilient design: The design of road markings and pedestrian walkways should be adapted to withstand extreme weather events. This includes using durable materials that can resist wear from heavy rainfall and floods. Walkways should be elevated or designed with appropriate drainage systems to prevent water accumulation, ensuring they remain functional even during peak storm

events. Road markings should be visible even during adverse weather conditions, incorporating reflective or photoluminescent materials to improve visibility at night or during rainfall.

Table 16. Adaptation options for the DRR sector

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Action step: Construction of improved drainage systems					
Reduce flood risk in urban and peri-urban areas Enhance stormwater management Protect infrastructure and livelihoods	Length of drainage constructed or improved Reduction in frequency of urban flooding Decrease in damage to infrastructure during rains	Medium to long term	Financial, human, technological	Department of Works and Physical Planning, NJSMA	NADMO, Ministry of Works and Housing, international development partners, private sector, local community, traditional authorities
Action step: Road markings					
Improve safety and visibility on roads Reduce accident risks during disasters or heavy rainfall Guide traffic and emergency responders during crisis	Number of roads with clear markings Reduced incidence of road-related accidents Positive feedback from drivers and road users	Short term	Human, financial	Urban Roads Department, NJSMA Physical Planning	DVLA, Ghana Police Service, Ghana Highways Authority
Action step: Pedestrian walkways					
Protect pedestrians during disasters and floods Encourage safe and climate-resilient mobility Reduce road casualties and congestion	Number of safe walkways constructed Increase in pedestrian use Reduction in pedestrian-related injuries	Medium term	Financial, human, technological	Urban Roads Department	NJSMA Physical Planning Unit, NADMO, Urban Roads Department
Action step: Community engagement and awareness					
Increase local knowledge on disaster risks and prevention	Number of sensitization events held Community participation rates	Short term	Human, technological	NADMO	NGOs, traditional authorities, ISD, local media, GMet, Municipal Environment and Health Unit, international

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Empower communities to take part in DRR activities Foster a culture of preparedness	Improvement in local response to early warning alerts				development partners, research and academia, Water Resources Commission, local health facilities, community, traditional and religious authorities, schools
Action step: Strict enforcement of by-laws					
Prevent risky settlement patterns and waste disposal Reduce vulnerability to hazards through compliance Enhance urban resilience	Number of inspections conducted Prosecutions or fines for non-compliance Decline in illegal structures or drainage blockage	Short term	Human, legal	NADMO	Lands Commission, Town and Country Planning Department, NADMO, EPA, traditional authorities, Regional Security Council (REGSEC), security authorities (police, army, immigration, national security), LUSPA
Action step: Early warning and response mechanisms					
Detect and communicate impending hazards in time Reduce disaster impacts through early action Improve institutional coordination in emergencies	Functionality of early warning systems Number of response drills conducted Time taken to disseminate warnings	Short to medium term	Human, technological	NADMO	GMet, Municipal Environment and Health Unit, international development partners, research and academia, Water Resources Commission, local health facilities, community, traditional and religious authorities, local media and information centres, schools
Action step: Afforestation					
Stabilize soil and reduce landslides or erosion Improve microclimates and storm buffering	Number of trees planted and maintained Area of green cover increased	Medium term	Environmental, human, technological	Forestry Commission	NGOs, traditional authorities, MoFA, EPA, NADMO, Municipal Assembly Development Planning, FBOs, international

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Protect water sources during disaster events	Reduced incidence of erosion/flood-related damage				development partners, community groups
Action step: Implementing zoning laws					
Guide land use away from hazard-prone areas Reduce exposure to floods and other hazards Promote orderly and risk-sensitive development	Adoption of updated land use plans Number of permits reviewed for risk compliance Decrease in new buildings in high-risk zones	Medium to long term	Legal, human, technological	Physical Planning Department, NJSMA	Lands Commission, Town and Country Planning Department, NADMO, EPA, traditional authorities, Regional Security Council (REGSEC), security authorities (police, army, immigration, national security)

Source: Authors

4.4.6 Transportation Sector

The transport sector in New Juaben South plays a crucial role in economic activities, mobility, and disaster risk reduction. However, climate-related challenges such as flooding, erosion, and poor urban planning threaten the resilience and sustainability of transport infrastructure. Adaptation strategies in this sector focus on enhancing road durability, improving urban planning, and ensuring efficient land use to mitigate the impacts of extreme weather events. Key measures include protecting roads and infrastructure from climate-induced degradation, enforcing proper development control, and implementing spatial plans that guide sustainable land management. Additionally, constructing and improving transport infrastructure, dredging drains to prevent water accumulation, and enhancing road markings and pedestrian walkways contribute to safer and more climate-resilient mobility (Table A7, p. 114).

In prioritizing adaptation options for the transport sector, the NJSMA emphasizes safeguarding and enhancing infrastructure to ensure resilience and mobility. Protection of roads and infrastructure ranks highest, highlighting the need to prevent damage from flooding and other climate-related impacts. This is followed by improvements in road markings and sidewalk systems, which aim to enhance safety and accessibility. Jointly ranked third are development of spatial plans and land management policies and dredging of drains, underscoring the importance of integrated planning and drainage maintenance in sustaining transport networks. While construction and improvement of infrastructure also remain a priority, proper development control and rezoning ranks lowest, due to its complex enforcement requirements and slower visible impact compared to infrastructure-based solutions.

Table 17. Ranking of adaptation options for the transport sector

Transport sector	Total	Rank
Protection of roads/infrastructure	48	1
Improve road markings and sidewalk ways	47	2
Development of spatial plans and effective land management policies	46	3
Dredging of drains	46	3
Construction and improvement of infrastructure	44	5
Proper development control and rezoning of the municipality	30	6

Source: Authors

The adaptation objectives, justifications, and estimated implementation costs for each of these actions are further elaborated.

4.4.6.1 Protection of Roads/Infrastructure

Objective

To enhance the resilience of transport networks against climate-related hazards such as flooding, erosion, and extreme weather events. This adaptation measure seeks to ensure the longevity of

critical roadways and bridges, minimize disruptions to transportation, and support economic activities and emergency response efforts.

Justification

Extreme weather conditions, including intense rainfall and rising temperatures, have significantly contributed to road deterioration in the NJSMA. Poor drainage systems and unregulated construction activities further exacerbate the damage, leading to increased maintenance costs and mobility challenges. Implementing protective measures such as climate-resilient road designs, effective drainage systems, and regular maintenance will help safeguard infrastructure, reduce repair costs, and improve transportation efficiency.

Key Considerations

Climate-resilient road design: Roads should be constructed with durable materials that can withstand heavy rainfall and temperature fluctuations. This includes using reinforced concrete, proper road elevation, and slope stabilization techniques.

Drainage system improvement: Enhancing drainage infrastructure is crucial to preventing waterlogging and erosion. The construction of well-maintained drainage systems along roads and urban centres will help mitigate flood risks.

Regular maintenance and monitoring: Implementing scheduled road inspections and maintenance activities will help identify and address vulnerabilities before they lead to major damage. This requires coordination among municipal authorities, engineers, and local communities.

Funding and policy support: Adequate financial and policy backing is necessary to sustain road protection efforts. Mobilizing resources through government funding, donor support, and public-private partnerships will be essential for long-term infrastructure resilience.

Gender-inclusive mobility access: Protective road infrastructure must ensure the safe and equitable movement of all population groups, especially women, who often rely on non-motorized or public transport. This includes safe pedestrian walkways, lighting around transport corridors and assessing specific mobility risks. Ensuring accessibility, particularly for PWDs, also facilitates their participation in markets, education, health care, and emergency responses during disasters.

4.4.6.2 Proper Development Control and Rezoning of the Municipality

Objective

The objective of proper development control and rezoning in the NJSMA is to ensure that urban expansion and land use are managed in ways that reduce climate vulnerabilities, prevent encroachment on flood-prone areas, and facilitate sustainable transport infrastructure development.

Justification

Unregulated urban expansion and the absence of strict development controls have led to increased environmental degradation, poor drainage systems, and the construction of roads in high-risk areas.

Rezoning and enforcing land use policies will help mitigate flooding, improve traffic management, and enhance the long-term sustainability of transport infrastructure in the municipality.

Key Considerations

Land-use planning and zoning enforcement: Ensuring that land is designated appropriately for residential, commercial, and transport infrastructure is crucial. Strict enforcement of zoning laws will prevent construction in high-risk flood zones and allow for planned road networks.

Stakeholder engagement and compliance monitoring: Effective development control requires collaboration between municipal authorities, urban planners, developers, and local communities. Regular inspections and strict penalties for non-compliance will reinforce adherence to zoning regulations.

Integration with climate adaptation strategies: Rezoning should align with climate resilience efforts by incorporating green spaces, water retention areas, and environmentally sustainable construction practices.

Gender inclusive planning: Development control policies and rezoning decisions should consider how land use affects men and women differently. Especially in terms of access to housing, services, livelihoods, and safe transportation. Gender-disaggregated data, inclusive stakeholder consultations, and gender-sensitive urban design (e.g., safe public spaces, adequate lighting, accessible walkways) must be integrated to ensure equitable urban outcomes.

4.4.6.3 Development of Spatial Plans and Effective Land Management Policies

Objective

The objective of spatial planning and effective land management in the NJSMA is to enhance the integration of transportation infrastructure within the broader urban framework, ensuring that land is used in a way that minimizes climate risks and promotes efficient mobility.

Justification

The lack of comprehensive spatial planning has resulted in inefficient land use, traffic congestion, and infrastructure damage due to climate-induced hazards such as flooding and erosion. Developing a well-structured land management framework will facilitate sustainable urban growth, improve road connectivity, and enhance resilience to climate impacts.

Key Considerations

Integrated urban planning: A comprehensive spatial plan should incorporate climate resilience, disaster risk reduction, and transport infrastructure development, ensuring a balanced approach to urban expansion.

Data-driven decision making: Using Geographic Information Systems (GIS) and climate risk assessments will help in identifying high-risk areas, optimizing land use, and planning future road networks accordingly.

Community involvement: Local participation in land management decisions will ensure that policies align with community needs and improve public acceptance of zoning regulations.

Gender inclusivity: Spatial planning should consider the differentiated mobility patterns, safety concerns, and land access constraints faced by women, men, and vulnerable groups. Gender-disaggregated data should inform decisions, and infrastructure (e.g., street lighting, transport routes, sanitation facilities) should be designed to promote equitable access and security for all.

4.4.6.4 Construction and Improvement of Road Infrastructure

Objective

The objective of constructing and improving infrastructure in the NJSMA is to enhance the durability and efficiency of transport networks by incorporating climate-adaptive designs that withstand extreme weather events and urban expansion pressures.

