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Vulnerability and Impact Assessment

Ecosystem-based Adaptation for Rural Resilience (EbARR) in Tanzania

Final Report

UNIQUE forestry and land use

Vulnerability and Impact Assessment

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Final Report

Client
Vice President's Office, Tanzania

Authors
Paul Manning (Independent Consultant, Team Leader)
Dr. Jochen Statz (UNIQUE forestry and land use, Germany)
Renuka Srinivasan (UNIQUE forestry and land use, Germany)
Dr. Gordon Stanger (Independent Consultant)
Demetrius Kweka (Independent Consultant)
Abdallah Henku (Independent Consultant)
Dr. Japhet Kashaigili (Independent Consultant)

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AOCGCM	Atmospheric-Ocean-Coupled Global Climatic Model
AR5	IPCC Fifth Assessment Report
CBD	Convention on Biological Diversity
CMIP-5	Coupled Model Inter-comparison Project, Phase 5
CRiSTAL	Community-based Risk Screen Tool – Adaptation and Livelihoods
CRVA	Climate Risk and Vulnerability Assessment
DoE	Division of Environment (VPO, Tanzania)
EbA	Ecosystem-based Adaptation
EbARR	Ecosystem-Based Adaptation for Rural Resilience in Tanzania
ESI	Ecosystem Service Indicators
EURAC	European Academy of Bozen
FAO	Food and Agriculture Organization
FBO	Faith-Based Organization
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
ICRAF	World Agroforestry Center
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
LDCF	Least Developed Country Fund
LGA	Local Government Authorities
LPG	Liquefied Petroleum Gas
MCA	Multi-Criteria Analysis
PMO	Prime Minister’s Office
PMU	Project Management Unit
PORALG	President’s Office, Regional Administration and Local Government
PROVIA	UNEP Programme of Research on CC Vulnerability, Impacts & Adaptation
RCP	Representative Carbon Pathways
RGovZ	Revolutionary Government of Zanzibar
SLR	Sea Level Rise
SMART	Specific, measurable, attainable, relevant and time-bound
SME	Small and Medium Enterprises
(S)RMP	(Sustainable) Rangeland Management Plan
TESSA	Toolkit for Ecosystem Service Site-based Assessment
TMA	Tanzanian Meteorological Agency
UNEP	United Nations Environment Programme
UNFCCC	UN Framework Convention on Climate Change
UNU-EHS	United Nations University, Institute for Environment & Human Security

VFMP	Village Forest Management Plan
VIA	Vulnerability and Impact Assessment
VLUP	Village Land Use Plan
VPO	Vice President's Office
WCMC	World Conservation Monitoring Center

EXECUTIVE SUMMARY

Background

Tanzania is implementing the project "Ecosystem-Based Adaptation for Rural Resilience in Tanzania" (EbARR), which aims to increase resilience to climate change in rural communities of Tanzania by strengthening ecosystem-based adaptation and diversifying livelihoods.

The most recent climate projections for Tanzania overwhelmingly indicate signals of increased climate variability, erratic and changing rainfall patterns and rising mean annual and daily temperatures – particularly in highland and semi-arid areas (VPO-DoE 2007). Community livelihoods and environmental resilience across rural Tanzania are being significantly affected by these adverse climate change signals. Resulting impacts include frequent and severe droughts, water scarcity, increased erosion and run-off and decreased food production, among others. The vulnerability of communities and ecosystems is further exacerbated by limited internal capacities to fund or implement adaptation activities, extreme poverty amongst most vulnerable populations, poor infrastructure, limited credit opportunities, and lack of climate information.

A Vulnerability and Impact Assessment (VIA) assignment has been conducted across the five districts targeted by the EbARR project, and the final deliverable of this assignment is this EbA report, which recommends cost-efficient and climate-resilient land and water resource management options, falling under the category of EbA. This executive summary provides an overview of the climate projections and impacts studied across the project areas, the targeted EbA interventions recommended for them, and a suggestion on ecosystem indicators to be used in the monitoring of project activities at a later stage.

Chapter 1 of the report provides an introduction (background, scope and main policies considered).

Chapter 2 describes the methodology used (work plan, study approach, methodologies to select EbA measures, produce climate projections, conduct risk mapping and for the VIA itself, as well as suggestions for monitoring and evaluation).

Chapters 3 to 7 present profiles for each of the five project areas; Kaskazini-A (Zanzibar), Mvomero (Morogoro), Simanjiro (Manyara), Kishapu (Shinyanga) and Mpwapwa (Dodoma). Each profile contains a description of the area (climate, population and land use), followed by the climate projections for the region (focusing on changes in temperature, rainfall and evapotranspiration; in some cases, trends in drought, storms and sea level rise are considered as well); followed by a description of the implications of climate change for forestry, rangelands, biodiversity, water supply, agriculture, and in the case of Zanzibar, coastal resources. A short assessment of the adaptive capacity of these areas is made (including a list of ongoing adaptation actions in the area, capacity of local institutions etc., wherever such information was available), and finally, the EbA interventions recommended for the ward or district are described and mapped.

Chapter 8 provides further details on the implementation of the four types of interventions, namely, **riverbank restoration, watershed rehabilitation, charco dam construction/upgrade and rangeland rehabilitation.**

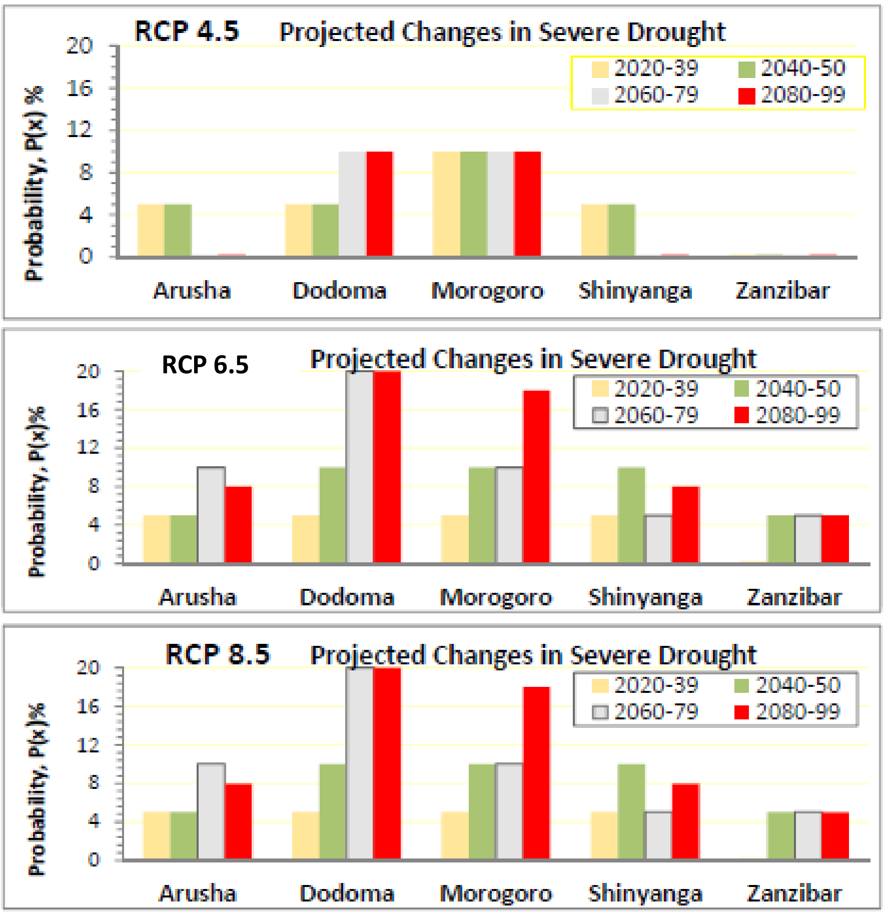
Summary of climate projections and impacts

Overall, more climate warming is projected over the Western side of the country (up to 3.4°C by 2100). A warming of less than 1.76°C for 2050 and 3.28°C for 2100 is projected over parts of the northern coast regions (around Zanzibar) and north-eastern highlands (near Simanjiro). A warming in excess of 1.39°C for 2050 is projected in central Tanzania zone (near Mpwapwa).

Rainfall projections indicate that some parts of the country may experience an increase in mean annual rainfall of up to 18-28% by 2100, particularly over the Lake Victoria Basin and North-Eastern Highlands. The South Western Highlands and Western zones of the country are projected to experience an increase in annual rainfall by up to 9.9% in 2050 and by up to 17.7% in 2100. The North Coast Zone is projected to have an increase of about 1.8% in 2050 and 5.8% in 2100, while the Central Zone is projected to have an increase of up to 9.9% in 2050 and up to 18.4% in 2100. In terms of occurrence of extreme precipitation and runoff, higher frequency/lower intensity events could be up to about 30% more intense than in the historic record. It is important to note that even a small increase in extreme rainfall will have a disproportionate impact upon hill-slope, soil and embankment erosion, causing enhanced quickflow (flash flooding).

None of the AOGCMs yield reliable quantitative assessments of drought probability, but some estimates can be made (Figure 1).

Figure 1: Projected changes in severe drought across project regions, by RCP



On the whole, drought intensities with an *average* recurrence interval of ten years will be extended by about ten days. Already dry areas risk more extreme future droughts whereas wet areas, notably Zanzibar, are projected to be more or less unaffected by changing drought conditions. The impact of high humidities will, however, be most noticeable in Zanzibar.

A summary of climate risks and projections, and resulting vulnerabilities and impacts felt in the project districts are listed below in Table 1.

Table 1: Summary of climate projections and impacts

Climate projections & risks	Resulting vulnerabilities and impacts
Kaskazini-A, Unguja (Zanzibar)	
▪ Increasing mean air and sea temperatures (by up to 1.6° C by 2099) ▪ Increasing number of hot days (above 35° C) ▪ Rapid increase in night-time minimum temperatures, esp. from May-Nov. ▪ Increase in mean annual rainfall ▪ Increased rainfall intensification, concentrated over shorter time periods ▪ Long dry seasons will become longer	▪ Increased intensity of drought (frequency does not change) ▪ Increased evapotranspiration = increased crop water requirements by 4.5% until 2050, leading to decreased cropland productivity ▪ Decreased water supply & reliability; crop water shortfalls in dry years; aquifers in northeast area severely threatened ▪ Increased sea surface temperatures = coastal and marine activities threatened, but low risk of tropical storm damage ▪ Disproportional runoff increases vulnerability to flash flooding ▪ Sea level rise causing coastal flooding, inundation and salinization of groundwater and soil ▪ Altered seasonality of biological events & marine resource distribution ▪ Coral bleaching and mortality ▪ Communities' livelihoods threatened due to changing climate conditions (esp. in agriculture as growing conditions worsen for key crops, fishing/seaweed harvesting productivity will decrease; tourism incomes may decrease as infrastructure deteriorates from SLR, decrease in water quality = less interest in water activities). ▪ Water shortage increases dependence on groundwater, which doesn't recharge fast enough due to lack of rainwater harvesting, urbanization/development, salinization and rainfall variability
Mvomero, Morogoro	
▪ Wet periods becoming shorter, wetter with more intense rains (rainfall to increase by 6.3%) ▪ Dry periods becoming drier and longer ▪ Increasing annual mean air temperatures ▪ Increase in number of very hot days; increasing minimum night-time temperatures (at a 3x faster rate than increase in day-time temp.)	▪ Increased shortage of water during dry season ▪ Increased probability of crop and other damage from high intensity rains during wet season ▪ Increased probability of severe drought (by 5-14%) ▪ Floods during rainy seasons exacerbated by unsustainable land use ▪ High flood risk across Sungaji, Hembeti, Mvomero, Kanga and Mtibwa wards, and in the southern tip of Kikeo ▪ Serious highlands erosion; however, relatively low erosion in lowland sites of target areas (6-10 tons/ha/year, which is relatively also low compared to other EbARR project districts); erosion caused by deforestation (itself suspected to be caused by a drought-induced lack of natural tree regeneration) ▪ Riverine erosion and sedimentation ▪ Water scarcity triggered by long dry seasons due to climate change, exacerbated by inadequate design (capacity) of storages (drying shallow wells, dams). Limited water also leads to health issues from humans/livestock sharing water sources

Climate projections & risks	Resulting vulnerabilities and impacts
	▪ Climate change impacts income potential from various land-dependent livelihoods (esp. cropping and livestock keeping, whose productivity is decreasing due to increasing temp., erratic rains and pest and disease). This increases dependence on wood products for alternative income generation, which drives deforestation and land degradation, and leads to erosion. The situation is exacerbated by an increase in livestock numbers and humans, leading to overgrazing and extensive agriculture. ▪ Decreased chance of success of afforestation/woodlot schemes
Simanjiro, Manyara	
▪ Increasing air temperature (by about 1.5° C) ▪ An increased frequency of hot days in Arusha ▪ No significant change in the occurrence of droughts ▪ Wet seasons will become wetter and dry seasons will be longer and drier ▪ Occurrence of floods and storms	▪ Climate change linked decrease in productivity of crops and livestock, leading to an increase in stock numbers and land clearing for extensive agriculture = further land degradation. Increased dependence on charcoal making, mining activities etc. causing deforestation, decrease in tree cover, and negative impacts on wildlife. ▪ High risk of floods along eastern/southeastern border of district ▪ Highlands erosion, worst in the central-east part of district (Liborsoit and Endonyongijape); erosion caused by deforestation (itself suspected to be caused by a drought-induced lack of natural tree regeneration) ▪ More intense rains over deforested land = riverine erosion and sedimentation from floods and storms ▪ Water scarcity for both human and livestock needs, especially during the dry season due to inadequate design (capacity) of storages (drying shallow wells, dams) ▪ Resultant water shortages leading to people and stock accessing the same limited water sources, causing serious sanitation and health issues
Kishapu, Shinyanga	
▪ An unclear trend for air temperature ▪ An unclear trend for rainfalls (possible increase) ▪ Dry season will lengthen on average ▪ No change in onset of the long rains	▪ Increased probability of droughts (4-10%) and lengthened duration by up to 1 month ▪ Drying up or disappearance of water resources (e.g. Rivers Manonga, Tambo and Tungu) ▪ High flood risk along entire southern belt of district ▪ Land degradation: due to an increase of the dried season ▪ Desertification triggered by climate change, increased livelihood dependence on wood products causing deforestation ▪ Highlands erosion (high risk all along north and central Kishapu), erosion caused by deforestation (itself suspected to be caused by a drought-induced lack of natural tree regeneration) ▪ More intense rains over deforested land = riverine erosion and sedimentation from floods and storms ▪ Longer dry season = water scarcity, which is exacerbated by inadequate design (capacity) of storages (drying shallow wells, dams) ▪ Water scarcity causing people and stock to access the same water, leading to health issues within the community
Mpwapwa, Dodoma	

Climate projections & risks	Resulting vulnerabilities and impacts
▪ Increasing air temperature ▪ Increased number of hot days over 33° C ▪ Night-time minimum temperature to increase 2.3x the rate of day-time warming ▪ Wet seasons will be shorter, wetter and the dry season longer and drier ▪ Long rains possibly will be delayed by 3-6 weeks	▪ Increased probability of occurrence of droughts (5-14%) ▪ Climate change linked decrease of vegetation, therefore smaller productive areas are being overgrazed ▪ Poor agricultural practices due to lack of capacity (awareness or improved land management means) compounded by decreasing productivity due to climate change ▪ Increased vulnerability to storms (will be fewer but more intense) and floods ▪ Increased winds (by up to 5-10%) may cause erosion and other damage to crops and infrastructure ▪ Increased highlands erosion, riverine erosion and sedimentation, erosion caused by deforestation (itself suspected to be caused by a drought-induced lack of natural tree regeneration) ▪ Water scarcity due to climatic but also anthropogenic activities, including inadequate design of storages ▪ Groundwater sources at Nghambi Village saline ▪ Adverse impacts to cropping and agricultural livelihoods due to increased soil moisture deficits

Consequences for agriculture

While the study does not produce recommendations for cropping and agriculture, climate projections and their consequences for agriculture (i.e. growing season, evapotranspiration and crop yields) have been considered. As these projections are largely applicable to all project districts, this information is presented in this summary, and not repeated in the specific district profile chapters.