Justification

Existing transport infrastructure in the NJSMA is often inadequate to handle increasing urbanization and climate-related risks. Poor road conditions, insufficient pedestrian facilities, and weak drainage systems contribute to mobility challenges and flood-related damages. Investing in climate-resilient infrastructure will improve accessibility, safety, and economic development in the municipality.

Key Considerations

Use of climate-resilient materials: Infrastructure projects should prioritize materials and designs that can withstand heavy rainfall, extreme heat, and other climate stressors to reduce maintenance costs and extend their lifespan.

Incorporation of pedestrian and cycling infrastructure: Road improvements should include pedestrian walkways, bicycle lanes, and designated crossings to enhance safety and encourage sustainable mobility.

Efficient drainage integration: New infrastructure developments should integrate flood management systems, including stormwater drainage and retention basins, to reduce the impact of heavy rainfall on roads and transport networks.

4.4.6.5 Dredging of Drains As an Adaptation Option in the Transport Sector

Objective

The objective of dredging drains in the NJSMA is to improve the municipality's drainage capacity, prevent road and infrastructure damage due to flooding, and enhance the overall resilience of transport systems against climate-related waterlogging.

Justification

Blocked and poorly maintained drainage systems contribute to recurrent flooding, leading to road deterioration and restricted mobility. Heavy rainfall further exacerbates the issue, causing disruptions

to transportation and economic activities. Regular dredging of drains will help mitigate these risks, ensuring a more efficient transport system.

Key Considerations

Regular maintenance schedule: Dredging activities should be conducted on a routine basis, especially before the peak rainy season, to ensure continuous water flow and prevent blockages.

Public awareness and community participation: Community involvement in drain maintenance and awareness campaigns will encourage responsible waste disposal, reducing the accumulation of debris in drainage systems.

Integration with infrastructure development: Dredging efforts should be complemented with improved road designs and upgraded drainage networks to enhance long-term flood resilience.

Table 18. Adaptation options for the transport sector

Objectives	Indicators of success	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	Lead institution	Implementing partners
Action step: Protection of roads/infrastructure					
Safeguard existing transport assets from climate-induced damage Reduce maintenance costs and disruption to mobility Ensure resilience of critical access routes	Kilometres of roads protected Frequency of road damage during rainfall events reduced Decrease in road maintenance costs	Medium to long term	Human, financial, technological	Urban Roads Department	Ministry of Roads and Highways, NJSMA Works Department
Action step: Improve road markings and sidewalk ways					
Enhance pedestrian and vehicular safety Support climate-resilient mobility Reduce accidents and improve walkability	Number of marked roads and sidewalk installations Reduction in road-related accidents Positive feedback from road users	Short term	Human, financial	Urban Roads Department	DVLA, Road Safety Commission, NJSMA
Action step: Development of spatial plans and effective land management policies					
Guide sustainable transport development Reduce congestion and risk-prone expansion Align land use with infrastructure resilience	Completion of spatial development plans Number of developments in line with new policies Reduced encroachment on transport corridors	Medium term	Human, technological, legal	Physical Planning Department	Town and Country Planning Department, NJSMA, Land Use and Spatial Planning Authority (LUSPA)
Action step: Dredging of drains					
Reduce flooding on transport routes Maintain road accessibility during heavy rains Protect road surfaces and substructures	Frequency of drains dredged Reduction in flooded roadways Decreased transport disruptions during storms	Short term and seasonal	Human, financial	NJSMA Works Department	Zoomlion, Ghana Water Company, NADMO, youth groups

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Action step: Construction and improvement of infrastructure					
Expand climate-resilient transport networks Improve accessibility and mobility Support economic activity through reliable infrastructure	Kilometres of roads constructed/upgraded Travel time improvements Increased user satisfaction and traffic flow	Medium to long term	Human, financial, technological	Urban Roads Department	Ministry of Roads and Highways, local contractors, NJSMA
Action step: Proper development control and rezoning of the municipality					
Prevent encroachment on transport routes Align growth with resilient transport systems Reduce damage and congestion from unregulated development	Number of zoning permits issued/monitored Reduction in structures blocking roadways or drains Compliance rate with development controls	Medium term	Legal, human, technological	Municipal Physical Planning and Development Planning Units	Lands Commission, NADMO, Assembly Task Force, NADMO, EPA, traditional authorities, Regional Security Council (REGSEC), security authorities (police, army, immigration, national security)

Source: Authors

4.4.7 Gender Mainstreaming

The gender sector in the NJSMA focuses on promoting inclusive climate adaptation by ensuring equitable access to resources, decision making, and livelihood opportunities. Strategies emphasize awareness creation, policy integration, and capacity building to strengthen resilience among vulnerable groups. Economic empowerment initiatives enhance adaptive capacity, while technological and behavioural interventions support sustainability and well-being. By fostering inclusive participation and long-term engagement, these efforts contribute to a more resilient and equitable response to climate change. The gender mainstreaming actions focus on delivering economic empowerment to women and other marginalized groups such as the youth and PWDs (Table A8, p. 116).

The prioritization of the gender mainstreaming sector shows that the NJSMA focuses on empowering vulnerable groups through targeted social and economic interventions. Creation of social support groups ranks highest, reflecting a strong emphasis on building community networks that enhance resilience and inclusivity. This is followed by palm kernel processing, highlighting livelihood support for women and marginalized groups. Jointly ranked third are gender mainstreaming in action plans and sustainable livelihood programs, which aim to embed equity in policy and practice while promoting income-generating activities. Mid- to lower-priority actions include climate education programs, diversification of livelihoods, and energy-efficient cookstoves.

Table 19. Ranking of adaptation options for the gender mainstreaming sector

Gender mainstreaming	Total	Rank
Climate education programs	39	5
Creating social support groups	43	1
Diversification of livelihoods	38	6
Energy-efficient cook stoves	35	7
Gender mainstreaming in action plans	41	3
Palm kernel processing	42	2
Sustainable livelihood program	41	3

Source: Authors

The adaptation objectives, justifications, and estimated implementation costs for each of these actions are further elaborated upon.

4.4.7.1 Climate Educational Programs

Objective

Climate education programs aim to build awareness and knowledge on climate adaptation strategies among different demographics in the NJSMA. By integrating climate change education into schools, community groups, and public campaigns, these programs enhance understanding of climate risks and empower individuals to adopt sustainable practices.

Justification

Limited awareness of climate change and its impacts remains a major barrier to effective adaptation. Climate education programs ensure that communities are informed about environmental challenges and solutions, enabling proactive adaptation. These programs are particularly crucial for vulnerable groups, including women and youth, who often face the greatest climate risks yet have limited access to relevant information and resources.

Key Considerations

Targeted awareness and gender inclusivity: Educational programs should be designed to reach all sectors of society, particularly marginalized groups such as women, children, and persons with disabilities. Outreach strategies should include the use of local languages, culturally appropriate materials, and communication channels that are accessible to different demographics. This can include radio broadcasts, town hall meetings, mobile learning platforms, and interactive community workshops.

Integration into existing curricula: Embedding climate education into school curricula and vocational training programs will ensure long-term knowledge transfer. This can be done by incorporating climate-related topics into subjects such as science, social studies, and environmental education. Schools and training centres should also partner with experts and NGOs to provide practical learning experiences such as climate resilience projects, tree planting, and water conservation initiatives.

Community participation and practical training: Beyond theoretical learning, climate education programs should include hands-on training sessions that teach practical adaptation strategies. Workshops on sustainable farming, disaster preparedness, water conservation, and renewable energy solutions will enable communities to apply their knowledge effectively. Engaging local leaders and role models as facilitators will increase credibility and community acceptance.

4.4.7.2 Sustainable Livelihood Programs

Objective

Sustainable livelihood programs aim to enhance the economic resilience of communities in the NJSMA by promoting income-generating activities that are less vulnerable to climate change impacts. These programs focus on providing alternative employment opportunities, particularly for groups dependent on climate-sensitive sectors such as rain-fed agriculture.

Justification

Many residents of the NJSMA, particularly farmers and informal workers, rely on livelihoods that are highly vulnerable to climate variability. Extreme weather events, such as prolonged droughts and flooding, threaten food security and economic stability. By promoting diversified and climate-resilient income sources, communities will be better equipped to withstand climate shocks and reduce their dependence on unstable sectors.

Key Considerations

Identifying climate-resilient income opportunities: Sustainable livelihood programs should focus on sectors that are less sensitive to climate variability, such as agro-processing, renewable energy, and sustainable fisheries. Local economic assessments should be conducted to identify viable industries that align with community skills and resources.

Skills development and training: Providing vocational training and entrepreneurship support is crucial for successful implementation. Training should cover business management, product development, market access, and climate-smart agricultural practices. Partnerships with technical institutions and development agencies can facilitate capacity building.

Access to finance and market linkages: For livelihood programs to be effective, participants need access to affordable financing options such as microloans and grants. Establishing cooperatives and linkages with markets will ensure that products and services have a stable demand, increasing economic security.

Gender-sensitive needs assessment: Conduct comprehensive assessments to identify the specific livelihood needs, preferences, and constraints faced by women and marginalized groups in New Juaben South.

Promotion of gender inclusivity: Ensure that program design actively promotes gender equality, addressing existing power dynamics and barriers that limit women's participation in livelihood activities.

Collaboration with local organizations: Partner with local women's organizations and NGOs to leverage their knowledge and networks for effective program implementation and outreach.

Market access and value chain development: Facilitate women's access to markets and support the development of value chains for their products, enhancing economic opportunities and income security.

4.4.7.3 Diversification of Livelihood

Objective

Diversifying livelihoods helps reduce economic vulnerability to climate change by enabling households and communities to engage in multiple income-generating activities. This approach reduces reliance on a single, climate-sensitive occupation and strengthens economic resilience in the NJSMA.

Justification

Climate change-related risks, such as unpredictable rainfall patterns and soil degradation, make traditional farming and fishing increasingly unreliable. By diversifying livelihoods, households can spread their risks and ensure a stable source of income, even when one economic activity is disrupted.

Key Considerations

Market assessment and opportunities: Conduct local market assessments to identify viable and diverse livelihood opportunities that align with the skills and interests of women and marginalized groups in New Juaben South.

Encouraging alternative economic activities: Programs should promote alternative livelihoods such as small-scale agro-processing, ecotourism, and sustainable crafts. Community-based business support services should be introduced to guide individuals in identifying profitable opportunities.

Strengthening local market networks: Access to reliable markets is critical for the success of diversified livelihoods. Initiatives should facilitate connections between producers and buyers through cooperatives, trade fairs, and digital marketing platforms.

Policy support and incentives: Local government policies should create an enabling environment for diversified livelihoods by offering tax incentives, grants, and infrastructure support to new businesses. Regulations should also promote fair trade practices and protect small-scale entrepreneurs.

Skill development programs: Implement training programs that equip women with skills in various sectors, such as agriculture, handicrafts, and services, enabling them to engage in multiple income-generating activities.

Support for small-scale enterprises: Provide support for women-led small-scale enterprises, including access to resources, mentorship, and networking opportunities, to encourage entrepreneurial diversification.

Access to financial services: Facilitate access to microfinance and savings programs tailored for women, enabling them to invest in diverse livelihood options without the burden of excessive debt.

4.4.7.4 Palm Kernel Processing

Objective

Palm kernel processing provides an alternative and sustainable livelihood option that enhances economic resilience while reducing agricultural waste. The initiative aims to establish small-scale processing industries that add value to palm kernels, creating employment opportunities in the NJSMA.

Justification

Palm kernels, a by-product of palm oil production, are often discarded despite their potential for economic use. Processing palm kernels into oil, animal feed, and cosmetics not only minimizes waste but also creates jobs, particularly for women and youth. This adaptation measure supports economic diversification and reduces reliance on climate-sensitive farming.

Key Considerations

Infrastructure and equipment support: Setting up palm kernel processing facilities requires adequate infrastructure, including energy sources, water supply, and transportation networks. Policies should

encourage private-sector investment in processing units while also promoting cooperative models where local producers can collectively own and operate small-scale processing facilities. These centres should be strategically located to minimize transportation costs and enhance efficiency.

Training and technical assistance: For effective operation and sustainability, palm kernel processors need training in various aspects, including machinery operation, product quality assurance, and environmental sustainability. However, stakeholder discussions revealed that technical efficiency of the use of this method is low, primarily because women find it difficult to adapt to it. Technical experts should provide training on oil extraction techniques, by-product utilization (such as using palm kernel cake for animal feed), and safe waste disposal methods. Capacity-building programs should also cover financial management and marketing strategies.

Market access and value chain development: Strengthening value chains will ensure a sustainable market for processed palm kernel products. This involves linking producers to bulk buyers, developing partnerships with cosmetic and biofuel industries, and facilitating access to export markets. Trade policies should encourage local consumption of palm kernel products while promoting their value addition through incentives such as tax breaks for processors.

Sustainability and environmental considerations: Palm kernel processing should be done in an environmentally sustainable manner to minimize deforestation and pollution. Technologies that promote energy efficiency and reduce water usage should be adopted. Waste from processing, such as palm kernel shells, can be repurposed for organic fertilizers. Environmental impact assessments should be conducted before setting up processing plants to ensure sustainable operations.

4.4.7.5 Energy-Efficient Cookstoves

Objective

Promoting energy-efficient cooking stoves in the NJSMA will reduce reliance on traditional biomass fuels, decreasing deforestation and improving indoor air quality. These stoves enhance energy efficiency while lowering household fuel costs.

Justification

Many households in the NJSMA still rely on inefficient cooking methods that contribute to environmental degradation and respiratory illnesses. Energy-efficient cooking stoves provide a cleaner alternative, reducing emissions and fuel consumption.

Key Considerations

Affordability and accessibility: One of the biggest barriers to adopting energy-efficient cooking stoves is their upfront cost. Policies should encourage local production to reduce costs and ensure affordability. Subsidies, microfinance schemes, and installment payment plans should be introduced to enable more households to purchase these stoves. Additionally, distribution networks should be expanded to make cooking stoves readily available in both urban and rural areas.

Community engagement and awareness: For widespread adoption, community engagement is crucial. Awareness campaigns should highlight the benefits of energy-efficient cooking stoves, such as

reduced indoor air pollution, lower fuel costs, and environmental sustainability. Demonstration programs in markets, schools, and community centres should showcase the efficiency and ease of use of these stoves. Testimonials from early adopters can also encourage more households to switch.

Sustainable supply chains: Raw materials for producing cook stoves, such as clay, metal, or ceramic, should be sustainably sourced to avoid environmental degradation. Additionally, production should prioritize durability to ensure that the stoves have a long lifespan. Local artisans and small-scale businesses should be supported to manufacture and distribute stoves, creating employment opportunities while promoting climate-friendly technology.

Integration with broader climate and energy policies: The introduction of energy-efficient cook stoves should align with national energy policies promoting renewable energy and reduced deforestation. Governments and stakeholders should integrate cooking stove initiatives with broader sustainable energy programs, such as improved biomass fuel production, solar energy adoption, and clean cooking strategies. Monitoring and evaluation mechanisms should be established to track adoption rates and assess impact.

4.4.7.6 Creating Social Support Groups

Objective

Creating gender social support groups in the NJSMA will provide a structured platform for marginalized and vulnerable groups, particularly women, to collectively build resilience against climate change impacts. These groups will serve as safe spaces for knowledge-sharing, skills development, advocacy, and support in accessing adaptation resources. Through collective action, they will strengthen social networks, improve access to climate-resilient livelihoods, and promote gender-responsive adaptation planning.

Justification

Climate change disproportionately affects women and other vulnerable groups due to pre-existing inequalities in access to economic resources, decision-making power, and adaptive capacity. Limited access to land, financial services, and climate-smart technologies further exacerbates their vulnerability. Gender social support groups can bridge these gaps by creating an enabling environment where members receive training on sustainable practices, access small-scale financing, and participate in decision-making processes regarding climate adaptation. Additionally, these groups enhance psychosocial well-being by fostering solidarity, reducing climate-related stress, and promoting collective action to advocate for gender-sensitive policies and programs.

Key Considerations

Economic and livelihood support: To promote self-sufficiency and resilience, gender social support groups should facilitate access to microfinance schemes, cooperative savings programs, and sustainable livelihood initiatives. Engaging members in income-generating activities such as agro-processing, handicrafts, and eco-friendly businesses will enhance financial stability and reduce dependency on external aid.

Community engagement and awareness: Active involvement of community leaders, men, and youth is essential to ensure inclusivity and social acceptance. Sensitization campaigns should be conducted to highlight the importance of gender-equitable adaptation strategies and to encourage broad-based support for the initiatives undertaken by the groups.

Institutional support and policy alignment: The establishment and sustainability of gender social support groups require strong institutional support from local government agencies, development organizations, and policy-makers. Mainstreaming gender-responsive adaptation strategies into municipal development plans will provide legitimacy and ensure that these groups are recognized as key stakeholders in climate resilience efforts.

Capacity building and empowerment: The effectiveness of these groups depends on equipping members with relevant skills in climate-smart agriculture, financial literacy, entrepreneurship, and disaster preparedness. Training programs should be tailored to address the unique vulnerabilities and strengths of different gender groups, ensuring that they can actively participate in and benefit from adaptation measures.

Sustainability and long-term impact: For these groups to remain effective, clear monitoring and evaluation mechanisms should be established to track progress and measure impact. Partnerships with NGOs, government agencies, and private sector actors can provide financial and technical support, ensuring the longevity of the initiatives. Additionally, sharing success stories and best practices can inspire replication in other districts, scaling up gender-sensitive adaptation efforts across the NJSMA.

Table 20. Adaptation options for the gender mainstreaming sector

Objectives	Indicators of success	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	Lead institution	Implementing partners
Action step: Climate education programs					
Increase awareness of climate impacts on women and vulnerable groups Empower communities to take climate-informed decisions Foster inclusive participation in adaptation	Number of people (disaggregated by sex) trained Inclusion of gender themes in climate curricula Community uptake of climate-resilient practices	Short term	Human, financial, educational	Gender Desk Unit, GES	WIAD, NADMO, NGOs, women's groups, WIAD, MoGCSP, EPA, traditional authorities, CSIR, research and academia
Action step: Gender mainstreaming in action plans					
Integrate gender perspectives into climate adaptation strategies Ensure equal benefits and participation Promote accountability in planning and budgeting	Number of sectoral plans with gender considerations Representation of women in planning processes Gender-sensitive indicators used in monitoring	Medium term	Human, legal, institutional	Gender Desk Unit, WIAD	MoGCSP, NJSMA Planning Unit, NDPC, NGOs and CSOs, NDPC, National Development Planning Commission, women's groups, international development partners
Action step: Sustainable livelihood program					
Strengthen women's economic resilience to climate change Reduce reliance on climate-vulnerable sectors Promote long-term adaptive capacity	Number of women enrolled in alternative income programs Increase in household income Diversified sources of livelihoods	Medium term	Human, financial, technological	WIAD	GEA, MoFA, NGOs, Business Advisory Centres (BAC), NBSSI, private sector, rural banks, CBOs, Microfinance and Small Loans Centre (MASLOC), Ministry of Trade and Industry, international development partners, private sector

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Action step: Diversification of livelihoods					
Reduce climate-related economic vulnerability among women Encourage adoption of less climate-sensitive livelihoods Build capacity for income resilience	Number of diversified income activities adopted Training sessions held for women Increase in livelihood options available	Medium term	Human, financial	BAC, Department of Agriculture	MoFA, NGOs, women's cooperatives, WIAD, private sector
Action step: Palm kernel processing					
Provide women with value-addition and agro-processing opportunities Enhance economic empowerment and independence Support sustainable resource use	Number of women engaged in processing Quantity of processed products sold Increased household income among beneficiaries	Short to medium term	Financial, technological, human	WIAD, Municipal Department of Agriculture	MoFA, women's groups, NGOs, BAC, private sector, microfinance institutions, COTVET, CSIR, NBSSI, GEA, technical universities, private agribusinesses, Department of Co-operatives, Ghana Standards Authority
Action step: Energy-efficient cooking stoves					
Improve health outcomes by reducing indoor air pollution Reduce pressure on biomass resources Promote women's safety and time savings	Number of stoves distributed and adopted Reduction in firewood usage Improved health outcomes (especially for women and children)	Short term	Technological, financial	WIAD, Municipal Department of Agriculture	EPA, NGOs, CSOs, municipal assembly, private sector, Environmental Health Unit, NBSSI, GEA, research and academia, private agribusinesses, Department of Cooperatives, Ghana Standards Authority, women's groups
Action step: Creating social support groups					
Strengthen women's networks for resilience-building	Number of functioning support groups	Short term	Human, institutional	Social Welfare Department	Women's groups, NGOs, religious leaders, WIAD, NBSSI, BAC

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Enhance psychosocial and economic support Facilitate information and skills sharing	Participation rates among women Member-reported improvements in well-being and adaptation				

Source: Authors

4.4.8 Tourism Sector

The tourism sector in the NJSMA remains under-developed. While the district recognizes its potential, it also acknowledges the impact of climate change on sector (Table A9, p. 118).