While there is no change to the duration of the temperature-governed growing season, there are changes in both the intensity of photosynthesis and in the duration of excess heat stress. A slight decrease in rainfall seasonality in coastal and near-coastal districts, and either no-change or a slight increase in rainfall seasonality in more inland areas are projected. **Some crops, such as some varieties of maize, beans and bananas, may actually benefit from climate change impacts, at least in the short- to medium-term, when CO_2 is increasing – which increases crop growth temporarily. However, the majority of modelling studies conclude that negative impacts will prevail from about the 2030s onwards when other growth factors become more significant.** Beyond about 2050, a broad spectrum of crop yields will decrease by more than 10%, when other factors such as water availability and nutrients become limiting. Higher CO_2 concentrations and warmer temperatures will lead to greater biomass production, but probably at the expense of crop quality and nutrition.

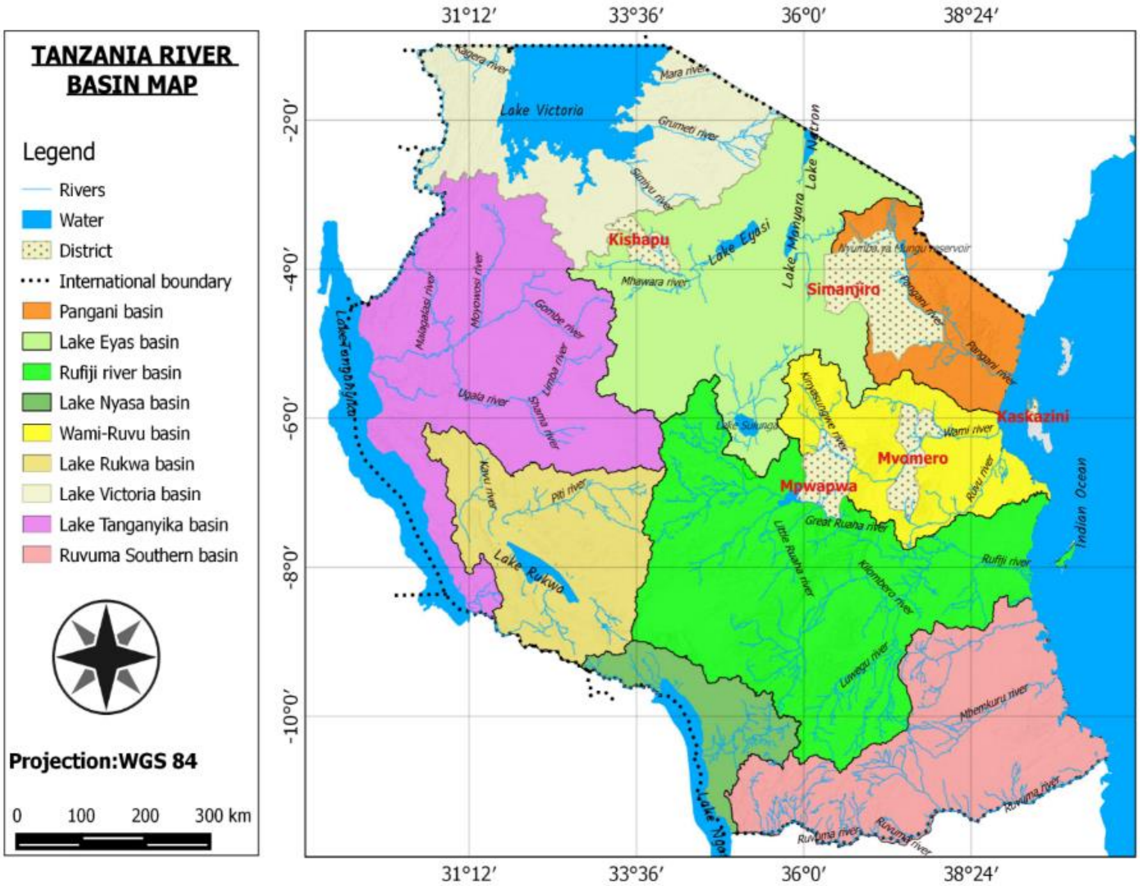
Recommended EbA interventions

EbA is the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change, which often provides social, economic and environmental co-benefits. As described, the study takes a landscape or watershed level approach to identifying the majority of EbA interventions. The main watersheds in Tanzania are shown in Figure 2.

Of the mainland districts, only Mvomero District is wholly in one basin, i.e. the Wami-Ruvu basin. Simanjiro District is largely within the Pangani Basin, but has a smaller area in the Lake Eyasi

Basin. Kishapu District is largely in the Lake Eyasi Basin, but has a smaller area in the Lake Victoria Basin. Mpwapwa District has about half of its area in both the Wami-Ruvu Basin and the Rufiji Basin. Ultimately, while implementing the recommended measures, it is crucial that the project **consider entire basin dynamics (i.e. flow rate, sedimentation, climate models, slope, soil type etc.)** in selecting specific intervention locations, in collaboration with local water basin experts particularly when undertaking watershed restoration activities, with additional studies undertaken where required.

Figure 2: Basin map of Tanzania



Source: own elaboration

Climate change is exacerbating the effects of land use change, as described in the summary of climate modelling for each of the districts in the following sections. A major change is the rainfall pattern with shorter and wetter wet seasons and longer and drier dry seasons. **While reforestation and riverbank restoration should be undertaken, as these will have significant ecosystem-level benefits, they are unlikely to significantly alter such patterns, nor the water cycle itself. Therefore, in addition we strongly recommend the development or improvement of charco dams.** At present, there is a shortage of water for people dependent on water harvesting in dams and river sources. As this is likely to become more extreme, particularly during periodic dry years of below average precipitation, improving water storage capacity and design of small dams (charco, hillside and valley dams), is an appropriate intervention, as it directly improves communities' adaptive capacity, using the landscape itself. In all the visits to the mainland districts, villages and in the workshops, this was seen as a priority.

Table 2 below presents the project intervention categories/budget lines, planned budget, and an indication on whether the measure is considered by the VIA team or Tanzanian authorities. **As per this list, the VIA has considered activities 2.3.1, 2.3.2, 2.3.3, and 2.3.4**.
Table 3 then presents the final list of recommended intervention activities for these budget lines, based on the findings of the VIA.

Table 2: EbARR project intervention activities (shaded: focus of this study)

Project intervention activities	Budget (USD)	Targeted by VIA	Targeted by Tanzanian auth.
2.3.1 Establish, through consultations with local communities, exclosure and no-take zones to support the **natural regeneration of degraded areas**	285 000	Yes	
2.3.2. Undertake **rangeland rehabilitation**	575 000	Yes	
2.3.3 Undertake **watershed rehabilitation and reforestation**, using local species	600 000	Yes	
2.3.4 Undertake **riverbank rehabilitation**	300 000	Yes	
2.3.5 Develop new, resilience and seasonality based natural resource **land use and management plans** with communities, notably Village land-use Management Plans (VLUPs), Rangeland Management Plans (RMPs), and Village Forest Management Plans (VFMPs).	Information not available	No	Yes, ongoing by National Land Use Planning Commission (NLUP)[1]
2.4.1 Implement **climate smart agricultural practices**, including conservation-based irrigation, water harvesting, crop rotation, etc.	900 000 (as per MoU with MoA)	No	Yes, ongoing by Ministry of Agriculture[2]
2.4.2 Improve **resilience of current livelihoods** and introduce alternative, income-generating, climate resilient livelihood activities for vulnerable groups, particularly women (livestock value chain, beekeeping…)	1 700 000 (as per MoU with Ministry of Agriculture)	No	
2.4.3 Introduce and promote efficient **cooking stoves and efficient charcoal production technologies** to reduce pressures on forest resources	410 000	No	Yes, already ongoing[3]
2.4.4. **Training and support to LGAs**, extension services and key producer groups on resilient livelihoods	Information not available	No	Yes, already ongoing

[1] MoU has been signed with the VPO
[2] However, the VIA team will stay in communication with the Ministry of Agriculture, which is currently developing work plans for these activities.
[3] Procurements currently on-going at district level.

Table 3: Final list of EbA interventions

EbA intervention category	Sub-activities	Expected adaptation benefits
Watershed-level interventions		
Forestry related investments	Reforestation on highland areas, focus on high erosion risk areas	Protection against erosion & run-off, alternative income, soil fertility, riverbank, improved biodiversity, bank and soil stabilization etc.
	Planting on boundaries of charco and other dams/water sources (riparian buffer zone) and other degraded areas	
	Natural regeneration of degraded areas	
	Reforestation coastal zones with coral rag vegetation	
	Enrichment planting (possible convergence with Agriculture budget line or alternative income generating budget line)	
	Establishing natural regeneration areas	
	Coppice regeneration management	
	Establishing stabilizing riparian vegetation	
Establishment of and improved designs of small dams	Charco dams (separate supply for human/cattle use)	Access to water (domestic & agri.) during dry months, sanitation/ health benefits Women gain opportunities (time and income) when not traveling long distances
	Hillside/valley dams	
River bank rehabilitation	Establishing stabilizing riparian vegetation on highland riverbanks (integrated with reforestation in highlands)	Stabilization of banks, reduced run-off, improved water supply etc.
	Engineering works (lay-back of banks, erosion head control, protective matting)	
Specific rangeland rehabilitation interventions		
Pasture and vegetation establishment	Use of drought resistant species etc. and use of pasture demonstration plots	Restored ability of rangelands to adjust to shocks, improved livelihoods, access to medicinal plants and other materials (e.g. for construction), general land use planning and management etc.
Undertake weed and pest control program	Invasive grass control in grazing area Pest and Tse-tse control with use of biological control	
Demarcation	Establish exclosure and no-take zones; paddock rotational system	
	Fencing of communal land	
	Demarcate specific watering points - At rivers (linked to riverbank rehabilitation) - At charco dams, separate from human supply locations	

Table 4 presents this intervention list, broken down by district.

Table 4: Recommended EbA interventions by district

Intervention category	Sub-activities	Specify location (also refer to district maps)	EbARR budget line
KASKAZINI-A			
Watershed rehabilitation	Coral rag restoration	Around degraded areas in Mahonda, Kinyasini and Mkokotoni	2.3.1 2.3.3
	Tree enrichment	Makonga caves	
MVOMERO			
Riverbank restoration	Establishing stabilizing riparian vegetation along highland riverbanks	High risk erosion areas along Melela river, near Magali village (based on further river and basin studies)	2.3.4
	Engineering works (lay-back of banks, erosion head control, protective matting, revetments)		
Watershed rehabilitation	Natural regeneration	3 locations tentatively identified in district – northeast, south west and south east	2.3.1 2.3.3
	Tree planting/enrichment		
Rangeland restoration	Pasture and vegetation establishment with drought resistant species, use of pasture demo plots, weed mgmt.	Around Lubungo and Melela villages (degraded patches in southeast also recommended, if feasible)	2.3.2
	Demarcation of exclosure zones, fencing communal land, demarcation of specific watering points		
SIMANJIRO			
Watershed rehabilitation	Tree planting/enrichment	Around Orkesumet ward	2.3.1 2.3.3
Rangeland restoration	Pasture and vegetation establishment with drought resistant species, use of pasture demo plots	Around Irkujit and Lengai villages	2.3.2
	Biological weed and pest control		
	Demarcation of exclosure zones, fencing communal land, demarcation of specific watering points		
Charco dam	Upgrading charco dams with vegetation buffer	In Langai and Irkujit	To be combined with 2.3.1
KISHAPU			
Watershed rehabilitation	Reforestation using local endemic tree species	2 locations tentatively identified in east and west of district	2.3.1 2.3.3
	Tree planting/enrichment		
Charco dam	Upgrading charco dams with vegetation buffer	Kiloleli (also possibly in Muguda, Beledi and Mihama villages)	To be combined with 2.3.1
Riverbank restoration	Establishing stabilizing riparian vegetation along highland riverbanks	High risk erosion areas north of Maganzo and south of Kishapu ward	2.3.4
	Engineering works (lay-back of banks, erosion head control, protective matting, revetments)		
Rangeland restoration	Pasture and vegetation establishment with drought resistant species, use of	In and around Kiloleli ward	2.3.2

Intervention category	Sub-activities	Specify location (also refer to district maps)	EbARR budget line
	pasture demo plots, pasture management on communal land		
	Biological weed and pest control		
	Demarcation of exclosure zones, fencing communal land, demarcation of specific watering points		
MPWAPWA			
Watershed rehabilitation	Reforestation using local endemic tree species	Nghambi ward, Kiborian highlands	2.3.1 2.3.3
	Natural regeneration		
	Tree planting/enrichment		
Charco dam	Upgrading and construction of charco dam with buffer vegetation	Kazania (upgrade) and Nghambi (construction) villages	To be combined with 2.3.1
Rangeland restoration	Pasture and vegetation establishment with drought resistant species, use of pasture demo plots	Around Nghambi ward	2.3.2
	Biological weed and pest control		
	Demarcation of exclosure zones, fencing communal land, demarcation of specific watering points		
Riverbank restoration	Establishing stabilizing riparian vegetation on highland riverbanks	Near Mpwapwa ward, along Kinyasungwi river	2.3.4
	Engineering works (lay-back of banks, erosion head control, protective matting)		

A note on 'conventional' adaptation measures

Aside from the EbA interventions, building capacity is also a strong recommendation. Adaptive capacity building is complementary to resilience enhancement among social-ecological systems. **Systems characterized by a high capacity to adapt are more likely to retain resilience** and evade substantial disruption for key functions following disturbance. To this end, capacity development measures for Local Government Authorities (LGA), support for developing VLUPs and livelihood enhancement activities are planned under parallel budget lines in the EbARR project. It is important that these EbA measures be implemented in this framework, to ensure their sustainability and positive impacts. For instance, without land use management plans, most interventions on demarcation and forestry will fail, as there is no community awareness or buy-in.