The prioritized adaptation strategies in the tourism sector focus on enhancing resilience, protecting natural and cultural assets, and ensuring environmental sustainability. These measures aim to mitigate climate-related risks, improve infrastructure, and promote sustainable development. Strengthening governance, enforcing regulations, and integrating climate considerations into planning processes are key to safeguarding tourism activities. Improved accessibility, conservation efforts, and enhanced public services contribute to maintaining a thriving and climate-resilient tourism sector that supports economic growth and community well-being.

Table 21. Ranking of adaptation options for the tourism sector

Tourism sector	Total	Rank
Construction and tarring of roads	48	1
Providing good sanitation services	48	1
Construction of improved drainage	47	3
Create protected areas	46	4
Afforestation	46	4
Enforcement of urban planning and land bylaws	44	6

Source: Authors

The adaptation objectives, justifications, and estimated implementation costs for each of these actions are further elaborated upon.

4.4.8.1 Create Protected Areas

Objective

The establishment of protected areas in the NJSMA aims to safeguard natural ecosystems and biodiversity while enhancing climate resilience. By preserving forests, wetlands, and other ecologically significant sites, this adaptation strategy ensures the long-term sustainability of tourist attractions that rely on natural landscapes. Protecting these areas helps mitigate climate change impacts, such as land degradation and habitat loss, while maintaining their appeal for ecotourism.

Justification

Climate change poses significant threats to biodiversity, natural habitats, and the aesthetic appeal of tourist destinations. Deforestation, urban encroachment, and unsustainable land use accelerate environmental degradation, making protected areas crucial for conserving ecosystems. Establishing these areas helps regulate local microclimates, control soil erosion, and protect water sources, thereby ensuring that tourism-dependent economies remain viable. Additionally, well-managed protected areas attract eco-conscious tourists, contributing to local economic development.

Key Considerations

Legislative and policy framework: Implementing protected areas requires a robust legal framework that defines their boundaries, management responsibilities, and enforcement mechanisms. The NJSMA must collaborate with relevant national agencies to ensure legal backing and create local bylaws for effective management.

Community engagement and alternative livelihoods: Since land use restrictions can affect local livelihoods, communities must be actively involved in decision making and benefit-sharing mechanisms. Alternative income sources, such as ecotourism services, handicraft sales, and sustainable agriculture, should be promoted to ensure community support.

Infrastructure and resource allocation: Protected areas require dedicated management infrastructure, including ranger stations, visitor facilities, and monitoring systems. Adequate funding, staffing, and equipment are essential for effective enforcement and conservation activities.

Tourism development and sustainable use: Establishing eco-friendly tourism facilities, such as nature trails and interpretive centres, can enhance visitor experiences while promoting conservation. Strict regulations must be enforced to prevent over-tourism, littering, and other forms of environmental degradation.

4.4.8.2 Enforcement of Urban Planning and Land Bylaws

Objective

Strict enforcement of urban planning and land bylaws in the NJSMA aims to prevent uncontrolled development that threatens tourism assets and increases climate vulnerability. Proper zoning and regulation help protect green spaces, cultural heritage sites, and scenic landscapes while reducing environmental degradation.

Justification

Rapid urban expansion and unregulated construction can undermine the tourism sector by causing habitat destruction, pollution, and poor infrastructure planning. Climate change intensifies these challenges by increasing flood risks, land subsidence, and heat stress. Enforcing urban planning laws ensures that tourism-related infrastructure is developed sustainably, reducing climate-related vulnerabilities and preserving the aesthetic and environmental quality of tourist sites.

Key Considerations

Institutional capacity and compliance monitoring: Effective enforcement requires well-equipped municipal agencies with trained personnel to conduct regular inspections and enforce regulations. Strengthening institutions through capacity building and resource allocation is necessary to ensure compliance.

Public awareness and stakeholder engagement: Raising awareness among property developers, business owners, and residents about the importance of urban planning laws can enhance voluntary compliance. Regular stakeholder forums can help align local interests with regulatory objectives.

Integration of climate resilience in planning: Urban planning guidelines should incorporate climate resilience measures, such as flood-proof construction, green building codes, and permeable surfaces to mitigate extreme weather impacts.

Strengthening legal framework and penalties: Land-use violations must be met with strict penalties, including fines and demolitions, to deter illegal developments. The municipality should also streamline legal procedures to ensure swift enforcement of land regulations.

4.4.8.3 Construction and Tarring of Roads

Objective

Improving road infrastructure in the NJSMA is critical for enhancing tourism accessibility, ensuring safety, and reducing climate-induced damage. Well-constructed roads facilitate transportation to tourist sites, support local economic activities, and reduce travel disruptions caused by extreme weather.

Justification

Poor road conditions limit access to key tourist attractions and discourage visitors. Heavy rainfall and flooding exacerbate road deterioration, making some areas impassable. Upgrading and maintaining roads with climate-resilient designs enhance connectivity, improve visitor experiences, and boost tourism revenues. Additionally, well-constructed roads reduce maintenance costs over time and support emergency response efforts during disasters.

Key Considerations

Use of climate-resilient materials and design: Roads should be built with durable materials that can withstand extreme weather conditions, such as high temperatures and heavy rains. Designs should include proper drainage systems to prevent erosion and waterlogging.

Strategic route planning and connectivity: Road networks should be planned to improve access to tourist destinations while minimizing environmental impact. The integration of bypasses, alternative routes, and pedestrian-friendly infrastructure should be considered.

Sustainable maintenance and funding mechanisms: A sustainable road maintenance program must be established, with dedicated funding from tourism levies, municipal budgets, or public-private partnerships. Timely repairs and preventive maintenance will ensure long-term infrastructure resilience.

Minimizing environmental impact: Road construction should consider ecological conservation by avoiding protected areas and sensitive ecosystems. Measures such as tree replanting and erosion control should be integrated into road development projects.

4.4.8.4 Providing Good Sanitation Services

Objective

Enhancing sanitation services in the NJSMA aims to maintain hygiene standards in tourism areas, prevent waterborne diseases, and improve the overall visitor experience. Reliable sanitation infrastructure is essential for protecting public health, preserving natural attractions, and promoting sustainable tourism development.

Justification

Inadequate sanitation facilities can deter tourists, lead to pollution of water bodies, and create public health risks. Climate change exacerbates sanitation challenges by increasing water scarcity and intensifying extreme weather events that damage infrastructure. Ensuring access to proper waste disposal, public restrooms, and wastewater treatment facilities contributes to a cleaner environment and supports the sustainability of the tourism industry.

Key Considerations

Investment in sanitation infrastructure: The construction of public toilets, wastewater treatment facilities, and efficient waste collection systems is necessary to improve hygiene in tourism areas. These facilities must be strategically located and well-maintained.

Public awareness and behaviour change: Tourists and local communities should be educated on proper waste disposal practices and the importance of sanitation. Awareness campaigns can help reduce littering and promote responsible tourism.

Sustainable waste management systems: Recycling initiatives, composting programs, and biodegradable waste disposal should be integrated into sanitation services. Partnering with waste management companies and promoting eco-friendly packaging can further enhance sustainability.

Monitoring and regulatory compliance: Strict sanitation regulations should be enforced, with penalties for businesses and individuals who fail to comply with waste management policies. Regular inspections and feedback mechanisms will ensure service improvements.

Table 22. Adaption options for the tourism sector

Objectives	Indicators of success	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	Lead institution	Implementing partners
Action step: Construction and tarring of roads					
Improve accessibility to tourist sites Enhance visitor experience and local economic benefits Reduce transportation challenges during rainy seasons	Kilometres of roads constructed/tarred Increase in number of tourist visits Reduction in travel-related complaints	Medium to long term	Financial, human, technical	Works Department	Department of Tourism, Department of Urban Roads, private sector, Ghana Tourism Authority (GTA), Ministry of Roads and Highways, traditional authorities, Ghana Highway Authority, Ministry of Transport, international development partners
Action step: Providing good sanitation services					
Improve environmental cleanliness in tourist areas Reduce health risks and pollution Enhance attractiveness of tourist destinations	Number of public toilets and waste bins installed Frequency of waste collection Positive visitor feedback on cleanliness	Short to medium term	Financial, human	Environmental Health Department	Waste management companies (Zoomlion), Ghana Tourism Authority, local community, EPA, Ghana Health Service, CSOs, traditional authorities, assembly men/women, local contractors
Action step: Construction of improved drainage					
Prevent flooding in tourist zones Protect tourism infrastructure Improve general public safety and hygiene	Length of drains constructed or improved Reduction in flood events in tourist areas Maintenance frequency of drainage systems	Medium term	Financial, technical	Works Department	NADMO, Department of Urban Roads, Ghana Water Company, EPA, Hydrological Services Department, Town Planning Unit, Ghana Institution of Engineering, District Assembly's environmental unit, community volunteers
Action step: Create protected areas					
Conserve biodiversity hotspots and heritage sites	Number of protected areas designated	Medium to long term	Human, financial, institutional	Forestry Commission	EPA, Department of Parks and Gardens, NGOs, Ghana Heritage

Objectives	**Indicators of success**	**Time frame** (short, medium, or long term)	**Resources** (finance, human, technology)	**Lead institution**	**Implementing partners**
Promote ecotourism Prevent encroachment and degradation	Biodiversity indexes or wildlife sightings Visitor count in protected ecotourism zones				Conservation Trust, Ministry of Tourism, Culture and Creative Arts, Forestry Commission – Wildlife Division, Ghana Museums and Monuments Board, traditional authorities, local landowners
Action step: Afforestation					
Restore degraded landscapes around tourist sites Improve aesthetics and microclimate Promote environmental sustainability	Number of trees planted and surviving Increase in green cover around tourism corridors Tourist feedback on landscape beauty	Medium term	Human, financial	Forestry Commission, Municipal Assembly Development Planning Unit	Youth groups, NGOs, traditional authorities, MoFA, EPA, NADMO, Municipal Assembly Development Planning, FBOs, CSIR, farmer cooperatives, international development partners, community groups
Action step: Enforcement of urban planning and land bylaws					
Ensure orderly development near tourist zones Prevent environmental degradation and slum formation Promote sustainable tourism infrastructure	Number of inspections and violations sanctioned Reduction in unauthorized structures Increased compliance with land use regulations	Short to medium term	Human, legal, institutional	Municipal Assembly Development Planning Unit	Town and Country Planning, Assembly Task Force, Physical Planning Department, assembly men/women, NADMO, EPA, traditional authorities, Regional Security Council (REGSEC)

Source: Authors

4.4.9 Cross-Cutting Impacts and Adaptation Considerations

Cross-cutting impacts and adaptation considerations highlight the interconnected nature of different adaptation strategies and their broader influence across multiple sectors in New Juaben South's disaster risk reduction (DRR) efforts. Addressing these cross-cutting themes enhances the overall resilience, efficiency, and social equity of adaptation options. Integrating these cross-cutting considerations strengthens the effectiveness of adaptation efforts, promotes a holistic approach to DRR, and creates a foundation for sustainable, resilient communities across New Juaben South.