Ecosystem indicators

The following section applies to all districts in the project. Within the watershed, the natural ecosystems of the terrestrial environment, which in the district are mainly the forests, river systems, bushland and coral thickets, have provided essential ecosystem services to the community, which include:

- Provisioning:
    - wood and charcoal for fires/cooking, construction and building materials
    - foods
    - medicines
    - handicrafts materials

- bush meat
    - development of good soils for agriculture
- Regulating
    - Catchment surface water flow regulation and groundwater recharge, important for agricultural supply, forests/rangeland and drinking water
    - Prevention of erosion and reducing impacts of natural hazards
    - Carbon sequestration
    - Maintaining biodiversity, pollination

Biodiversity indicators help us measure and monitor:

- Pressures or threats, such as trends in land and water use, habitat loss or invasive species,
- The state of species and ecosystems, such as the health of species or integrity of ecosystems,
- The conservation response, such as the protection of important biodiversity areas, and/or
- Benefits to people, such as the ecosystem services that freshwater provides.

Fine scale indicators may be developed to inform local decisions on the ground, such as determining the degree to which restoration or management practices are working. Data needed to develop and monitor indicators may be available through local studies, national statistics or remote sensing. The most commonly available data will likely be for supply and delivery indicators.

With regard to the above, proposed indicators are:

- Habitat availability

Trends in the areal extent of available habitat, including forests, woodlands, bushland, native grassland and wetlands.

- Habitat condition

Proportion of area/number of flora species which are weeds, changes in canopy cover and habitat fragmentation.

- Habitat Protection

The extent of habitat protection, through management plans such as village forest reserves, rangeland management plan, forest management plan, reserves and wetland management plans

1 INTRODUCTION

1.1 Background

The most recent climate projections for Tanzania overwhelmingly predict signals of increased climate variability, erratic and changing rainfall patterns and rising mean annual and daily temperatures – particularly in highland and semi-arid areas (VPO-DoE 2007). Community livelihoods and environmental resilience across rural Tanzania are being significantly affected by these adverse climate change signals. Climate signals are long-term trends and projections that caused by climate change. Examples of observed long-term trends linked to climate change include increasing extreme precipitation or prolonged heat periods. Resulting impacts include frequent and severe droughts, water scarcity, increased erosion and run-off and decreased food production, among others. The vulnerability of communities and ecosystems is further exacerbated by limited internal capacities to fund or implement adaptation activities, extreme poverty amongst most vulnerable populations, poor infrastructure, limited credit opportunities, and lack of climate information.

As a beneficiary to the LDC Fund, Tanzania is implementing the project "Ecosystem-Based Adaptation for Rural Resilience in Tanzania" (EbARR), which aims to increase resilience to climate change in rural communities of Tanzania by strengthening ecosystem resilience and diversifying livelihoods. The second component of this project aims to increase resilience in project sites through **demonstration of Ecosystem-based Adaptation (EbA) practices** and improved livelihoods. Ecosystem-based Adaptation (EbA) includes nature-based solutions that harnesses biodiversity and ecosystem services to reduce vulnerability and build resilience to climate change (IUCN, 2020). One output of the project is the identification of locally specific climate change vulnerabilities, risks and adaptation options by local stakeholders, in a **comprehensive consultative process, realized through a Vulnerability and Impact Assessment (VIA) study**.

This VIA assignment has been conducted across the five districts targeted by the EbARR project. The results of this assessment may be used in the further elaboration of activities stipulated in the EbARR project, as well as Tanzania's environmental sector development programmes and national climate strategy action plans. The participatory nature of the VIA has provided additional opportunities to enhance coordination and collaboration between different sectors and stakeholders. In the long run, it is expected that the outcomes of this assignment will enhance the capacities of relevant Tanzanian government ministries in climate change policymaking, mitigation and adaptation. Essentially, **this report recommends cost-efficient and climate-resilient land and water resource management options, falling under the category of EbA,** with acknowledgement of other necessary, conventional adaptation measures. This is not to say that the EbARR project should cover this latter category of measures. However, they should be taken into account and realized through alternative funding to ensure an appropriate enabling environment for the EbA interventions to succeed in the long-run.

1.2 Scope

1.2.1 Thematic scope

The thematic scope of this assignment is based on the tenets of EbA, the basic criteria set by the overarching project, and observed priorities in the target regions. For the mainland, the VIA scope is as follows.

Water and freshwater resources
Real and projected climate change impacts on water resources include changes in the runoff in river basins, decreased water availability, disturbances to stream ecosystems and riverbanks, and increased health risk through deteriorating water quality. Water issues also have significant cascading effects on all other sectors and community well-being and is, therefore, a starting point for the study.

Biodiversity and wildlife
Climate change puts additional pressures on wildlife and biodiversity, in the face of changing weather patterns, shrinking habitats, the disappearance or vulnerability of species, as well as increasing human-wildlife conflicts.

Forestry
The forestry sector and forest-dependent/adjacent communities are facing adverse impacts of climate change exacerbated by deforestation attributed to agricultural expansion and charcoal production. The impacts include severe erosion and runoff, the disappearance of medicinal plants, more frequent forest fires, desertification, reduced seed dispersal, loss of water retention capacity, and a decline in associated forest livelihoods.

Rangelands
Rangelands are facing impacts from grazing pressures, agricultural development, erosion, lack of water for stock, weed infestation and occurrence of new pests and diseases. The domestic livestock population has been increasing by 5% per annum over the past 15 years. Cattle also hold strong cultural and social values to communities, thereby making this a critical EbARR focus area.

Coastal focus
The impact of climate change on sea-level rise (SLR) /inundation, fishing, seaweed harvesting, coastal marine ecosystems and recreation and tourism are vital issues in Zanzibar and have been considered in this study as well.

Finally, while the agriculture sector (cropping and livestock) has been taken into account in the study scope for all districts as far as climate change impacts and implications for rural resilience are concerned, *the study does not produce EbA recommendations for it*. This is as per agreement with the Tanzanian VPO, as Climate Smart Agriculture (CSA) is one of the EbARR project's interventions, and is already being undertaken by the Ministry of Agriculture through the Climate Smart Agriculture Program.

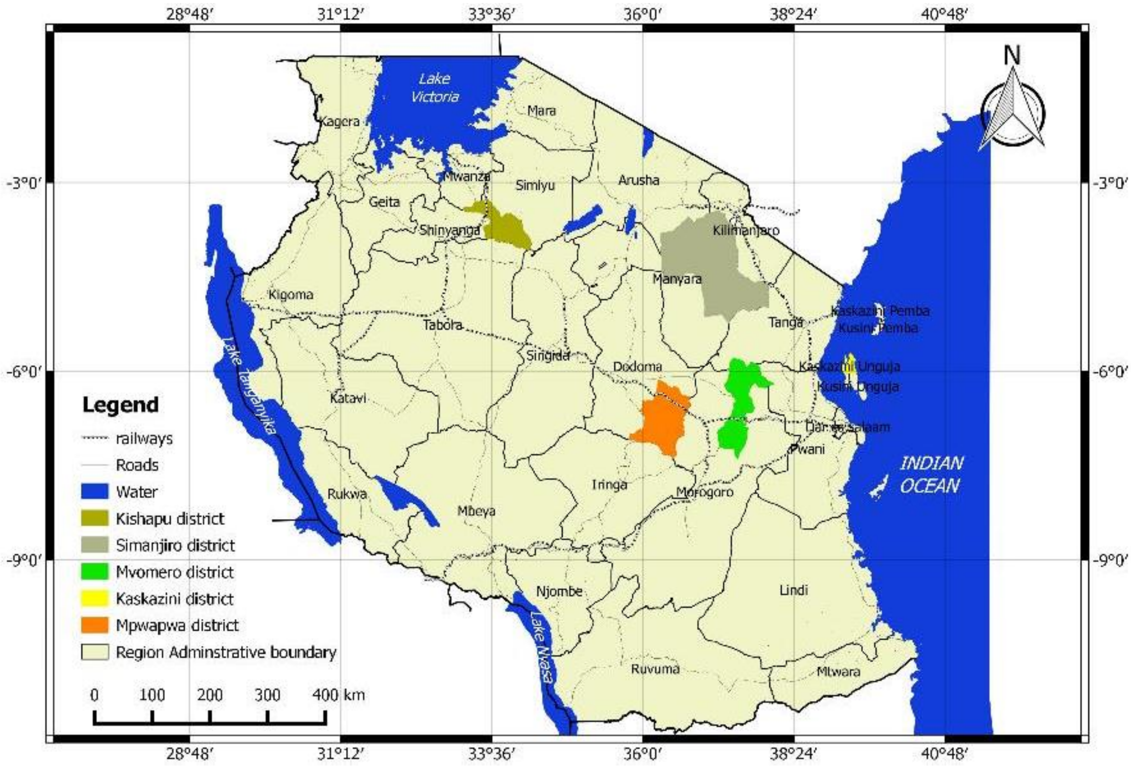
1.2.2 Geographic scope

The study has adopted a landscape-level approach, befitting the ecosystem level focus of the project. Although the EbARR project has target wards and villages, forests, rangelands, water and biodiversity must be addressed on a broader geographic scale, *at least* at district level, if not at the wider region or watershed level. For the sake of project planning (i.e. planning of site visits, community consultation and future implementation), the focus is narrowed down to five districts nominated by the Client. Wherever possible, the team has looked at individual wards and villages (even as potential demo sites). As presented in the Inception report, the districts and wards covered under the EbARR Baseline Study are:

- Matemwe Shehia, Kaskazini-A, Unguja Island (Zanzibar)
    - Note: Kijini ward was also consulted during the VIA
- Melela ward, Mvomero district (Morogoro region, Mainland)
    - Note: Lubungo ward was also consulted during the VIA
- Orkesumet ward, Simanjiro district (Manyara region, Mainland)
- Kiloleli ward, Kishapu district (Shinyanga region, Mainland)
    - Note: Lagana ward was also consulted during the VIA
- Ngh'ambi ward, Mpwapwa district (Dodoma region, Mainland)

The selected project districts and regions are shown below in Figure 3. Of these, Orkesumet, Ngh'ambi, Melela and Kiloleli are rural mainland wards. Matemwe ward in Zanzibar, while also largely rural, is a coastal ward and as such, has other climate change issues. A memorandum of understanding (MoU) between the governments of Tanzania and Zanzibar enabled the study team to engage with stakeholders in Zanzibar during the study.

Figure 3: EbARR project areas



Source: Kashaigili 2019

1.3 Main policies, legislations and strategies in the land use sector

To ensure the sustainability of adaptation activities, it is essential that the project operates within the existing framework of climate change-related policies, legislations and targets in Tanzania. We therefore identified the following crucial documents, which serve as a guide to the implementation of the VIA, and the development of EbA interventions. In addition, we have also considered Tanzania's commitments to various international conventions, including the Paris Agreement, CBD, UNCCD, RAMSAR and CITES and developed recommendations that seek to further Tanzania's progress on these fronts, while being aligned with the country's strategic climate and development goals. A full list of relevant policies can be found in the VIA Inception Report.

- Environmental Act (2015): Amongst other things, the Act allowed for the introduction of Integrated Coastal Zone Management (ICZM), which falls under the remit of the Climate Change Technical and Steering Committees. ICZM committees at the community level draw on members of the other committees, including forest conservation, fisheries and environment, providing an opportunity for information sharing and joint working.
- Zanzibar Development Vision (2020): Besides its focus on economic growth, the target of achieving sustainable human development is also enshrined in the Vision, and a significant element of this is achieving resilience to climate change.
- National Climate Change Strategy (2012): Adaptation goals are highlighted for priority sectors (water, coastal, forestry, wildlife and agriculture).
- National Gender Development Policy (2000): intends to ensure that the gender perspective is mainstreamed into all policies, programmes and strategies. There are gender focal points in ministries, independent government departments, regional and local authorities. It has helped increase women's participation in decision making processes and utilization and ownership of natural resources as well.
- The Land Use Planning Act (2007), directs the land use planning authorities to work in collaboration with the National Environment Management Council. It also ensures participation of local communities and villages in managing their resources.
- The Land Act (1999) and Village Land Act (1999) provides for provide for complete gender equality in ownership, access and control over land. Gender being a cross-cutting issue, is also considered in the utilization of the natural resources including environment and the related activities.

Land tenure in Tanzania and its implication for the project

The study has also taken into account land tenure in Tanzania. The legal framework supports private property rights. Individualized control of resources in farming areas is permitted, and private investments that utilize Tanzania's natural resources for economic gain are promoted. The policy retained the rights that women were granted in the *ujamaa* period and continued some of the laws regarding the communal management of rangeland, forests and wildlife.

Very little land in Tanzania is presently under formal registration. More than 93% of the rural population are smallholders and according to a rough estimate, approximately 78% of those hold unregistered customary land rights (United Republic of Tanzania, 2005). Although formal authorities play a strong role in land decisions, the traditional leaders of the various ethnic groups are important as interpreters of indigenous 'customs', and for conflict resolution.

Under the land acts, land in Tanzania is divided into three categories: reserved land, village land and general land. **Reserved land** is all land set aside for special purposes, including forest reserves, game parks, game reserves, and land reserved for public utilities and highways. Approximately 25% of Tanzania is categorized as reserved lands. **General land** includes all urban areas. Control over general land is firmly vested under the control of the Commissioner of Lands. **However, most villages under the EbARR project fall under the village land category**, which is land falling under the jurisdiction and management of a registered village. In Tanzania, these account for 12,000 villages, of which only 10,500 are registered). Importantly, land that villagers have been regularly using in the 12 years before the VLA was passed, including lands lying fallow, lands used for pasturing cattle, and land used for passage to pasture lands is also included.

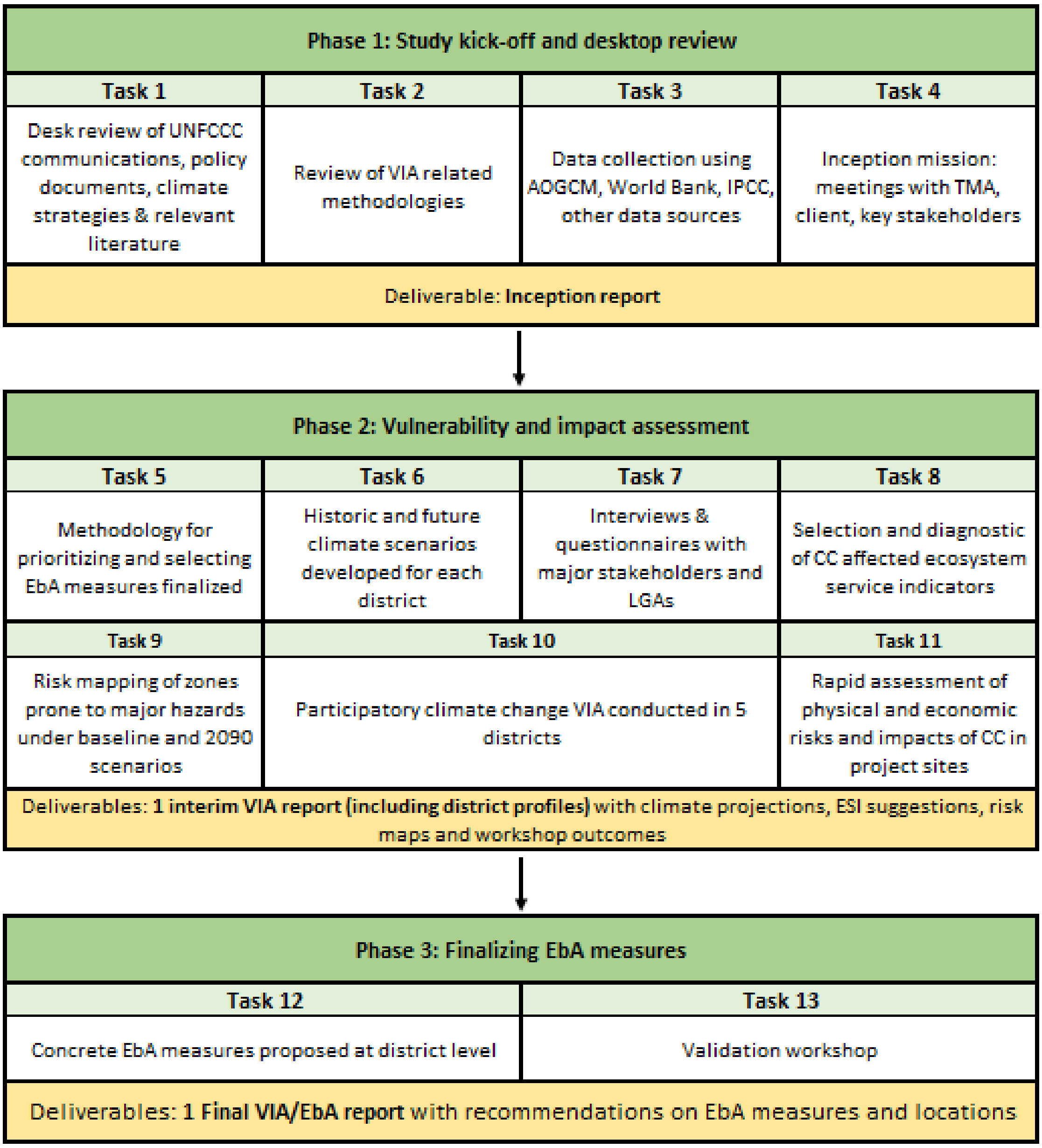
That is to say, the role of traditional village leaders, the rules governing use and ownership of land, and its implications for initiating private and public investments on these lands must be taken into account during project implementation.