Community engagement, social acceptance, and traditional compatibility: Community involvement is vital across all adaptation options, from water management to infrastructure protection and disaster volunteer groups. Engaging communities fosters local ownership, increases acceptance, and ensures that interventions are culturally relevant. When communities actively participate, there is a greater likelihood of sustainable, long-term success across diverse sectors.

Adaptation measures that align with traditional practices and cultural values gain higher acceptance and support within the community. Sectors such as water resource management, volunteer disaster groups, and flood-prone community relocation require culturally sensitive approaches to ensure smooth integration and greater community buy-in.

Gender responsiveness and equity: Ensuring gender equity and including marginalized groups, such as women and the disabled, enhances the inclusivity of adaptation measures across DRR, water management, and infrastructure sectors. Gender-responsive approaches improve the effectiveness and reach of interventions by addressing unique vulnerabilities and enabling all community members to benefit from DRR strategies.

Institutional support and capacity building: Across sectors, the success of adaptation options is heavily reliant on the capacity of local institutions, especially for initiatives involving infrastructure, community-based water management, and disaster response. Institutional capacity building, including support for NADMO and other local agencies, enables efficient implementation, monitoring, and integration of these efforts into broader DRR frameworks.

Financial sustainability: Economic feasibility is a recurring theme across all sectors, with affordability often being a limiting factor for high-impact adaptation options. Approaches that spread costs—through community contributions or phased investments—promote financial sustainability, ensuring these adaptation measures remain viable over the long term.

Environmental efficiency and climate resilience: Effective adaptation strategies often promote environmental benefits beyond immediate DRR objectives. Practices such as afforestation, community-based management, and protection of water bodies enhance biodiversity, improve water retention, and contribute to carbon sequestration, strengthening ecosystem resilience against climate change impacts across all sectors.

Flexibility, replicability, and scalability: Adaptation options must be flexible to respond effectively to New Juaben South's evolving climate risks, such as shifting rainfall patterns and increasing flood occurrences. Cross-sectoral flexibility, particularly in infrastructure and community-based management, ensures that resources can be reallocated or strategies modified as conditions change. Many successful adaptation options, such as community-based management and early warning

systems, can serve as models for other municipalities. The potential to replicate and scale up these strategies contributes to resilience building not only in New Juaben South but also in other regions facing similar challenges.

4.4.10 Implementation Needs and Resource Mobilization

The New Juaben South vulnerability assessment identified barriers to the effective participation of stakeholders in climate change adaptation, and the results were broadly captured under the following themes. Stakeholders recognized that by addressing these, New Juaben South can strengthen its approach to adaptation and improve its overall resilience to climate impacts.

Inadequate financial resources: New Juaben South's limited budget restricts its capacity to finance high-cost adaptation measures such as infrastructure improvements, resettlement projects, and incentives for disaster response officials. This financial shortfall makes it challenging to implement sustained adaptation actions, pushing reliance on inconsistent external funding sources that can delay or even halt progress.

Weak institutional capacity and coordination: The lack of adequately trained personnel and limited inter-departmental collaboration creates barriers to implementing complex adaptation projects. The town's institutional structures lack the coordination needed to manage cross-cutting initiatives effectively, which hinders efficient disaster response and sustainable community-driven adaptation initiatives.

Limited community engagement and social buy-in: Community involvement in adaptation initiatives is low, often due to limited awareness and mistrust. There is a need to foster greater public understanding of climate resilience measures, as well as actively involve communities in the decision-making process to enhance ownership. New Juaben South's adaptation efforts will struggle without widespread social acceptance and engagement, particularly for measures involving relocation or shifts in traditional practices.

Technical knowledge and skills gaps: New Juaben South's local authorities and stakeholders face a shortage of the technical skills required to maintain early warning systems, manage infrastructure, and oversee community-based resource management. This skills gap restricts the town's ability to implement adaptation options effectively and reduces resilience, as maintenance and technical support are key for ongoing project sustainability.

Lack of reliable funding channels: Limited access to sustained funding streams restricts New Juaben South's ability to mobilize the resources needed for adaptation. The absence of frameworks to attract, manage, and allocate funds for long-term adaptation projects constrains progress, particularly for financially demanding initiatives like infrastructure improvements and capacity-building programs.

Policy and regulatory gaps: New Juaben South's policy environment lacks clear guidelines for implementing and supporting community-led adaptation, water protection, and incentives for NADMO officials. Conflicting regulations and gaps in clear mandates between local agencies can slow down progress, reduce accountability, and create confusion over responsibilities, diminishing effective adaptation planning.

Environmental instability due to climate variability: Frequent and severe weather events caused by climate variability pose ongoing challenges to New Juaben South's adaptation efforts. Unpredictable rainfall and fluctuating weather patterns complicate long-term planning and demand flexible strategies, which are difficult to sustain without a robust adaptive framework. Limited adaptive capacity hinders New Juaben South's ability to respond effectively to these environmental challenges.

Insufficient focus on equity and gender sensitivity: New Juaben South's adaptation initiatives often lack a focused approach on gender equity and social inclusion, particularly for vulnerable groups such as women, youth, and marginalized communities. Without specific policies and resources dedicated to ensuring inclusivity, many adaptation projects miss the mark in addressing the diverse needs of the population, reducing the overall effectiveness of climate resilience efforts.

4.4.11 Knowledge Co-Creation and Information Sharing

Increased knowledge co-creation and information sharing on climate change adaptation can help to build the capacity of stakeholders and promote effective and sustainable adaptation actions in the New Juaben South Municipality. This can be achieved through the following:

Strengthening local community networks: Leveraging traditional knowledge systems and existing social structures can promote greater knowledge exchange. Establishing community-based learning groups or forums facilitates regular, localized information sharing and builds trust within the community.

Capacity building for local authorities and stakeholders: Providing training and resources to local officials, NADMO staff, and community leaders in data management, climate adaptation, and disaster risk management will enhance their ability to co-create and share knowledge effectively across sectors.

Integration of ICT tools: Using accessible technology, such as mobile alerts, radio broadcasts, and community information centres, can streamline communication, allowing real-time information sharing on disaster risks, weather patterns, and best practices. Providing access to tools and technologies that support climate change adaptation, such as climate data and modelling software, can help build the technical capacity of the NJSMA staff.

Partnerships with external agencies: Collaboration with research institutions, NGOs, and government agencies can bring in external expertise and resources, facilitating workshops, knowledge-exchange programs, and collaborative research that enriches local knowledge bases.

Community-driven feedback mechanisms: Establishing platforms for communities to share feedback on adaptation efforts and to discuss local observations enables continuous improvement and creates a sense of ownership, driving collective knowledge sharing and co-creation.

Multistakeholder platforms: Establishing multi-stakeholder platforms that bring together representatives from the NJSMA, civil society organizations, academia, and other relevant stakeholders can help facilitate knowledge co-creation and information sharing. This could include organizing workshops, training sessions, and conferences to provide opportunities for the NJSMA staff to learn about best practices and innovative approaches to climate change adaptation from experts and peers.

4.4.12 Funding and Support

To mobilize funds for adaptation in New Juaben South, the district can explore a mix of local, national, and international funding avenues. These include:

NGOs and foundations: Numerous NGOs and foundations provide grants for climate adaptation and disaster risk reduction. Collaboration with NGOs focused on climate resilience, like ActionAid or CARE International, can help fund and implement locally tailored adaptation programs, especially those supporting community engagement and infrastructure improvement. For example, collaboration with CARE International in Ghana resulted in the construction of solar powered mechanized boreholes in some selected areas in New Juaben South. This can be scaled up and replicated in other sectors.

Local revenue generation and community contributions: Mobilizing funds locally generated by the NJSMA, as well as encouraging voluntary community contributions or small levies can support minor, community-specific adaptation activities. This approach also reinforces local ownership and sustainability of adaptation projects.

Public-private partnerships: Establishing partnerships with private sector entities interested in corporate social responsibility (CSR) initiatives can attract funding and resources for community-led adaptation projects. For instance, water bottling companies might be interested in funding water resource protection, or infrastructure firms in building resilient roads and drainage systems.

Donor funding and international development agencies: New Juaben South can tap into adaptation funding from international donors such as USAID, DFID, GIZ, and UNDP, which frequently support climate resilience and disaster risk reduction in vulnerable regions. These agencies offer grants and technical assistance, especially when proposals align with their goals of reducing climate vulnerability and fostering sustainable development.

Green Climate Fund and Global Environment Facility: New Juaben South can apply for international funds specifically allocated for climate change adaptation and readiness programs, which provide technical assistance and support to help identify and prepare for climate finance opportunities. Partnering with accredited entities like the Environmental Protection Agency (EPA) or other registered local agencies can increase the district's access to these funds.

Capacity building for carbon market participation: Equipping local government officers with training on carbon markets could open new funding channels. By understanding carbon credits and market dynamics, the district could partner with organizations involved in carbon trading, potentially selling carbon credits from projects like reforestation or sustainable agricultural practices. While this is more complex, building the capacity of local officers could make the New Juaben South Municipal Assembly eligible to participate in carbon offset projects aligned with national carbon policies.

5.0 Framework for Adaptation Monitoring, Evaluation, and Learning

Monitoring, evaluation, and learning (MEL) plays a crucial role in adaptation planning by tracking progress, evaluating impact, and ensuring the efficient use of resources (Beauchamp et al., 2024; Gkika et al., 2024). Within the New Juaben South Municipal Assembly, MEL ensures accountability to stakeholders and facilitates adaptive management, allowing for timely adjustments based on up-to-date data. By capturing both successes and challenges, MEL fosters a culture of ongoing learning, encouraging knowledge exchange and guiding future initiatives (Ahsan, 2025). Furthermore, the insights gained through MEL can help local policy-makers fine-tune policies, identify successful approaches, and scale best practices, thereby improving the overall effectiveness and long-term sustainability of adaptation efforts in the region.