2 METHODOLOGY

2.1 Work plan overview

The study has completed Tasks 1 through 13, shown in the workflow below.

Figure 4: Work plan



The methodology adopted for this study has been described in detail in the Inception Report.

VIA methodology

UNEP PROVIA (Global Programme of Research on Climate Change Vulnerability, Impacts and Adaptation) is an informative reference document covering a wide range of available approaches, methods and tools for conducting a VIA; it is not a prescriptive guidance. Rather than pursuing one of the many extensive VIA tools presented in the guidance, **the team used PROVIA's general conceptual basis (i.e. the five-stage iterative adaptation learning cycle** – of which Steps 1-3 have been conducted in this study and are shown in Figure 5), and its various guiding questions) - **along with the various experiences and lessons accumulated by the team in conducting similar studies in other parts of Tanzania and East Africa - as the foundation for the VIA**.

There are two reasons for this decision; first, it was unclear how much and what quality data would be accessible for the VIA, and therefore a large degree of flexibility in the approach to the assignment was required, which would not be possible if a single methodology was adopted. Secondly, the time, financial and information resources required to properly apply one of the many methods described in the guide in practice is simply not available in this project.

Figure 5: Methodology for VIA and selection of EbA interventions based on UNEP PROVIA

Working off the adaptation learning cycle, the methodology was therefore to (i) set a context for the assignment, iteratively (ii) identify adaptation needs (a function of impacts and capacities to manage those impacts), and (iii) identify and appraise adaptation options.

As informed by PROVIA, the following guiding questions were used to identify needs in each district:

- What are your current challenges in relation to land use? What impacts may be expected under climate change? What implications will this have for ecology, society and the economy?
- Aside from adverse impacts, do any opportunities arise from these changes?
- Where exactly are the risk hotspots, based on land use/cover, and vulnerability to climate hazards?
- What are actors' vulnerabilities and present capacities (availability of knowledge, technology, finance etc.), particularly taking into account the gender perspective?
- Are vulnerable actors aware of potential threats? What are their required adaptive capacities? What major decisions or issues need to be addressed?

Next, the focus was on identifying options targeted directly at these needs, which was achieved through the various consultation meetings and workshops held from July to November 2019, which ensured that the options were both scientifically sound, as well as validated by local communities and government authorities.

The final step was to appraise the options and thus define the interventions. This has been undertaken in February 2020 through the EbARR Technical Committee and Steering Committee meetings. More detail on methodology can be found in the VIA Inception Report.

2.2 Phase 1: Desk review

In Phase 1, the team conducted a desk review of relevant policy documents, climate strategies, literature and UNFCCC communications pertinent to climate change adaptation in Tanzania, and the results of the analysis is presented in the Inception Report, along with a review and selection of a VIA methodology for identifying appropriate EbA interventions for the target regions. Climate data collection and historical and future climate scenario modelling was undertaken by the team meteorologist, the outcome of which has been an extensive climate projections report (also submitted).

2.3 Phase 2: Vulnerability and Impact Assessment

Study approach for Phase 2

In Phase 2, following an inception mission and various stakeholder consultations (more information in Section 2.3), a look into possible Ecosystem Service Indicators (ESI) and risk mapping of vulnerable zones (focusing on drought, flood and erosion) was undertaken. The results of this entire process are presented in this VIA report, which describes the climate-related vulnerabilities and impacts faced by communities in the five target regions. Using this as a basis, recommendations for relevant EbA interventions are presented in each district profile as part of Phase 3.

Consultations with district, ward and community officials

The VIA team made use of various participatory techniques in consulting key officials from districts, wards and communities in several villages. These consultations were done through meetings, one to one consultations, observations and workshops. Where needed, follow-up consultations were made through telephone conservations, skype calls and through e-mail exchanges. It is important to note that the District Technicians (project contact persons) through the Project Manager in the VPO were key players in identifying sites and actors, organizing meetings and inviting stakeholders to the respective meetings or consultation sessions, in line with basic requirements provided by the VIA team and Client. It is also worth noting that most of the villages consulted had their village councils and other influential village members attending the consultation meetings. The approach used therefore allowed the team insight into raw issues and ideas from each locality. In addition, it has ensured strong feelings of ownership among LGAs and communities over the project, which will ensure success and sustainability of interventions.

To ensure gender inclusivity and participation of community members - including the marginalized - the District Technicians and the Extension officers in the project sites ensured their attendance and fair representation. Women in particular were present at all meetings and encouraged to share their experiences, as they are disproportionately affected by climate change impacts, and play a strong role in determining the success of future interventions.

Field visits

As part of the process, the study team visited the proposed project implementation villages and wards. Prior to the visits, questionnaires were sent to district authorities responsible for, or knowledgeable on, water, forestry, biodiversity, rangelands and agriculture. These questionnaires were then collected during the visits and follow-ups with specific respondents was carried out wherever required.

In each of the five districts, at least two villages were identified by the Client for EbA project implementation. Furthermore, specific project sites were selected between the Client and individual district/ward authorities, based on immediate needs, and stakeholders presented their own ideas for interventions. Some ideas included riverbank rehabilitation, sites for woodlot establishment and development, charco dams and tree-planting sites, etc. Many ideas falling outside the realm of EbA (as well as adaptation itself) were also raised, which have been noted, although the scope of EbARR funding was made clear during all visits. As a follow-up, recap sessions were held in the villages to triangulate the information gathered in the field.

Production of climate data models (historical and projected)

This study used both approaches to forward projections of the climate available for planning purposes: (i) to run 'hindcast calibrated' atmospheric-ocean-coupled global climatic models, a.k.a. 'AOGCMs' or just 'GCMs' (widespread and data-intensive method), and (ii) to extrapolate trends from evidence-based field instrumentation from hydro-meteorological, synoptic and climatic stations. The report models climate projections upon the basis of four representative carbon pathways (RCPs), i.e. RCPs 2.6, 4.5, 6.0 and 8.5 to show best (2.6); realistic (6.0 or 4.5); and worst-case (8.5) scenarios. The report is heavily based upon CMIP-5 modelling outputs, which compares the outputs of 25 to 35 selected AOGCMs from around the world, including research consortia from many countries, in addition to international cooperative models. The World Bank portal's assemblage was also used, based on its ease of accessibility and consistency of presentation.

It is important to note the following, on the issue regarding downscaling models due to physiographic variation. This climate-change assessment strongly resists this approach on the grounds that: (a) the multi-model CMIP-5 assemblage of outputs is already 'as good as it gets'; (b) The apparent improvement in accuracy and precision is illusory, if not positively misleading, it is scientifically unsupportable; (c) Downscaled 'precision' becomes far less than the compounded error bounds, and is therefore meaningless; and (d) the difference in grid-scale between the current generation of AOGCMs and downscaled models is not as high as formerly, and hence the distinction becomes increasingly unimportant.

The projections focus on three main issues; temperature change, precipitation change and evapotranspiration (addition estimates on sea level rise, drought and groundwater are made in some cases, where relevant).

Risk mapping methodology

The global data set used for the risk mapping exercise is relevant for the period 1979 to 2014, and therefore represents the historic and baseline situation.

<u>Soil erosion</u>

The Universal Soil Loss Equation (USLE) was used to estimate the annual soil loss using QGIS 2.18 software:

USLE equation: A = R K (LS) C P

Where:
A is the average annual soil loss in tons/ha/yr,
R is the rainfall-runoff factor [MJ · mm · ha $^{-1}$· hr $^{-1}$· yr^{-1}]
K is the soil erodibility factor [tons·ha · hr · ha $^{-1}$ · MJ $^{-1}$· mm $^{-1}$]
LS is the topographic factor
C is the cover-management factor, and
P is the support practice factor.

The rainfall erosivity factor (R) was computed from rainfall data using a 30-min intensity of the storm (Alnoldus 1977). Due to the lack of dense meteorological networks, some of the data were acquired from the National Centers for Environmental Prediction (NCEP) (https://global-weather.tamu.edu/). Soil erodibility factors were extracted from the European Soil Data Centre (ESDAC) (https://esdac.jrc.ec.europa.eu). The topographic factor was computed from Digital Elevation Model acquired from United States of Geological Survey (https://earthexplorer.usgs.gov/). The cover management factor was calculated from Land Sat 8 (OLI) through the Normalized Difference Vegetation Index (NDVI). Since the C factor ranges from 0 (full cover) to 1 (bare land) and the NDVI values range from 1 (full cover) to 0 (bare land), the calculated NDVI values were inversed based on Van der Knijff et al. (1999) equation.

*C = exp (-2 * NDVI / (1 - NDVI))*

Following the lack of land management practice factors (P-F=factor), the value was set to 1 for the entire study area, assuming that no protection measure is taken (Sotiropoulou *et al*. 2011).

Drought Index

Drought is a continuous and abnormal moisture deficit, meaning the continuation of deficit and deviation of the favourite index of natural condition from the mean. The Standardized Precipitation Index, which is an indicator of extreme rainfall events - whether they are drought or excess rainfall - was used. The SPI (McKee *et al.*, 1993) is the number of standard deviations that observed cumulative rainfall deviates from the climatological average.

To compute the index, a long-term time series of rainfall accumulations over months are used to estimate an appropriate probability density function namely Pearson Type III distribution (i.e., 3-parameter gamma) as suggested by Guttman (1999). The associated cumulative probability distribution is then estimated and subsequently transformed to a normal distribution.

Table 5: Standardized Precipitation Index (SPI) classification

SPI value	Drought Category
≥ 2	Extremely Humid
1.5 to 1.99	Very Humid
1.0 to 1.49	Moderately Humid
0.5 to 0.99	Lightly Humid
-0.49 to 0.49	Normal
-0.99 to -0.5	Lightly drought
-1.0 to -1.49	Moderate drought
-1.5 to -1.99	Severe drought
≤ -2	Extreme drought

Following limited availability of precipitation data (only one station per study district), global data were sourced to complement the limited available information. The drought index was computed based on the global Standardized Precipitation Index data acquired from the International Research Institute for Climate and Society (IRI) data library (https://iri.columbia.edu/). Data were interpolated using the Inverse Distance Weighted method using QGIS 2.18 and categorized based on SPI value (Table 5).

Flood Risk Mapping

The automatic extraction of flood prone areas was done using geomorphic approaches based on Digital Elevation Models (DEMs) of HydroSHEDS (Hydrological Data and Maps Based on Shuttle Elevation Derivatives at Multiple Scales). This product is based primarily on elevation data obtained during NASA's Shuttle Radar Topography Mission (SRTM) with ancillary data sources (Lehner and Döll 2004). The SRTM data contain regions with a missing data point (voids or anomalies) and a large number of sinks or depressions. A void-filling procedure was applied to remove all unnatural sinks, producing a continuous elevation surface called the void-filled elevation model (DEM VOID). Furthermore, in order to establish a continuous flow for hydrological applications, a hydrologically conditioned elevation model (DEM-CON) was produced by applying a sequence of conditioning procedures.

The identification of flood-prone areas was made through the use of linear binary classification techniques. In particular, starting from morphological attributes of a basin related to hydrologic surface processes, linear binary classifiers were used to delineate flood-prone areas based solely on the information contained in DEMs. They include some traditional morphologic features (e.g., slope, contributing area, distance to the nearest channel, topographic convergence, etc.) as well as composite indices formulated with the specific aim to represent a metric of flood hazard.

The hydrogeomorphic descriptor, called Geomorphic Flood Index (GFI) (Samela *et al*. 2017) was adopted to develop a linear binary classification procedure able to identify flood susceptible areas. Based on GFI, flood risk maps were generated and 3D Analyst from ArcScene 10.3.1 software used to map flood-prone areas.

Risk maps for each target district are presented in Chapters 3 to 7.

Future risks

The generation of future risk maps of drought, flood and erosion under climate change require projected time series of climate data, mostly rainfall data at daily or monthly resolution. Other information includes projected future land use and land cover. **Rainfall runoff relationships and actual historic runoff data are required to undertake future analysis and this information is not available.** Nevertheless, the climate change analysis revealed a marginal future change in rainfall amount over the study areas, **which does not change the risk profile of these districts**.

Risks of pest and disease and fire

Spatial data on pest, disease and fire are not available. The many variables required to compute such data cannot be estimated or projected, hence these risk maps were impossible to generate.

District-level multi-stakeholders' workshops

All these sessions were followed by combined district stakeholders' workshops held at the District Council's halls, in which the District Commissioners and the District Executive Directors officiated the events and attended the sessions to the end.

It is important to note that it was through these meetings and workshops that participants were able to define adaptation/coping strategies that would be socially accepted; are likely to succeed; and which are most urgently needed. This was achieved through a prioritization or ranking exercise of EbA related interventions. Specifically, each workshop produced three to five feasible interventions for the district. Please see the Annexes for more information on the second mission (workshop participants, questionnaires etc.)

Figure 6: Multi-stakeholder workshop held in Mvomero

Suggestions for M&E: Ecosystem Service Indicators

The dependence of communities on natural ecosystems becomes apparent with the recognition of the services they provide, and the importance of ecosystem health for community wellbeing. The four categories of ecosystem services are defined in Table 6.

In this study, which has the overall aim of improving rural resilience, **the focus is on provisioning and regulation services**. Based on literature and observations made during the study, it can be said that services falling under these two categories are more measurable and relevant for this project, as compared to supporting and cultural services. For example, EbA interventions properly implemented in the project regions will show direct financial value and results in terms of improved supply and quality of products (provisioning services) or protection against natural hazards and risk reduction through water and climate regulation over the next few years. Cultural services meanwhile can be highly subjective, and their impacts are hard to measure concretely. The change in quality of supporting services may also only be visible over long time periods, e.g. over several years or decades.

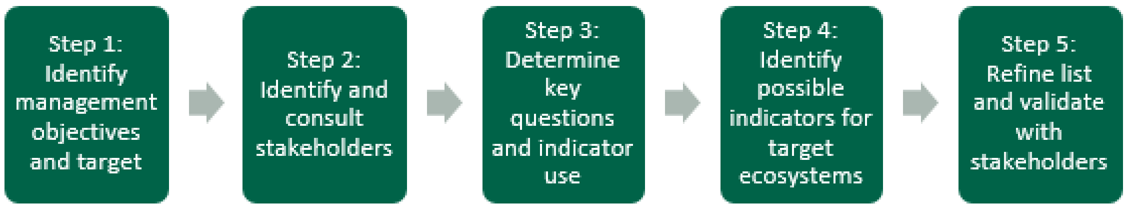
Ensuring that the provision of these services is maintained on a sustainable basis requires the incorporation of ecosystem services into management strategies. To do this requires ecosystem service indicators (ESI), which are metrics to measure ecosystem health and progress, as well as effectiveness of applied interventions. Ecosystem Service Indicators (ESI) are therefore recommended to be used in the planning, monitoring and evaluation of these interventions.

Table 6: Four types of ecosystem services

Categories of ES	Details
Supporting services	The services necessary for the production of all other ecosystem services including soil formation, photosynthesis, primary production, nutrient cycling and water cycling.
Provisioning services	**The products obtained from ecosystems, including food, fiber, fuel, genetic resources, biochemicals, natural medicines, pharmaceuticals, ornamental resources and freshwater.**
Regulating services	**The benefits obtained from the regulation of ecosystem processes, including air quality regulation, water and erosion regulation, water purification, disease regulation, pest regulation, pollination and natural hazard regulation**
Cultural services	The non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences – thereby taking account of landscape values

ESI provide information which enables policymakers and project implementers to understand the condition, trends and rate of change in ecosystem services. Robust indicators make it possible to measure whether essential services are being maintained and used in a sustainable manner (UNEP-WCMC 2011). For the purposes of this study, a document from the UNEP-WCMC project – Measuring Ecosystem Services – was consulted.

Figure 7: Ecosystem service indicator development, based on UNEP-WCMC (2011)



While the WCMC guidance proposes an elaborate framework for developing ESI, we have used a more rapid or lean approach, in keeping with the scope and time restrictions of the VIA assignment. This process consisted of identifying and consulting with key stakeholders, agreeing upon the management objectives and targets of the EbARR project and local administration, developing key questions for the consultations, identifying possible indicators based on literature and existing information among local administrations, and finally, communicating these to the project. The ESI proposed for this EbARR project are presented in the Executive Summary.

2.4 Phase 3: Finalization of EbA interventions

Finally, taking into account the findings of the risk mapping, climate projections and extensive stakeholder consultations, a final list of recommended EbA interventions was developed and presented to the Technical Committee and Steering Committee meetings for approval. Based on their feedback, the list has been honed and presented in this report.

3 KASKAZINI-A, UNGUJA ISLAND - ZANZIBAR

3.1 Description of study district

Kaskazini-A is one of the six districts on Unguja Island, Zanzibar. Within the district, Matemwe ward has been selected as the target ward, and the team has visited three Shehia[4] over the course of the assignment – Mbuyutende, Juga Kuu and Kijini. Currently, no land use plans exist in any of the three Shehia visited. With respect to the EbARR project, relevant information on climate, population and area, and land use and land cover are given below.

Climate

Not yet taking into account the effects of climate change, described in Section 3.2 below, the district is described as having a tropical, humid climate, with temperatures ranging between 20°C and 40°C. It normally has a bimodal rainfall pattern, with a long rainy season, which lasts from March or April to May, while the shorter one occurs during the months of September or October to December each year. The district usually receives between 900 mm to 1200 mm of rainfall during the longer period, and 400 to 500mm during the shorter rainy season.

Population and area

The district has an area of 460.7km^2, and a population of about 105,750 people; about 8% of the total population of Zanzibar (NBS 2012). The population growth rate is 3.2, with an average household size of 5.6 and a population density of 399 people per km^2. Zanzibar is inhabited mostly by ethnic Swahili, a Bantu population of sub-Saharan Africans. There are also a number of Arabs, as well as some ethnic Persians and Indians.

The current population and growth rate will affect Kaskazini-A and Zanzibar significantly in terms of population flow and increased pressure on all sectors, through greater natural resources use and dependence, water abstraction and land use pressures. Informal/unplanned development is occurring in previously undisturbed areas, which are often more marginal or have higher risks (e.g. low-lying areas with risk of flooding).

Land tenure, land use and land cover

In Zanzibar, all land is public and was vested in the government in 1965. The Land Tenure Act of 1992 provides that the government can grant rights of occupation, which are perpetual and transferable. The government may also revoke occupation rights if the holder fails to use the land in accordance with 'good' land use principles. Under the Zanzibar Land Tenure Act, the maximum leasehold is 99 years, although Members of the House of Representatives have been protesting against this. Under the leasehold the right of occupancy cannot be sold or assigned but can be inherited. The government also retains the right to approve any transfer of land rights under the Land Transfer Act of 1994. Most land-occupancy rights have not been registered and are held and transferred under principles of customary and Islamic law.

Clove and coconut farms on the island have been nationalized and the land apportioned in the Three Acre Plots (TAP) and distributed to peasants, with a caveat that they could not transfer ownership or inheritance rights. Most rural land is either under individual or state ownership.

[4] Shehias are the lowest official administration unit in the country, with each Shehia consisting of a number of villages and households

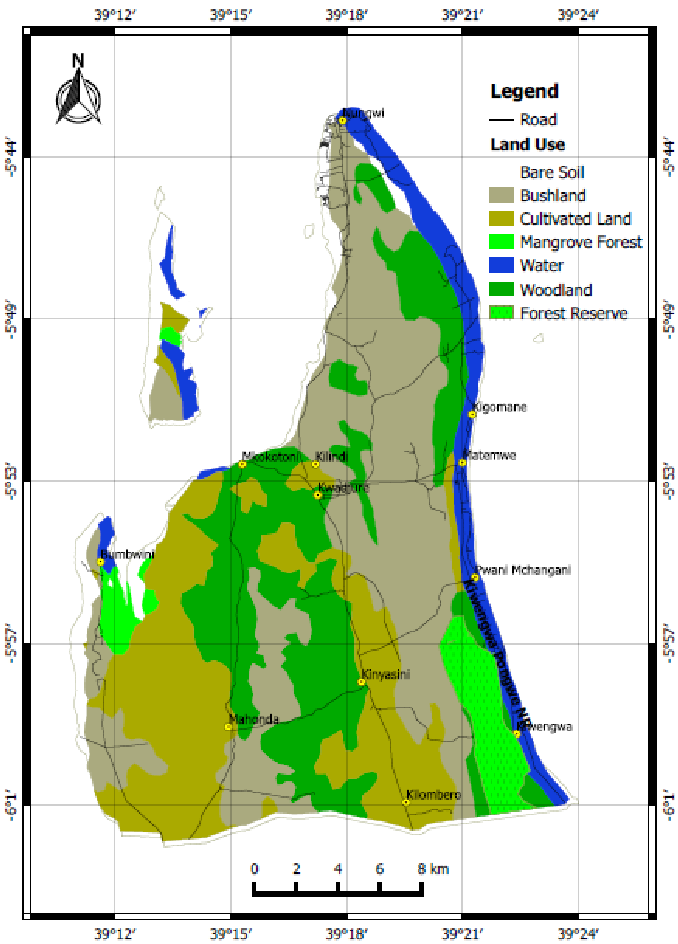
Some of the TAPs have been sold as granted parcels, changed into residential or commercial lands, been subdivided, or been inherited contrary to provisions of the decree. Based on various sources (e.g. agricultural census data and numbers from the TAP program, less than 10% of these parcels were formally (that is to say, digitally) registered (Lugoe 2012*)*.

Table 7 shows land cover changes in Kaskazini-A, according to the Baseline Study. The data is based on the Landsat TM for 1996/1995 and Landsat 8 for 2016. **Figure 8**: Land use and land cover in Kaskazini-A, 2019

Table 7: Land use and land cover change, 1996-2016

Landcover Types	1996		2016		Relative change 1996-2016	
	Area (ha)	Area %	Area (ha)	Area %	Area (Ha)	Area %
Forest	74.00	0.44	244.00	1.46	170	1.0183
Woodland	3773.00	22.60	6328.00	37.90	2555	15.3040
Cultivated Land	863.00	5.17	5835.00	34.95	4972	29.7814
Scattered Cropland	8951.00	53.61	3856.00	23.10	-5095	-30.5181
Water	2578.00	15.44	257.00	1.54	-2321	-13.9024
Bare Soil	456.00	2.73	175.00	1.05	-281	-1.6831
Total	16695.00		16695.00			

Figure 8: Land use and land cover in Kaskazini-A, 2019



Most of the area in this district covered by the EbARR project is woodland, with major land uses being scattered cropland and cultivated land, with some settlement areas concentrated in the north. There are no classified rangelands in Unguja; livestock is managed domestically using feed and crop residue. Large tracts of degraded and unused range area and bushlands do exist but are not studied and thus no information is available on them. Interviews also revealed that LGAs do not have the capacity for managing these lands, and proposals to establish community forest/range management groups have been raised.

Within Matemwe, changes in the dominant land uses are summarized in Table 8 below for the more recent period 2003-2016. There has been approximately a 7% loss of woodland, but an equivalent increase of bushland of 7.5%. Urban areas have increased from 13.23 to 49.95 ha.

Table 8: Major land use changes in Matemwe 2003-2016

	2003		**2016**	
	(ha)	**(%)**	**(Ha)**	**(%)**
Woodland	1016.1	41.22	944.28	38.3
Bushland	1342.62	54.46	1444.33	58.59
Built up (urban)	13.23	0.54	49.95	2.03

The terrestrial coastal and marine environment of Zanzibar features rich biodiversity. As described in RGovZ (2017), Zanzibar's forests form part of the East African Coastal Forests Ecoregion, which is one of the world's 200 biodiversity hotspots. Zanzibar has about 15,000 hectares of reserved forest, which includes JozaniChwaka Bay (National Park), Ngezi, Masingini (Forest Reserve) and Kiwengwa-Pongwe (Forest Reserve) that are strictly for biodiversity conservation; and Unguja Ukuu, Chaani, Kibele, Dunga and Msitu Mkuu, which are for exploitation and conservation in some places (including deep soil forests and some mangroves). Besides this forest, the island has 11,806 ha (44.5% of land area) coral rag thickets, managed as community land.

The marine environment includes coral reefs, sea grass beds, mangrove forests, sandy beaches as well as cultural resources. It supports the important fisheries industry in Zanzibar, and as indicated above, is the main occupation in Matemwe. The corals are among the most productive ecosystems on the planet (Srinivas 1998), as they provide valuable socio-economic and ecological services, including protection from storm surges. Mangrove ecosystems, which are particularly important for many commercial species as they are nursery areas, cover a total of 18,000 hectares in Zanzibar and they are widespread and best developed in natural estuaries.

Because of the ecological and economic importance of the marine coastal ecosystem, the Government of Zanzibar has created three Marine Conservation Areas (MCAs), the Menai Bay Conservation Area -MBCA (470km^2), the Mnemba Island Marine Conservation Area - MIMCA (720 km2) and the Pemba Channel Conservation Area – PECCA. Furthermore, two MCAs are expected to be gazetted in the near future.

In Matemwe, the main economic activities are the following, which are also those activities which will be affected most by climate change:

- Fishing: there are approximately 3000 fishermen, out of the total population of 5014 (Revolutionary Government of Zanzibar, 2017)
- Seaweed harvesting: involving 732 persons (721 women), out of the total 5014
- Tourism: Matemwe village is a well-known tourist location because of its relatively unspoiled white sandy beaches, with the village area fronted by a lagoon and coral reef as

well as the small Mnemba atoll. The location is popular for snorkeling and scuba diving. As of 2016, there are six hotels (63 in District), and seven guest houses (50 in district).

- Agriculture. Although the cropping area is small (approx. 1.5% of Unguja Island total), this sector has the potential for expansion.

The importance of Matemwe as a centre is indicated in the proportion of the main annual fish caught in the district and MK:

- Changu 10130 kg (6.3% of district total), 42186400 TSh (85 of district total)
- Kolekole 2035 kg (6.9% of district total), 7991600 TSh (3.9% of district total)
- Mbasi 468 kg (0.8% of district total) 2290000 TSh (12.3% of district total)
- Pweza 14897 kg (44% of district total), 49504000 TSh (45.65 of district total)

However, fisheries are in decline and coastal ecosystems are being impacted by current activities, all along shallow waters of the region through:

- Overfishing
- Destruction of fish nurseries as a result mangrove cutting. Mangroves are also known for their high rates of carbon sequestration.
- Destructive fishing, including the use of illegal fishing techniques, such as spear fishing, drag netting and dynamiting.
- Beach erosion due to sand mining,
- Pollution through:
    - Uncontrolled solid and liquid waste disposal,
    - Inadequate sewerage control,
    - poor solid waste management,
    - use of beaches and bushes as toilets,
    - Uncontrolled solid waste dump sites, as well as untreated sewage from domestic uses and tourist hotels in the area,
    - Influx of pesticides, nutrients and fertilizers from nearby farms, especially in valleys with agricultural areas close to the shore,
    - Possible oil leak during loading/unloading fuels in landing sites and small local harbors.
- Coastal construction, Jetties, badly designed seawalls, or other protective measures,
- Seaweed Harvesting, through:
    - Seaweed extraction (dragged ashore, maybe across seagrass meadows),
    - Effect of seaweed removal on wave climate and erosion (seaweed beds can act as a buffer/baffle),
    - Drying seaweed on top of coastal vegetation, which stabilizes sand.
- Loss of coastal stabilizing vegetation through trampling, vehicle access associated with fishing seaweed activities,
- Inappropriately planned tourism development,
- Currently, mangroves of Zanzibar face a diverse number of threats that jeopardize their existence, including salt production, fuelwood demand, urban expansion and tourism industry development.

3.2 Climate change projections for district

3.2.1 Summary of Climate Change for Zanzibar

The key findings of the modelling study in relation to changes in temperature and rainfall/evap-otranspiration are summarized below. Also summarized are the projections on SLR, the intrusion of saltwater into aquifers and the occurrence of tropical storms.

Temperature

Zanzibar's temperatures have been increasing, a trend which will continue, as shown in **Table 9** and Figure 9. An example of the seasonal variation in temperature with the different RCPs is shown in Figure 10.