5.1 Building on Existing Structures to Facilitate Mainstreaming

In the context of climate adaptation, monitoring, evaluation, and learning (MEL) is a vital tool for tracking the progress of adaptation actions and measuring advancements toward climate resilience. This system is intended to complement and strengthen both national and municipal monitoring and evaluation (M&E) frameworks, creating a cohesive approach to evaluating outcomes and effectiveness. By aligning with existing structures, MEL not only tracks adaptation progress but also promotes learning about climate change, ensuring that development objectives are met while contributing to long-term sustainability.

In Ghana, various laws, policies, and frameworks guide the development of monitoring and evaluation systems for development initiatives. The National Development Planning Commission (NDPC) is responsible for M&E at the national level, providing a system that connects inputs, activities, outputs, outcomes, and impacts within public service delivery. Relevant legal frameworks such as Articles 86 and 87 of the 1992 Constitution, the National Development Planning System Act (Act 480) of 1994, and the National Development Planning (System) Regulations (LI. 2232) of 2016 mandate the implementation of M&E by government agencies for their programs and policies.

For the New Juaben South Municipal Assembly (NJSMA), developing an M&E plan at both the municipal and sub-district levels is a key expectation, in line with the NDPC's guidelines (NDPC, 2020). While there is no dedicated M&E plan specifically for climate change adaptation, the NDPC's frameworks incorporate indicators that address climate change, the Sustainable Development Goals (SDGs), Agenda 2063, and green economy initiatives. The integration of climate adaptation considerations into the NJSMA's Medium-Term Development Plan (MTDP) emphasizes the importance of monitoring and assessing related indicators. However, the NDPC's M&E framework does not explicitly address the learning dimension, which is critical for fostering continuous improvement. The learning aspect of MEL is a growing concept globally, requiring focused efforts to enhance its integration in climate adaptation practices.

5.2 MEL Design

The framework for the New Juaben South Municipal Assembly (NJSMA) adaptation Monitoring, Evaluation, and Learning (MEL) system is designed to achieve the following objectives:

- track the implementation of agreed-upon adaptation measures within the municipality to ensure their effective execution,
- evaluate the effectiveness of adaptation actions in mitigating community vulnerabilities,
- generate insights and knowledge that inform policy development, decision making, and raise awareness among stakeholders,
- provide data for local government and national reporting, ensuring transparency and accountability,
- develop a system for acquiring and storing climate data to monitor and assess adaptation progress at the local level, and
- establish clear communication channels for disseminating information regarding the adaptation strategy and efforts within the municipality.

Operationalizing the adaptation MEL system involves integrating climate adaptation considerations into municipal development plans and policies, including the Annual Action Plans (AAP) and the district's Medium-Term Development Plan (MTDP), ensuring a seamless link between adaptation goals and development priorities.

Table 23. Outline of approach to MEL of the NJSMA adaptation actions

Steps	Indicative activities – to be led by the NJSMA Planning Coordination Unit
1. Monitoring the adaptation actions	Identify and select adaptation activities for monitoring using a mixed method of qualitative and quantitative performance indicators to assess progress toward the adaptation goals. Define relevant metrics and indicators to document progress for the identified adaptation activities. Gather data on the defined metrics and indicators consistently throughout the adaptation implementation process.
2. Reviewing the adaptation process to assess progress, effectiveness, and gaps – evaluation	Develop methods for assessing the effectiveness of adaptation measures and identifying any gaps in the adaptation process. Incorporate findings from recent studies, emerging scientific advancements, and feedback from ongoing adaptation efforts to evaluate and refine strategies. Revise adaptation activities based on evaluation results and performance metrics.
3. Iteratively updating the adaptation plan – learning	Adjust adaptation actions in response to the information obtained through monitoring and evaluation activities. Document and analyze key lessons learned, emphasizing successful strategies and areas for improvement. Establish criteria to determine the success or failure of adaptation initiatives. Take remedial actions based on evaluation results, ensuring that adaptation efforts remain aligned with the defined objectives. Ensure that learning outcomes and corrective actions align with broader goals outlined in the NJSMA Medium-Term Development Plan (MTDP).
4. Reporting progress, process effectiveness, outreach, and knowledge dissemination – communication	Share adaptation-related reports, documents, and learning outcomes with relevant stakeholders. Include progress updates in the NJSMA annual report, detailing the advancement and effectiveness of adaptation actions.

Source: Adapted (and modified) from the Government of Liberia's four-step approach to the MEL of its NAP. See Environmental Protection Agency, Republic of Liberia, 2022.

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Appendix A. Validated Sector Adaptation Action Catalogue

Five stakeholder groups assigned scores to the indicators set out in the following tables. The stakeholders undertook the ranking based on their expert assessment of the indicator's performance against the criteria. The five stakeholder groups were agriculture biodiversity, water resources, DRR and transport, health and sanitation, and gender and tourism.

Table A1. Indicator scores

1	Low
2	Neutral
3	Medium
4	High
(…)	Enclose a number in a bracket to show high uncertainty.

Source: Authors

Table A2. Agriculture adaptation measures

Adaptation action	Afforestation and agroforestry	Sensitization and training	Conservative agriculture	Early warning and response mechanisms	Diversification	Irrigation systems	Aquaculture	Animal husbandry
Adaptation type	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction
Implementation level	Municipal or government and community	Municipal or government and community	Municipal or government and community	Municipal or government and community	Municipal or government and community	Municipal or government and community	Municipal or government	Municipal or government and community
Risk gradient	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk
Governance implications	Alignment with existing structure	Alignment with existing structure	Requires amendment to existing structure	Alignment with existing structure	Alignment with existing structure	Alignment with existing structure	Requires amendment to existing structure	Alignment with existing structure
SDGs and development co-benefit	Promotes SDG 13, 15, 2	Promotes SDG 4, 13	Promotes SDG 2, 15	Promotes SDG 13, 11	Promotes SDG 8, 12	Promotes SDG 6, 2	Promotes SDG 14, 6	Promotes SDG 2, 13
Risk mitigation potential	4	3	4	4	3	4	3	3
Effectiveness	3	3	4	4	4	4	4	4
Affordability	1	4	3	2	4	1	3	3
Institutional feasibility	4	3	4	3	3	3	4	4
Alignment with municipal priorities	1	3	3	2	3	3	3	3
Technical feasibility	4	4	4	3	3	3	4	4
Traditional acceptance	3	3	3	3	3	3	4	4
Social acceptance	4	3	3	3	3	3	4	4
Flexibility	2	2	3	2	3	3	4	4

Adaptation action	Afforestation and agroforestry	Sensitization and training	Conservative agriculture	Early warning and response mechanisms	Diversification	Irrigation systems	Aquaculture	Animal husbandry
Environmental efficiency/climate resilience	4	3	4	3	3	3	4	4
Gender responsiveness	3	4	3	2	4	1	3	4
Equity	1	2	2	2	3	3	4	4
Replicability	2	3	3	3	3	3	4	4
Cross-sectoral maladaptation	NA	NA	NA	NA	NA	NA	NA	NA
GHG emissions	3	1	3	1	2	2	1	1
Biodiversity	4	1	3	3	2	2	4	2
Human health	3	3	3	4	3	3	3	3
Soil quality	4	1	4	1	1	4	1	3
Water quality	3	1	3	3	1	4	3	3
Air quality	4	1	3	3	3	3	3	3
Climate	4	1	3	2	2	1	3	3
Landscape	3	1	3	1	2	2	1	1
Prioritized communities	Municipal wide	Municipal wide	Municipal wide	Municipal wide	Municipal wide	Municipal wide	Municipal wide	Municipal wide
Potential negative outcomes	Risk of land use conflicts	Low engagement	Decreased yields due to poor practice	Over-reliance on technology	Unequal benefits	High initial cost	Pollution risk	Disease transmission
Barriers to implementation	Land tenure issues Lack of awareness	Resource constraints Resistance to change	Lack of knowledge Limited market access	High set-up cost Monitoring capacity	Access to inputs Market fluctuation	Water access issues Maintenance costs	Technical expertise Environmental concerns	Animal diseases Poor veterinary care

Source: Authors

Table A3. Biodiversity sector adaptation measures

Adaptation action	Afforestation	Create protected areas	Formation of disaster volunteer groups	Sustainable land use
Adaptation type	Risk reduction	Risk reduction	Risk reduction	Risk reduction
Implementation level	Municipal or government and community	Municipal or government led	Municipal or government and community	Municipal or government and community
Risk gradient	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk
Governance implications	Requires amendment to existing structure	Requires amendment to existing structure	Alignment with existing structure	Alignment with existing structure
SDGs and development co-benefit	SDG 13, 15, 2	SDG 13, 15, 11	SDG 13, 11, 2	SDG 13, 15, 2
Risk mitigation potential	3	4	3	4
Effectiveness	4	4	4	3
Affordability	2	4	4	2
Institutional feasibility	4	4	4	3
Alignment with municipal priorities	2	3	3	3
Technical feasibility	4	3	3	4
Traditional acceptance	4	4	3	3
Social acceptance	4	4	3	3
Flexibility	3	2	3	2
Environmental efficiency/climate resilience	4	4	4	4
Gender responsiveness	2	3	3	2
Equity	1	3	3	3
Replicability	2	2	3	3
Cross-sectoral maladaptation	NA	NA	NA	NA
GHG emissions	3	2	1	2
Biodiversity	4	4	3	4
Human health	3	3	4	3
Soil quality	4	3	2	4
Water quality	3	3	3	3
Air quality	3	3	2	3
Climate	4	3	3	4
Landscape	4	4	3	4
Prioritized communities	Community-based	Municipal-wide	Municipal-wide	Community-based

Adaptation action	Afforestation	Create protected areas	Formation of disaster volunteer groups	Sustainable land use
Potential negative outcomes	Risk of land use conflicts	Resistance to change	Low engagement	Land tenure conflicts
Barriers to implementation	Land tenure issues Lack of awareness	Lack of funds Political challenges	Mobilization challenges Volunteer retention	Lack of awareness Resistance to change

Source: Authors

Table A4. Water resources sector adaptation measures

Adaptation action	Practice afforestation	Early warning and response mechanisms	Enforce illegal gold mining laws	Community education and involvement	Water quality monitoring program	Construct and improve water management infrastructure	Increase access to potable water supply	Communal water storage	Enforcement of permit laws
Adaptation type	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction
Implementation level	Municipal or government and community	Municipal or government and community	Government led, municipal, and community	Municipal or government and community	Municipal or government led	Municipal or government and community	Municipal or government led	Municipal or government led	Municipal or government led
Risk gradient	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk
Governance implications	Alignment with existing structure	Alignment with existing structure	Requires amendment to existing structure	Alignment with existing structure	Alignment with existing structure	Alignment with existing structure	Alignment with existing structure	Alignment with existing structure	Requires amendment to existing structure
SDGs and development co-benefit	SDG 13, 15, 2	SDG 13, 11, 16	SDG 16, 13, 11	SDG 4, 11, 13	SDG 6, 3, 13	SDG 9, 6, 13	SDG 6, 13	SDG 6, 13, 3	SDG 16, 13
Risk mitigation potential	4	4	4	3	4	4	4	3	4
Effectiveness	4	1	2	4	4	4	4	3	4
Affordability	3	1	1	3	1	1	3	3	3
Institutional feasibility	4	4	3	4	4	4	4	4	4
Alignment with municipal priorities	4	4	4	4	4	4	4	4	4

Adaptation action	Practice afforestation	Early warning and response mechanisms	Enforce illegal gold mining laws	Community education and involvement	Water quality monitoring program	Construct and improve water management infrastructure	Increase access to potable water supply	Communal water storage	Enforcement of permit laws
Technical feasibility	4	4	4	4	4	4	3	4	4
Traditional acceptance	4	4	3	4	4	4	4	4	4
Social acceptance	4	4	4	4	4	4	4	4	4
Flexibility	4	4	1	4	4	3	4	4	4
Environmental efficiency/ climate resilience	3	4	4	4	4	4	4	4	4
Gender responsiveness	4	4	4	4	4	4	4	4	4
Equity	2	2	2	4	4	4	4	4	4
Replicability	4	4	4	4	4	4	4	4	4
Cross-sectoral maladaptation	NA	NA	NA	NA	NA	NA	NA		NA
GHG emissions	3	2	2	1	2	2	3	1	2
Biodiversity	4	3	2	3	3	3	3	4	2
Human health	3	4	2	4	4	4	3	4	2
Soil quality	4	2	2	3	3	3	4	4	2
Water quality	3	4	3	4	4	4	4	4	3
Air quality	3	3	2	3	3	3	3	3	3
Climate	4	4	3	3	3	3	3	3	4
Landscape	4	4	3	3	4	4	3	3	4
Prioritized communities	Community-based	Municipal-wide	Municipal-wide	Community-based	Community-based	Municipal-wide	Municipal-wide	Community-based	Municipal-wide

Adaptation action	**Practice afforestation**	**Early warning and response mechanisms**	**Enforce illegal gold mining laws**	**Community education and involvement**	**Water quality monitoring program**	**Construct and improve water management infrastructure**	**Increase access to potable water supply**	**Communal water storage**	**Enforcement of permit laws**
Potential negative outcomes	Risk of land use conflicts	Late response, risk of false alarms	Political resistance	Low engagement, misinformation	Data inaccuracies, underreporting	Inadequate infrastructure	High costs, maintenance issues	Overcrowding, mismanagement	Resistance, enforcement challenges
Barriers to implementation	Land tenure issues Lack of awareness	Lack of coordination Resource constraints	Political will Enforcement capacity	Cultural barriers Lack of resources	Funding limitations Technical capacity	Budget constraints Political will	High costs Logistical challenges	Space constraints High costs	Lack of political will Resource constraints

Source: Authors

Table A5. Health and sanitation sector adaptation measures

Adaptation action	Afforestation/ agroforestry	Public health education campaign and sensitization	Early warning signs	Construct and improve health infrastructure	Construction and extension of potable water and sanitation facilities
Adaptation type	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction
Implementation level	Municipal, community	Municipal-wide, community	Municipal-wide, community	Government-led, community	Government-led, community
Risk gradient	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk
Governance implications	Alignment with existing structure	Alignment with existing structure	Alignment with existing structure	Alignment with existing structure	Alignment with existing structure
SDGs and development co-benefit	SDG 13, 15, 2	SDG 3, 13, 16	SDG 13, 11, 16	SDG 3, 6, 13	SDG 6, 3, 11
Risk mitigation potential	4	3	4	4	4
Effectiveness	4	2	4	4	4
Affordability	3	2	2	2	3
Institutional feasibility	4	4	4	4	4
Alignment with municipal priorities	3	4	4	4	4
Technical feasibility	4	4	3	3	3
Traditional acceptance	4	4	4	4	4
Social acceptance	3	3	4	4	4
Flexibility	4	4	4	4	4
Environmental efficiency/climate resilience	4	3	3	4	4
Gender responsiveness	4	4	4	4	3
Equity	4	4	4	4	3
Replicability	3	4	4	4	4
Cross-sectoral maladaptation	NA	NA	NA	NA	NA
GHG emissions	NA	1	1	2	2
Biodiversity	4	2	3	3	3
Human health	3	4	4	4	4
Soil quality	4	2	2	2	2

Adaptation action	Afforestation/ agroforestry	Public health education campaign and sensitization	Early warning signs	Construct and improve health infrastructure	Construction and extension of potable water and sanitation facilities
Water quality	3	3	4	4	4
Air quality	3	2	2	3	2
Climate	4	3	3	3	4
Landscape	4	3	4	4	4
Prioritized communities	Community-based	Municipal-wide, community	Municipal-wide, community	Municipal-wide, community	Municipal-wide, community
Potential negative outcomes	Risk of land use conflicts	Resistance to change	Late response, confusion	High costs, inadequate resources	High maintenance costs, space constraints
Barriers for implementation	Land tenure issues Lack of awareness	Lack of resources Political will	Lack of coordination Limited capacity	High costs Political resistance	High costs Maintenance issues Political will

Source: Authors

Table A6. Disaster risk reduction sector adaptation measures

Adaptation action	Afforestation	Early warning and response mechanisms	Community engagement and awareness	Strict enforcement of bylaws	Implementing zoning laws	Construction of improved drainage system	Road markings	Pedestrian walkways
Adaptation type	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction
Implementation level	Municipal, community	Municipal-wide, community	Municipal-wide, community	Municipal-wide	Municipal-wide	Municipal-wide, community	Municipal-wide	Municipal-wide
Risk gradient	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk
Governance implications	Alignment with existing structure	Alignment with existing structure	Requires amendment to existing structure	Requires amendment to existing structure	Requires amendment to existing structure	Alignment with existing structure	Alignment with existing structure	Alignment with existing structure
SDGs and development co-benefit	SDG 13, 15, 2	SDG 13, 11, 16	SDG 4, 13, 16	SDG 16, 11	SDG 11, 13	SDG 11, 13, 6	SDG 11, 3	SDG 11, 3
Risk mitigation potential	4	4	3	3	4	4	3	3
Effectiveness	4	3	4	3	3	4	4	4
Affordability	4	4	4	3	4	4	4	4
Institutional feasibility	4	1	4	4	4	4	4	4
Alignment with municipal priorities	3	4	4	4	4	4	4	4
Technical feasibility	4	4	4	4	1	4	4	4
Traditional acceptance	4	4	4	4	3	4	4	4
Social acceptance	4	4	3	3	3	4	4	4
Flexibility	3	4	3	3	4	4	4	4
Environmental efficiency/climate resilience	4	4	3	4	4	4	2	2

Adaptation action	Afforestation	Early warning and response mechanisms	Community engagement and awareness	Strict enforcement of bylaws	Implementing zoning laws	Construction of improved drainage system	Road markings	Pedestrian walkways
Gender responsiveness	2	4	4	4	4	4	4	4
Equity	1	1	1	1	1	1	1	1
Replicability	2	3	3	3	3	4	4	4
Cross-sectoral maladaptation	NA	NA	NA	NA	NA	NA	NA	NA
GHG emissions	3	2	1	1	2	2	1	1
Biodiversity	4	3	3	2	3	3	2	2
Human health	3	4	4	4	4	4	4	4
Soil quality	4	2	2	2	2	3	2	2
Water quality	3	4	3	2	3	4	2	2
Air quality	3	2	2	2	3	3	3	3
Climate	4	3	3	3	4	4	3	3
Landscape	4	4	3	3	4	4	3	3
Prioritized communities	Community-based	Municipal-wide, community	Municipal-wide, community	Municipal-wide	Municipal-wide	Municipal-wide, community	Municipal-wide	Municipal-wide
Potential negative outcomes	Risk of land use conflicts	Late response, confusion	Resistance to change	Public resistance, political interference	Land use conflicts	High costs, maintenance challenges	Low compliance	Space constraints
Barriers to implementation	Land tenure issues Lack of awareness	Lack of coordination Limited capacity	Lack of resources Political will	Resistance to enforcement Corruption	Limited technical capacity Resistance from developers	High costs Maintenance issues	Poor enforcement Funding constraints	Space availability Infrastructure costs

Source: Authors

Table A7. Transport sector adaptation measures

Adaptation action	Protection of roads/infrastructure	Proper development control and rezoning of the municipality	Development of spatial plans and effective land management policies	Construction and improvement of infrastructure	Dredging of drains	Improve road markings and sidewalk ways
Adaptation type	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction
Implementation level	Municipal-wide	Municipal-wide	Municipal-wide	Municipal-wide, community	Municipal-wide	Municipal-wide
Risk gradient	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk
Governance implications	Alignment with existing structure	Requires amendment to existing structure	Requires amendment to existing structure	Alignment with existing structure	Alignment with existing structure	Alignment with existing structure
SDGs and development co-benefit	SDG 11, 9	SDG 11, 13	SDG 11, 13, 15	SDG 9, 11	SDG 11, 6, 13	SDG 11, 3
Risk mitigation potential	4	4	4	4	4	3
Effectiveness	4	4	4	4	4	4
Affordability	4	2	4	2	2	3
Institutional feasibility	4	2	4	4	4	4
Alignment with municipal priorities	4	2	4	4	4	4
Technical feasibility	4	4	4	4	4	4
Traditional acceptance	4	1	3	4	4	4
Social acceptance	4	1	3	4	4	4
Flexibility	4	3	4	3	4	4
Environmental efficiency/climate resilience	4	3	4	3	4	4
Gender responsiveness	4	2	4	4	4	4
Equity	4	2	4	4	4	4