Table 9: Median Ensemble Mean Annual Temperature Change Projections, °C

CMIP-5 data for Zanzibar (Bias Corrected)

Station	Historical mean	RCP	2020-39	2040-59	2060-79	2080-99
Zanzibar	26.40°C N=61	4.5	27.10	27.40	27.70	27.80
		6.0	27.00	27.30	27.70	28.20
		8.5	27.20	27.80	28.60	29.40

Figure 9: Ensemble Model Projections of Changing Temperature in Zanzibar

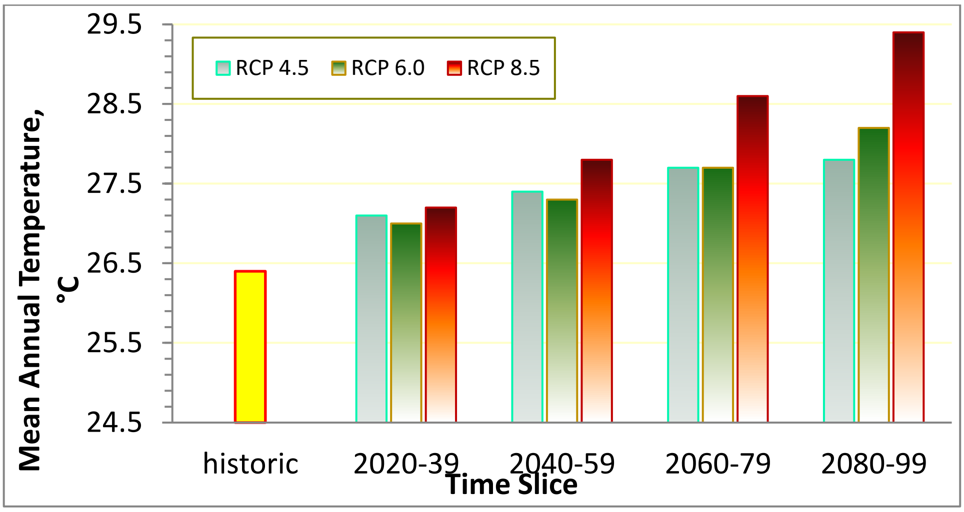
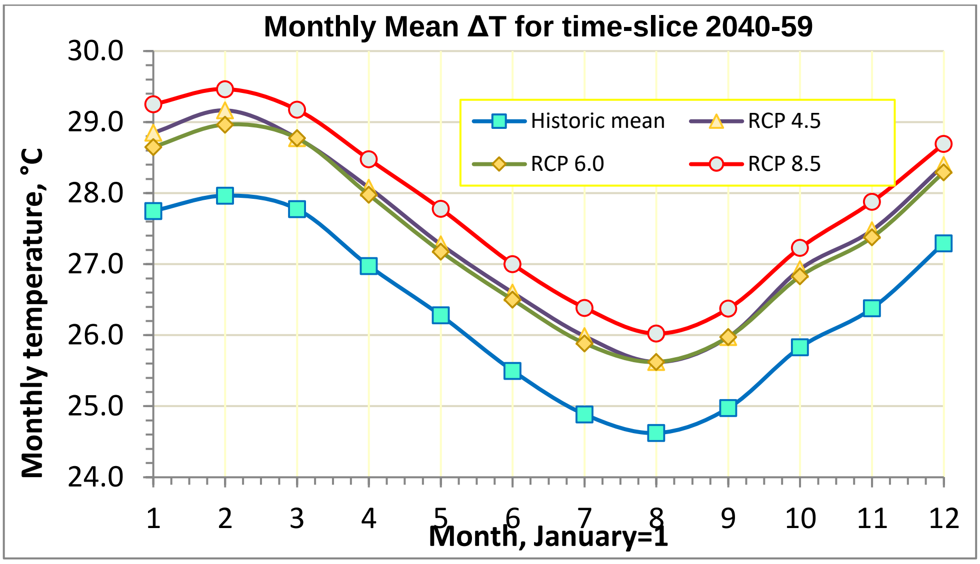


Figure 10: Projected Seasonal Changes in Temperature for Zanzibar

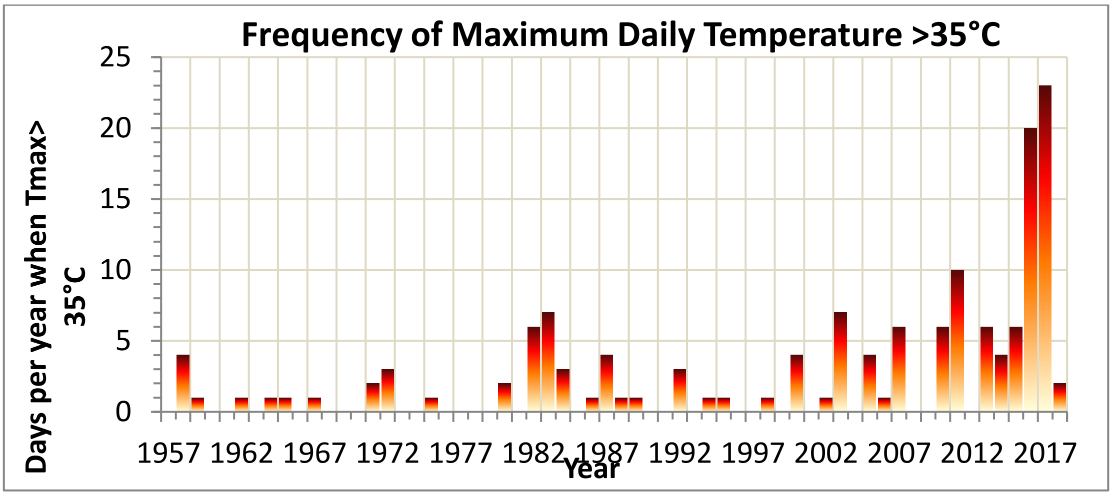


Public perceptions of an increase in the historical daytime temperatures are confirmed by the frequency of maximum daily temperatures at or above 35°C, as shown in Figure 11. Climate modelling indicates that this trend will continue. However, there is a mismatch between the measured trend and projected rates of change. Even conservative non-linear extrapolation of the instrumental trend would imply that, by century end, the number of additional days >35°C will more closely approximate the modelled maximum than the modelled median (see Table 10).

Table 10: Modelled number of additional days of >35°C by 2080-99 at Zanzibar

RCP	Median number of days/year	Maximum number of days/year
4.5	+2	+8
6.0	+3	+10
8.5	+14	+24

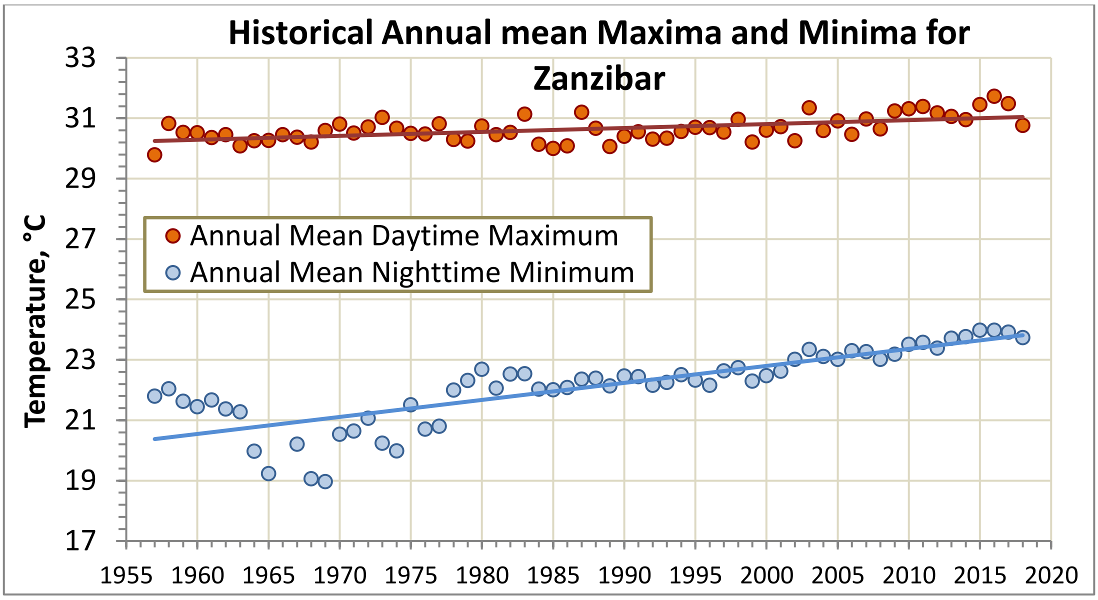
Figure 11: Historically Increasing Frequency of Hot Days in Zanzibar



The ameliorating influence of sea surface temperature (SSTs) will ensure that there will be few, if any, additional days of >40°C in Zanzibar, whatever the emissions trajectory.

From the perspective of heat stress in both humans and livestock, by far the biggest impact has been the rapid increase in night-time minimum temperatures since the 1980s. This has consistently risen at about three times the rate of maximum day-time temperatures. This is shown in Figure 12, with increasing night-time temperatures occurring most notably from May to November.

Figure 12: Night-time minima warming faster than day-time maxima



3.2.2 Rainfall and evapotranspiration

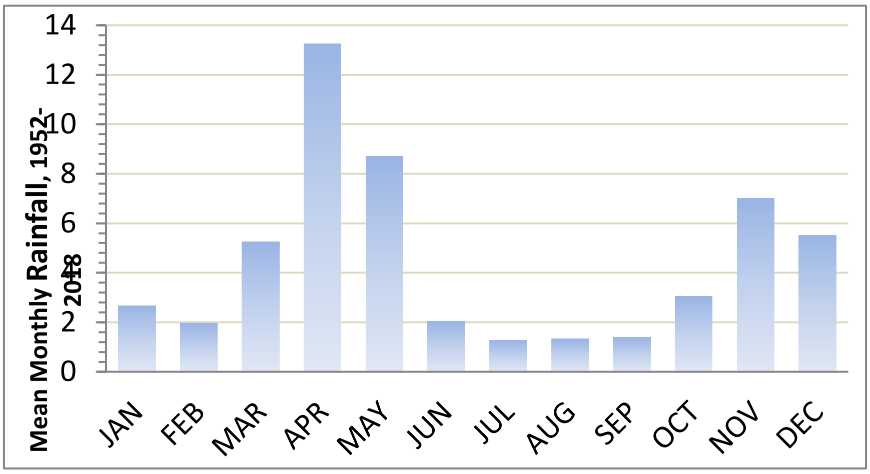
Modelling indicates that mean annual rainfall will increase, as summarized in Table 11 below. Currently, the mean annual rainfall is 1627 mm with an inter-annual variability of 26.5%. The mean monthly/ seasonal rainfall distribution is shown in Figure 13, indicating long rains predominantly from March to May, and short rains from October to December.

Table 11: Median Ensemble Mean Time-slice Rainfall Projections, mm

CMIP-5 data for Zanzibar (Bias Corrected)

Station	Historical Mean, mm	RCP	Incremental Additions, mm			
			2020-39	2040-59	2060-79	2080-99
Zanzibar	1630	4.5	14	13	35	62
		6.0	13	39	43	80
		8.5	18	26	40	89
			Projected Average Total Rainfalls			
		4.5	1644	1643	1665	1692
		6.0	1643	1669	1673	1710
		8.5	1648	1656	1670	1719

Figure 13: Historical Mean Daily Rainfall in Zanzibar, mm

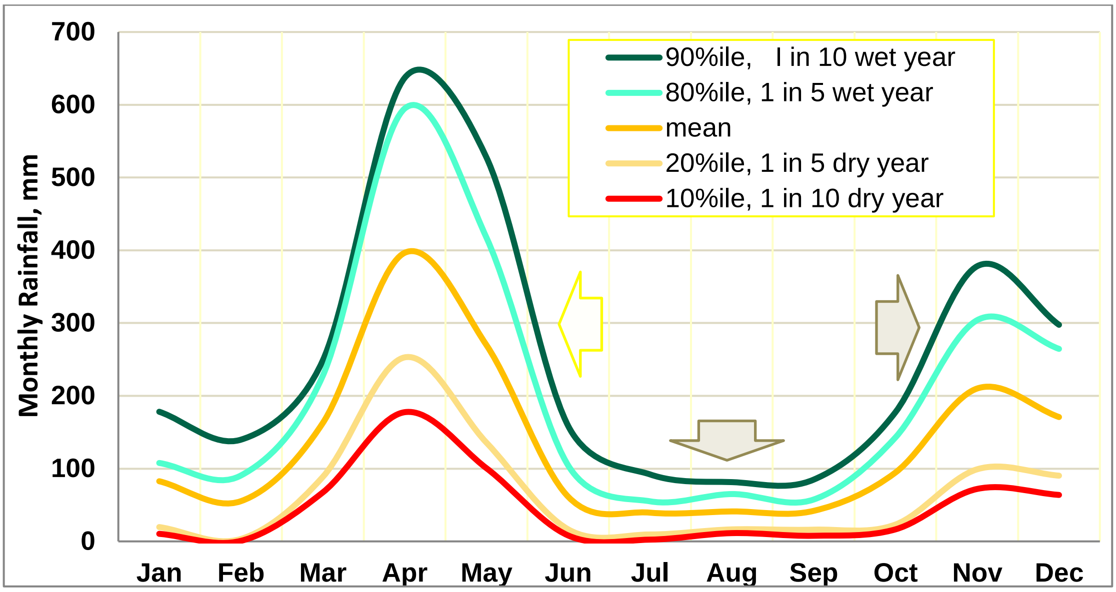


It is important to note the following while interpreting these models:

- With respect to annual rainfall and 24-hour rainfall intensity (>30 mm), there has been no discernible change over time, prior to 2018, although there is a 26.5 inter-annual variation.
- There is a weak statistical trend towards the onset of the main rainy season ('long rains'), currently occurring about ten days later than in the mid- 20th century – *on average*. However, this trend is largely masked by strong inter-annual variability in which the onset can occur anywhere within the first ten weeks of the year.
- Zanzibar is on the boundary of two climatic regimes, being the Indian Ocean and continental East Africa. Within the Indian Ocean, rainy seasons are controlled by SSTs and a water circulation pattern is known as the annual migratory locus of the inter-tropical convergence zone ('ITCZ'). Within continental East Africa, this is not the case, and the rainfall is predominantly a function of low-to mid-level tropical storm instability. As Zanzibar is at the boundary of these two climatic regimes it is not possible to predict whether or not this weak trend in rainfall delay will intensify.
- Generalized rainfall extremes can be estimated, and the most extreme precipitation is only about 5% greater than those of the historical record. Higher frequency / lower intensity events could be up to about 30% more intense than in the historical record.
- The runoff is not directly proportional to the rainfall, so an increase of only 10% in extreme rainfall can, and almost certainly will, result in a much higher proportion of runoff, resulting in greatly enhanced quickflow (flash flooding). In addition, the erosive power of quickflow is approximately proportional to the fourth power of the runoff velocity, so a small increase in extreme rainfall will have a disproportionate impact upon hill-slope, soil and embankment erosion.

On the other hand, process studies and projections at the regional level, particularly in respect of the ITCZ behavior, suggest some degree of rainfall intensification, concentrated over a shorter time-frame. That is, more rain is expected to fall throughout shorter rainy seasons, both in the 'long rains' and 'short rains'. What is particularly important for the reliability of water supply is the statistical spread of historical monthly rainfall at Zanzibar, which is shown in Figure 13 and is listed in Table 12 below. The projected future dry-season trends are indicated by the arrows of Figure 14.