Adaptation action	Protection of roads/infrastructure	Proper development control and rezoning of the municipality	Development of spatial plans and effective land management policies	Construction and improvement of infrastructure	Dredging of drains	Improve road markings and sidewalk ways
Replicability	4	4	4	4	4	4
Cross-sectoral maladaptation	NA	NA	NA	NA	NA	NA
GHG emissions	2	2	2	3	2	1
Biodiversity	3	3	4	3	3	2
Human health	4	3	3	4	4	4
Soil quality	2	3	3	3	3	2
Water quality	3	3	3	4	4	2
Air quality	3	3	3	3	2	3
Climate	3	4	4	4	3	3
Landscape	3	4	4	4	3	3
Prioritized communities	Municipal-wide	Municipal-wide	Municipal-wide	Municipal-wide, community	Municipal-wide	Municipal-wide
Potential negative outcomes	Increased costs for maintenance	Resistance from developers	Land use conflicts	High costs and maintenance burden	Temporary displacement, sediment disposal issues	Poor enforcement, non-compliance
Barriers to implementation	High costs Infrastructure maintenance	Resistance from developers Bureaucratic delays	Lack of technical expertise High planning costs	High costs Funding constraints	High costs Equipment availability	Poor enforcement Infrastructure costs

Source: Authors

Table A8. Gender mainstreaming sector adaptation measures

Adaptation action	Climate education programs	Gender mainstreaming in action plans	Sustainable livelihood program	Diversification of livelihoods	Palm kernel processing	Energy efficient cook stoves	Creating of social support groups
Adaptation type	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction
Implementation level	Municipal-wide, community	Municipal-wide	Municipal-wide, community	Community-based	Community-based	Community-based	Municipal-wide, community
Risk gradient	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk
Governance implications	Alignment with existing structure	Requires amendment to existing structure	Requires amendment to existing structure	Alignment with existing structure	Alignment with existing structure	Alignment with existing structure	Alignment with existing structure
SDGs and development co-benefit	SDG 4, 13	SDG 5, 13	SDG 1, 8	SDG 8, 12	SDG 9, 12	SDG 7, 13	SDG 3, 10
Risk mitigation potential	3	3	4	4	3	3	3
Effectiveness	3	4	4	3	4	4	4
Affordability	3	3	3	2	3	2	3
Institutional feasibility	4	4	3	3	3	2	4
Alignment with municipal priorities	4	4	4	4	4	3	4
Technical feasibility	3	3	3	2	2	2	4
Traditional acceptance	2	2	4	3	4	2	3
Social acceptance	2	2	4	4	4	2	4
Flexibility	3	4	4	3	4	4	4
Environmental efficiency/climate resilience	3	3		3	2	3	2

Adaptation action	Climate education programs	Gender mainstreaming in action plans	Sustainable livelihood program	Diversification of livelihoods	Palm kernel processing	Energy efficient cook stoves	Creating of social support groups
Gender responsiveness	4	4	4	4	4	4	4
Equity	4	4	4	4	4	4	4
Replicability	4	4	4	3	4	3	3
Cross-sectoral maladaptation	NA	NA	NA	NA	NA	NA	NA
GHG emissions	2	2	3	3	2	1	1
Biodiversity	3	2	3	3	2	3	2
Human health	4	3	4	4	3	4	4
Soil quality	2	2	3	3	3	3	2
Water quality	2	2	3	3	3	3	2
Air quality	2	2	3	3	3	4	2
Climate	3	3	4	4	3	4	3
Landscape	3	2	4	4	3	3	3
Prioritized communities	Municipal-wide, community	Municipal-wide	Municipal-wide, community	Community-based	Community-based	Community-based	Municipal-wide, community
Potential negative outcomes	Limited behavioural change	Resistance due to cultural norms	Unequal access to benefits	Market instability	Environmental pollution	Resistance to change	Limited participation
Barriers to implementation	Low awareness Limited outreach	Cultural barriers Policy constraints	Funding limitations Need for capacity building	Market access challenges Skills gap	High initial investment Waste management issues	High cost of stoves Behavioural resistance	Low engagement Social stigma

Source: Authors

Table A9. Tourism sector adaptation measures

Adaptation action	Afforestation	Create protected areas	Enforcement of urban planning and land bylaws	Construction and tarring of roads	Construction of improved drainage	Providing good sanitation services
Adaptation type	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction	Risk reduction
Implementation level	Municipal-wide, community	Municipal-wide	Municipal-wide	Municipal-wide	Municipal-wide	Municipal-wide, community
Risk gradient	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk	Useful beyond risk
Governance implications	Alignment with existing structure	Requires amendment to existing structure	Requires amendment to existing structure	Alignment with existing structure	Alignment with existing structure	Alignment with existing structure
SDGs and development co-benefit	SDG 13, 15, 2	SDG 15, 13	SDG 11, 13	SDG 9, 11	SDG 11, 6	SDG 6, 3
Risk mitigation potential	4	4	3	3	3	3
Effectiveness	4	4	3	4	4	4
Affordability	2	2	3	4	3	4
Institutional feasibility	4	4	4	4	4	4
Alignment with municipal priorities	4	4	4	4	4	4
Technical feasibility	4	4	4	4	4	4
Traditional acceptance	4	4	3	4	4	4
Social acceptance	4	4	3	4	4	4
Flexibility	4	4	4	4	4	4
Environmental efficiency/climate resilience	4	4	4	4	4	4
Gender responsiveness	4	4	4	4	4	4
Equity	4	4	4	4	4	4
Replicability	4	4	4	4	4	4

Adaptation action	Afforestation	Create protected areas	Enforcement of urban planning and land bylaws	Construction and tarring of roads	Construction of improved drainage	Providing good sanitation services
Cross-sectoral maladaptation	NA	NA	NA	NA	NA	NA
GHG emissions	1	1	2	3	3	2
Biodiversity	4	4	2	2	2	2
Human health	3	3	3	3	3	4
Soil quality	3	3	2	3	3	3
Water quality	3	3	2	3	3	4
Air quality	3	3	2	3	3	3
Climate	4	4	3	3	3	3
Landscape	4	4	3	3	3	3
Prioritized communities	Municipal-wide, community	Municipal-wide	Municipal-wide	Municipal-wide	Municipal-wide	Municipal-wide, community
Potential negative outcomes	Land-use conflicts	Restricted access to resources	Displacement of settlers	High maintenance costs	Construction delays	Poor waste disposal practices
Barriers to implementation	Land tenure issues Deforestation pressures	Community resistance Land acquisition challenges	Lack of enforcement Political influence	High construction costs Land acquisition	Funding limitations Engineering constraints	Inadequate waste management infrastructure Behavioural resistance

Source: Authors

Appendix B. Multicriteria Analysis Score Sheet

Name of sector:

Adaptation action:

The assessment is divided into two depending on whether weight or score is applied to the indicator of the criteria.

Weighting

Certain adaptation actions by their nature may carry more weight or be more effective than others. For example, a community-led action would generate higher ownership and sustainability and should carry more weight than other actions that are autonomous or institution-led. Secondly, an action that has established structures for implementation already may carry greater weight than those that require new structures.

Table B1. Multicriteria analysis score sheet

Criteria	Description	Indicator	Which of the indicators apply	Weight
Adaptation type	This criterion evaluates the risk reduction or risk transfer potential of an identified adaptation option. For example, an irrigation system has a drought risk reduction potential, while crop insurance would transfer the risk.	Risk reduction		
		Risk transfer		
Implementation level	The level of implementation of an identified adaptation option.	Municipal/government level led		
		Place or community led		
		Autonomous		
Risk gradient	This evaluates whether an identified adaptation option has a "risk-specific" gradient or could be useful beyond the risk. "Risk-specific" gradient refers to adaptation strategies that mitigate specific risks.	Risk-specific gradient		
		Useful beyond risk		
Governance implications of the measure	The adaptation option is aligned with, or requires amendments to, existing governance structures or necessitates the establishment of new governance structures or processes.	Alignment with existing structure		
		Requires amendment to existing structure		
		Establishment of new governance structure		

Source: Authors

Scoring

Score is assigned to an indicator based on the stakeholders' assessment of the indicator's performance against the criteria.

Table B2. Indicator scoring

1	Low
2	Neutral
3	Medium
4	High
(…)	Enclose a number in a bracket to show high uncertainty.

Source: Authors

Table B3. Criteria and indicators

Criteria	Description	Indicator	Score (1–4)
SDGs and development co-benefit	How the adaptation option aligns with the SDGs and the municipal development agenda	Number of SDGs that it addresses	
Risk mitigation potential	The ability of the adaptation option to mitigate specific climate impacts	Level of risk mitigation potential	
Upscaling and replicability potential	The extent to which a particular adaptation intervention can be expanded	Level of scalability	
		Level of replicability	
Cost-effectiveness	Cost associated with the implementation of the identified option, covering planning to implementation		
Social and cultural acceptance	A project must be socially and culturally accepted to ensure local buy-in	Level of social and cultural acceptance	
Cross-sectoral maladaptation	Actions intended to reduce climate change impacts in one sector may create more risk and vulnerability in the same or other sectors, potentially causing more harm than good	Level of perceived cross-sectoral maladaptation	
Deliverability and feasibility	Delivered with existing institutional structures	Level of feasibility	
Technical feasibility	The technical know-how, capacity, and availability needed for implementing a particular adaptation intervention	Level of technical feasibility	
Social considerations	Impacts on social inclusion and cohesion	Level of positive impact on social inclusion	
Environmental considerations	Improving or worsening GHG emissions		
	GHG emissions	Level of lowering GHG emissions	
	Biodiversity	Level of enhancing biodiversity	
	Human health	Level of improving human health	
	Soil quality	Level of enhancing soil quality	
	Water quality	Level of enhancing water quality	
	Air quality	Level of enhancing air quality	
	Climate	Level of improving climate	
	Landscapes	Level of enhancing landscape	
Stakeholder interest	Stakeholders' buy-in potential		
Prioritized communities			

Source: Authors

Appendix C. List of Stakeholders

Development Planning Unit

National Disaster Management Organisation (NADMO)

Koforidua Technical University

GBD Sunrise FM – media

Assembly members

Municipal Statistical Unit

Community members

Department of Agriculture (NJSMA)

AG Church – religious leader

Traditional authority (Queen Mother)

Persons With Disability

Ghana Health Service

Students (KNUST)

Techfarm Hub – private sector

Forestry Commission

Farmers' groups

Ghana National Fire Service (GNFS)

Africa Environmental Sanitation (AFES) Ghana – non-governmental institution

Information Service Department

Municipal Planning Department (NJSMA)

Municipal Chief Executive

Municipal Coordinating Director

Department of Works (Municipal Engineer)

Gender Desk Office

Environmental Protection Agency (EPA)

Chief Imam (religious group)

Municipal Physical Planning Department

National Commission of Civic Education (NCCE)

Youth Parliament President (Youth group)

Zoomlion waste management company

Municipal Environment and Health Unit


NEW JUABEN SOUTH
MUNICIPAL ASSEMBLY
ASOMDWEE NE NKOSOO


FREEDOM
AND
JUSTICE