Figure 14: Historical Wet and Dry Year Contrasts in Zanzibar



The CMIP-5 modelling consistently indicates that the long dry season will become longer, with more intense droughts. However, the frequency of drought occurrence will not change. There is some ambiguity / lack of clarity regarding rainfall trends during the 'between season' of December to February.

Table 12: Historical wet and dry year contrasts at Zanzibar, mm

ZANZIBAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
90%ile, I in 10 wet year	178	140	249	637	528	159	92	81	85	177	378	298	**3002**
80%ile, 1 in 5 wet year	108	91	228	595	418	104	55	65	58	143	304	265	**2432**
mean	83	55	163	397	270	61	39	41	42	95	210	171	**1627**
20%ile, 1 in 5 dry year	20	3	89	253	136	17	10	17	16	23	99	90	**772**
10%ile, 1 in 10 dry year	10	1	67	178	101	8	2	11	8	16	72	64	**539**

It is strongly emphasized that agricultural viability is not determined by mean or median conditions, but by the crop-water shortfall during dry years. Historically, there has been a more than three-fold variation in, for example, the I-in-5 dry year and I-in-5 wet year. Regardless of which carbon trajectory eventuates, this inter-annual variability is expected to deepen throughout the remainder of this century.

Because of its maritime position, Zanzibar has by far the highest dry-season rainfall of any of the EbARR project areas.

Changes in the evapotranspiration, 'ET_0', have also been calculated. It is significant in several respects. Firstly, when combined with growing-season crop factors ('K_c'[5]) and taking account of local drainage conditions, it indicates the crop-water requirement. **Whether the crop is rain-fed or irrigated, changes in the mean annual ET_0 indicate an *increased* water requirement of 4.5% by mid-century and more than 9% by end-century.** The increased crop-water demand will also

[5] Such as those supplied by FAO, http://www.fao.org/3/X0490E/x0490e0b.htm

be concurrent with increased seasonal soil-moisture deficits between the soil surface and the base of the root zone, especially during April to November.

Thirdly, even small changes in ET_0 will have a disproportionate impact on the effective precipitation. This latter may be crudely approximated as positive values of daily rainfall less daily evapotranspiration, which is essentially the water available for runoff and infiltration.

3.2.3 Other projections

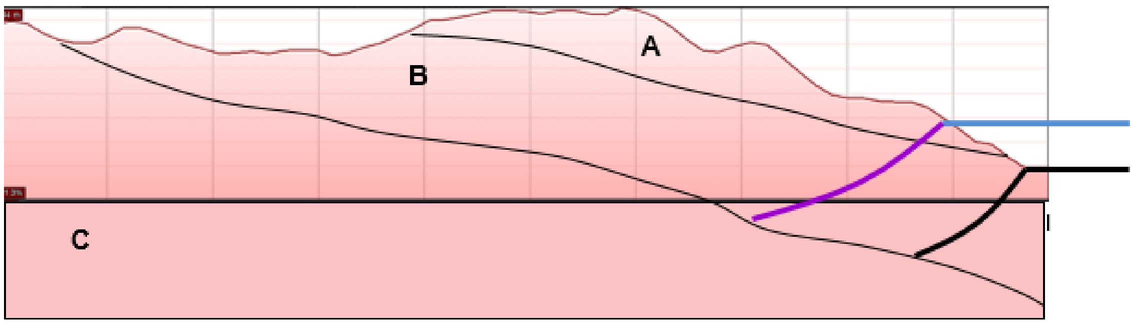
Groundwater and Seawater Intrusion

The geology of northeast Zanzibar consists of recently uplifted coralline limestone overlying more thoroughly lithified Miocene limestone, which in turn overlies relatively impervious sandy clay and marl. This sequence has a gentle easterly dip such that the limestone coastline is in hydraulic continuity with the Indian Ocean. Copyright prevents the reproduction of the geological map and section, but it may be accessed on page 4 of Hardy et al (2015). A conceptual cross-section is shown in Figure 15.

There is almost no surface drainage on the limestone areas although some perennial flow occurs in the drainage divide area, on the sandy-clay 'bedrock'. Otherwise, both the coralline and Miocene limestones are permeable, with the development of sub-karstic conditions.

Groundwater recharge is generated by both runoffs from the island divide, and by direct vertical infiltration. A quantitative assessment is impossible without field hydrogeological investigations. However, qualitatively, it is obvious that climate-change will stress the groundwater resource by reducing the effective precipitation (and hence the recharge), and by rising sea level inducing saline intrusion into the limestone aquifer.

Figure 15: Conceptual 5 km E-W section of the Northeast Coast of Zanzibar

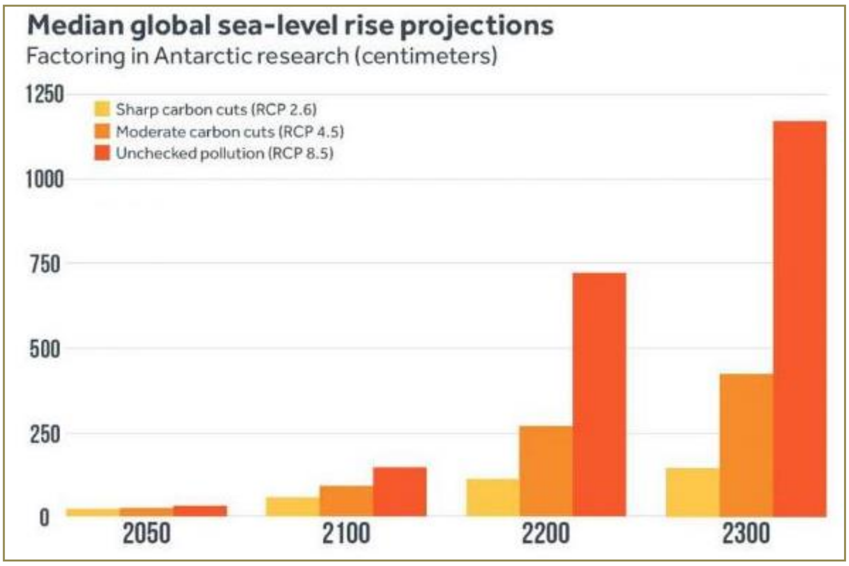


A= Coralline aquifer, B = Miocene aquifer, C= Oligocene (?) sandy clay. Thick black line = current sea level and saline interface in the aquifer. Blue/purple = projected sea level and saline interface.

Sea Level Rise

As of September 2019, the sea-level rise at the turn of the century appears to be in the range of 85 ± 25 cm. Whatever the century-end sea level rise will be, the rate of sea level rise will still be accelerating, resulting in much worse rises in subsequent centuries, as shown in Figure 16.

Figure 16: Median global sea level rise projections (generally applicable to Western Indian Ocean)

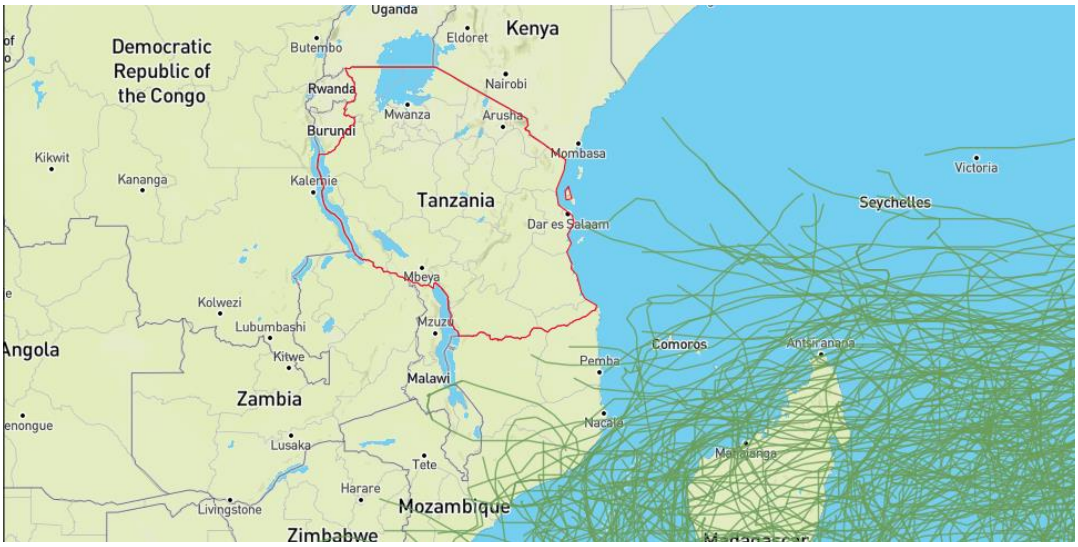


Source: Global Central

Tropical Storms

Sea surface temperatures (SSTs) are certainly set to increase east of Tanzania, and since an SST of >27°C is a pre-requisite for the development of tropical storms/hurricanes, some concern has been expressed regarding the future potential for such storms. Two factors run counter to this concern for Tanzania. Firstly, the low latitude of Tanzania ensures that there is insufficient spin to 'kick-start' the tropical storm[6]. This is apparent from the historical pattern of tropical storms and hurricanes, shown in Figure 17.

Figure 17: Historical loci of tropical storms and hurricanes southeast of Tanzania



[6] The law of 'conservation of angular momentum' does not allow rising tropical air to begin spinning significantly until the Coriolis effect becomes substantial, at about 6 to 8°S.

Secondly, as global warming progresses, wind-shear intensifies, and hence disruption of convective cell complexes tends to break up tropical storms before they evolve further.

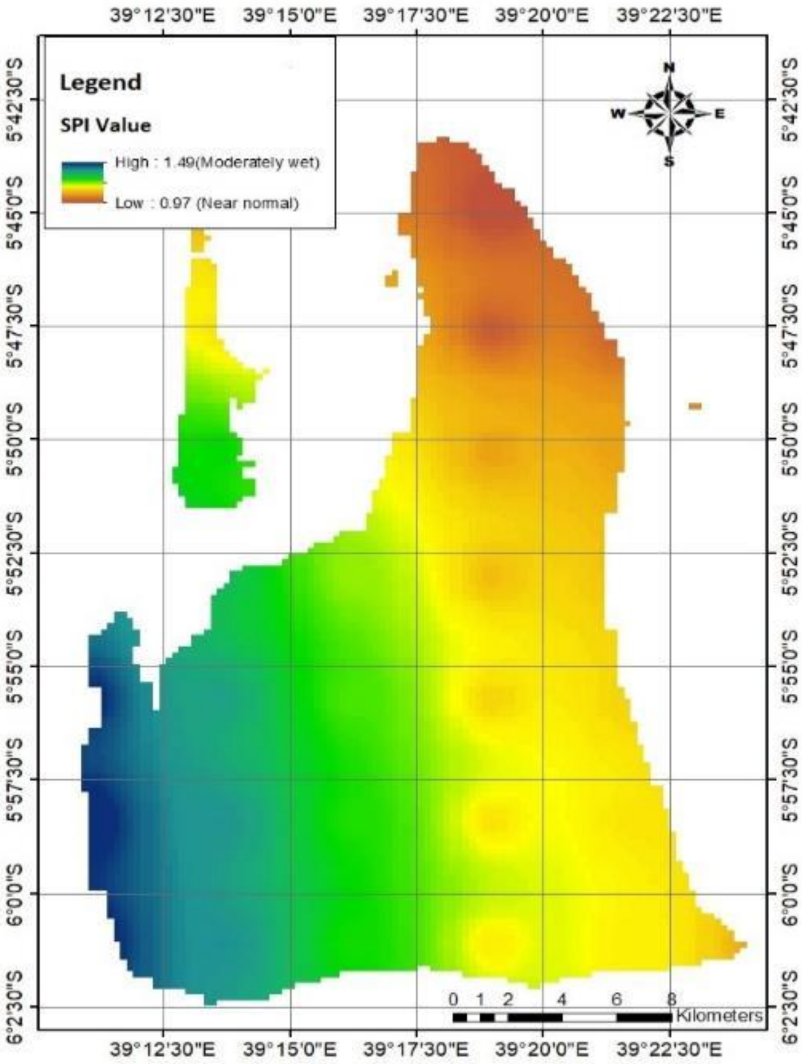
The net effect is that the future frequency and location of tropical storms is unlikely to change much from the historical picture. Zanzibar is close to the theoretical northern limit of tropical storm locations. There is a small risk of tropical storm damage across the whole island, but the future risk is unlikely to be much different from historical conditions. For the rest of this century, the south-eastern-most tip of Tanzania will incur a slightly elevated hurricane risk which could cause severe damage to areas within about 30 to 40 kilometers from the coast.

3.3 Risk maps and risk analysis for district

Drought hazard

As seen in Figure 18, where SPI values are low (brown), concentrated in the north of the district, the drought category is "lightly humid" or near normal. The southeast of the district faces an extremely low probability of drought. Any project interventions targeting water access and drought would, therefore, have their highest impact when implemented in and around the brown areas, around the locations of the project areas.

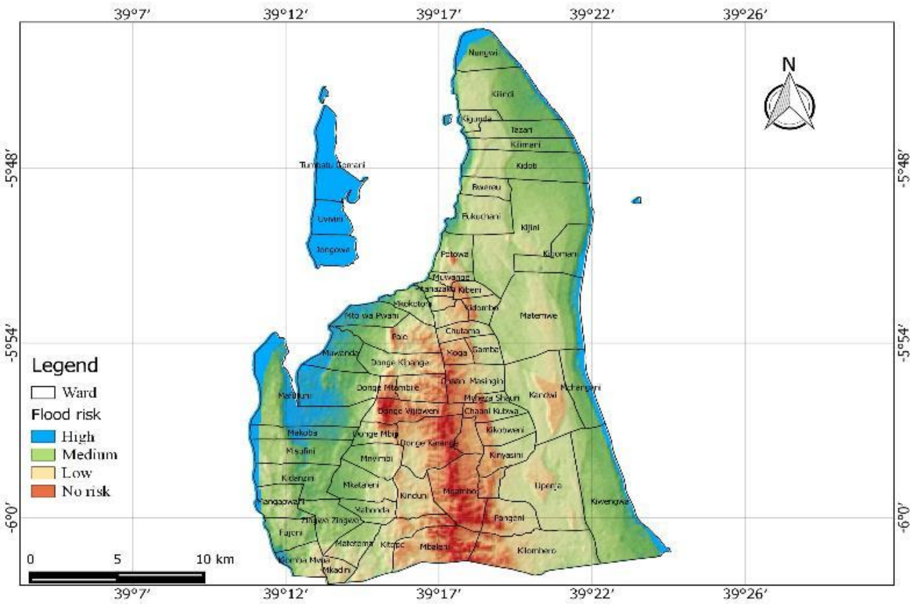
Figure 18: Drought risk map for Kaskazini-A



Flood risk

Flood risk in Kaskazini-A is mapped in Figure 19. All coastal wards (which generally lie under the 5-meter contour line) face a high risk of flooding along their coastal lengths. A medium to a low level of risk is present for all inland wards as well.

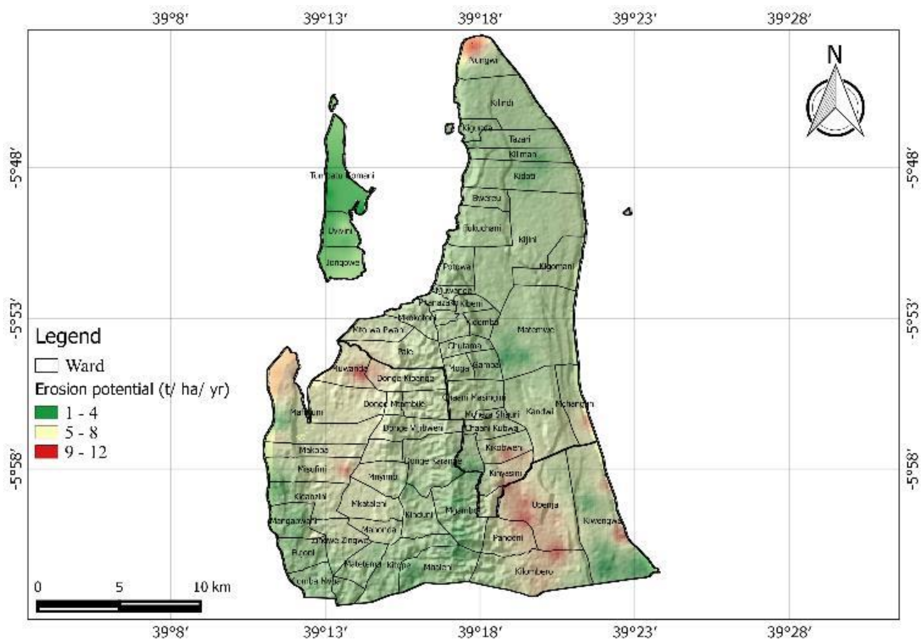
Figure 19: Flood risk map for Kaskazini-A



Erosion risk

Erosion potential on Kaskazini-A is highest in the areas shaded in red. It should be noted that in planning EbA measures to reduce erosion and erosion linked damages, targeting upstream or higher elevation areas (visible in Figure 20) would have the most significant impact.

Figure 20: Erosion risk map for Kaskazini-A



3.4 Climate change impacts for the watershed in the context of current land use

The implications of climate change for the terrestrial ecosystems, specifically with regard to forests/woodland/bushland, general biodiversity and also water supply and agriculture, are discussed below in the following sections.

3.4.1 Forestry

As per an assessment of the Global Forest Watch, none of the tree cover in Kaskazini-A is 'intact forest'. While tree cover diminished greatly since the past century, much has been recovered in the past decade as a result of afforestation and woodlot establishment. Kijini ward is reported to have ongoing sparse regeneration and a few reforestation sites, with the Kijini being the main tree species planted here.

Based on the team's observations, the main impacts of climate change on forests in Kaskazini A include:

- Increased incidence of forest fires; reducing forest cover and area
- Drier conditions leading to reduced growth and survival of trees and plants
- Increase in pests and diseases
- Invasion of rare and exotic species suppressing native species
- In mangroves and coastal forests: diseases affecting seaweeds and seagrasses
- Young mangroves overgrown by seaweeds and affected by higher temperatures
- Changes in distribution and composition of species
- The water recharge capacity of forests is decreasing

This is affecting the following economic, forest-based activities:

- Beekeeping affected by more forest fires
- Reduced productivity and production of timber
- Forest dependent people get fewer services from the forests (firewood, wild fruits, other NTFPs)
- Production of fish is reduced in mangroves, local fishing communities are affected
- Reduced occurrence of wildlife makes the place less attractive for tourists
- Forests and agriculture are closely interlinked, as a result, agricultural production is also affected by climate stress on forests.

The climate impacts on forests in Zanzibar will follow trends predicted for Eastern Africa in general: the 2xCO_2 Holdridge life model predicts potential changes in vegetation, for example, subtropical dry forest and subtropical moist forest life zone classes will change as CO_2 doubles, to very dry tropical forest, tropical dry forest and tropical moist forest. The model predicts that subtropical thorn woodland currently in existence will be completely replaced, i.e. changes in forest type, species and distribution is expected. Subtropical dry forest and subtropical moist forest will decline by 61.4% and 64.3% respectively. The Forest Gap Model predicted that some species are more vulnerable to climate change than others, particularly those that are drought/heat intolerant; with low germination rates; with low survival rate of seedlings; and with limited seed dispersal/migration capabilities.

3.4.2 Biodiversity

As indicated, natural habitats have been reduced both in area and in species richness. Further population growth leading to a higher demand for settlements, agriculture and other infrastructural developments will continue to impact natural resources and services (Kombo *et al*, 2006).

Changes in land use and land cover and the resultant decline in the state of natural habitats and biodiversity are also caused by encroachment, mining, industrial activities, and the unsustainable harvesting of forest products, invertebrates and fish, conversion of coastal forest areas for cultivation, and poorly planned developments (Kabanza et al., 2013; Kashaigili et al., 2006). Already, some species are reported to have disappeared, including *Psidium cuminii*, *Sorendeiya usambarensis* and *Virtex* spp in Matemwe Kijini. Opening up new areas for agriculture has itself caused a change in vegetation, a loss in habitat availability and maybe fragmentation, usually resulting in a loss of biodiversity. As indicated above species change is expected with zonal shifts as climate change occurs, providing conditions adverse to some species but suitable for others. Overall, climate change will exacerbate the changes already occurring due to human activities.

Discussions and meetings with stakeholders in Zanzibar revealed the effect of climate change on regional biodiversity, and in turn, on communities. Participants reported increased changes in rainfall, erratic weather patterns, reduced amount of rain and number of rain days, occasional unexpected dry spells, exacerbated by an increase in temperatures. These changes have culminated in reduced growth and survival of trees and plants in the area.

In the discussion, communities reported more cases of invasion of pest and disease compared to the past. Major climate-induced pests and diseases for crops include army warms, mole cricket, stalk borers, and ants. Invasion of weeds and exotic species are suppressing native species. Mangroves and coastal forests are further affected by diseases.

3.4.3 Water supply

Without adequate intervention, climate change will increasingly adversely affect water supplies. In the longer- term, the combined effect of increased temperatures and changed rainfall patterns/seasonality and intensity will affect agriculture domestic supplies and natural ecosystems, potentially with zonal shifts.

The principal source of water supply in Zanzibar is groundwater. This is clearly apparent through the Population and Housing Census of 2012, (RGoZ 2017), as well as through the team's observations. Water sources are classified as 'improved' or 'unimproved'. Improved water sources have less risk of contamination and can include piped water into dwellings (20.6%), piped water to yards/plots (16.0%), public tap/standpipes (37.4%), tube well/ boreholes (0.4%), protected dug wells (2.1%) and protected springs (0.1%). Unimproved drinking water sources include unprotected dug wells (20.2%), rainwater harvesting (2.4%), carts with small tank/drums (0.2%), tanker trucks (0.2%) and surface water (river, dam, lake, etc.; 0.3%). The use of bottled water is not included. In general, the level of connection to water supply in the district is still very low.

Distance to a safe water source for households is important, impacting on consumption and hygiene practices. The situation has been improving, with the percentage of households in the district within less than 1 km from a drinking water source during the dry season has improved from 64.7% in 2004/5 to 90.7% in 2014/15 (RGoZ 2017).

Even without considering future climate change, there are already significant environmental and sustainability challenges, a key one of which is the provision of drinking water (RGovZ 2013, 2017). Water sources are deteriorating through existing impacts on ecosystems, which help regulate and clean water, including:

- Deforestation and destruction of water catchments and wetlands due to agriculture, timber for construction, quarrying and fuel wood and charcoal;
- Environmental pollution aggravated by inadequate management of solid waste and wastewater;
- Pit latrines, septic tanks and soak pits used widely in urban settlements, often constructed near or within the vicinity of ground water sources. This situation can cause rapid spreading of water borne diseases.

In addition, supplies are impacted by:

- Increasing depletion of fresh water resources as a result of:
  - increased demand, with increased population, unplanned settlements, coastal tourism development;
  - failing monsoon rains;
  - the potential for expanding agriculture with increased agricultural water requirements.
- Salt water intrusion from the sea into aquifers. This could be particularly significant to coastal communities and tourist developments which source their supplies locally from bores.

As shown in the figures above, there is already a large difference in annual rainfall due to inter-annual variability. Even without a high risk of drought, there are periods of above-average and below-average rainfall. The difference between total rainfall in a 1:5 year average return interval (ARI) and a 1:5 year ARI wet period are 772 mm and 2432 mm. The effective precipitation is approximately 68% of the total.

For agriculture and the harvesting of surface resources, it is these drier periods, which need to be managed. With climate change, this situation will be exacerbated with shorter and wetter rain seasons and a longer drier dry period. Also, as noted above, soil moisture levels will be lower than the point ideal for crops to grow, and effectively, delays in the onset of the wet season. Evapotranspiration rates will increase, meaning that to maintain the status quo requires additional water, approximately 4.5% mid-century, to approximately 9% by end of century.

In summary, it can be noted that in addition, during the shorter rain seasons, increased rainfall intensity may result in reduced groundwater recharge, affecting resources available to service existing demand as well as future demands. Increased rates of salt-water intrusion (sea-level rise) into aquifers will harm supply to agriculture and domestic purposes. Finally, there will be socio-economic consequences. Changes in the source of suitable water is having, and will continue to have, significant impact on gender roles and burden on women, as women have to go further inland to obtain suitable water. As most of the population is located near the coast, this could be a major issue.

3.4.4 Agriculture

Agriculture is another mainstay of the economy (after tourism and marine/coastal environment) that sustains livelihoods around Kaskazini A. Main crops cultivated in Zanzibar are maize (80.5%) beans (24.7%) cassava (23.4%), millet (5.2%) and rice (2.6%). It is also a recognized climate-sensitive sector. Agriculture is largely dependent on rainfall. With the recent drought and changes to rainfall patterns, the shortage of water has negatively impacted not only agriculture and agroforestry, but woodlots as well.

Communities narrated that climate variability, notably poor and erratic rains affected farmers and production in exceptionally in 2006/2007, and almost led to food shortages. Climate variability will continue to pose risks to crop production around the region. Positive and negative effects were described based on individual crops and their locations.

Temperature-sensitive crops like maize are affected negatively, although there is low production of maize on the island. Effects on rain-fed crops such as rice are more pronounced with climate variability, with the possibility of yield reduction based on the severity of precipitation and temperature changes. Banana yields are affected by climate change and changes in the occurrence of pests and diseases, while cassava is proven to be a more resilient crop, and used as an adaptation strategy to cope with potentially hotter and drier climate predictions.

The estimated loss of maize yield due to climate change is in the range of 10 to 20% by 2030 and 20% to 40% by 2050 with no adaptation (Tumbo et al, 2011). However, the scale will depend on variability of temperature and precipitation. Considering a price of US$ 330 per ton, maize losses could translate to up to US$ 0.5 million/year, assuming no adaptation measures are taken.

Rice in particular is emerging as an important crop for the island and is sensitive to temperature changes, though not to the same degree as maize. A reduced yield (by 16%) is estimated with a temperature increase of 2 degrees, and a small increase in rice yield might arise with precipitation increase, and changes in seasonal precipitation (a 20% change in variation) could lead to a reduction of around 8%.

For banana and plantain, climate change may alter both yields up to a 10% reduction as well as vulnerability to diseases. The increase in pests and disease as earlier reported will create agro-ecological shifts in the long-term, which is riskier considering the small geographic area of Zanzibar. The greatest impact in the short term is the intensification of rainfall during the rainy season and higher levels of variability. Communities reported a decrease in soil quality due to sea-water intrusion as well. Some coastal rice fields are intruded with saltwater while the high-value cloves are vulnerable to increased storm and high winds.

3.4.5 Coastal resources

Fisheries and seaweed harvesting are major industries, and Matemwe is a major centre. In Matemwe Kusini Shehia (MK), approximately 60% of the population are fishermen and 15 % (virtually all women) are involved in seaweed harvesting.

Current and expected impacts of climate change include:

- With sea-level increase, it will cause coastal erosion, inundation of low-lying areas, and collapse of buildings,
- Increased sea surface and ambient air temperatures (approx. 1.5^0C by turn of century),
- Coral bleaching and mortality,
- Increased incidence of disease in marine animals,
- Altered seasonality of biological events and distribution of fish (there is likely to be a geographic biological zone shift). Marine animals, such as fish, do not control their body temperatures, but have the same temperature as the surrounding water. A rise of 1.5^0C can be devastating for many species. Fish are reported to have declined all along the coast. Some of this may be due to destructive fishing. However, changes in fish catch may also be due to

cyclical changes. While catches off the Tanzanian coast increase when the SSTs and humidity are below normal, and vice versa. SSTs are only partly controlled by climate change. They are mainly a function of phases in the quasi-decadal IOD and related currents. While it could be expected the overall trend of rising SSTs to decrease fishery productivity towards the end of the century, other factors such as the broader ecological changes caused by ocean acidification, and changes in species occurrence and composition due to zonal shifts, will have a significant effect,

- Increased ocean acidification,
- Weakened corals, which together with temperature results in death. Eventual loss of in-shore reefs, exposes the coast to increased erosion potential,
- Affects the calcium carbonate shells of such as shellfish, affecting the food web,
- Salt water intrusion into aquifers used for agriculture and domestic supply. This is occurring at other coastal locations on the island and is a very serious matter,
- Impacts on tourism, reefs and long white beach are the major features that attract the tourists, both of which will be impacted.

3.5 Ongoing adaptation efforts

Water

Communities and LGAs are engaged in disinfecting activities around boreholes near rivers to avoid the spread of disease on a small scale. This appears to be sufficient for domestic purposes, however, an in-depth look into health impacts has not been conducted.

In addition, in 2013, an African Development Bank funded project constructed two water tanks in the area (in Kiyashange and Mwangua), which have a capacity of 2 million liters. Each tank takes three days to fill up, and is supplied by three boreholes. The boreholes themselves recharge at a rate of $30mm^3$ per hour. There is a strong interest in increasing the number of boreholes in the area, as not every household in the area appears to be served by the existing infrastructure. However, adaptation measures must be cognizant of the fact that (over-)extraction of groundwater is not sustainable, particularly given the island's vulnerability to sea-level rise. Further comment on the impacts of SLR are made in Section 3.2.

So far, the district does not do any rainwater harvesting, and has no plans to do so on a medium to large scale. They are however open to the idea, if supported by the government or a development project. Other small-scale adaptation measures currently in place include tree planting near water sources and educational outreach to communities. There is no watershed rehabilitation work ongoing or planned in Zanzibar, as there are only some natural small springs in the forest rag ecosystem in Matemwe.

Biodiversity

A major gap observed is the lack of generic data, studies or measurements on biodiversity, as well as data related to climate change impacts on biodiversity, whether in the form of reports, or knowledge among LGAs. Particularly for biodiversity considerations, such information is crucial for monitoring and awareness, as these factors cannot be as easily measured as outputs within agriculture and forestry.

Agriculture

Agriculture is a key priority for adaptation, especially in relation to existing climate variability. There are a number of adaptation strategies, the key is to find the most suitable one - given the context - and prioritization of the most efficient and urgent measures. Awareness raising, institutional strengthening (particularly extension services) as well as strengthening the capacity of agricultural research institutions have been mentioned repeatedly in various reports and policies (ZAPA 2007). Improved agriculture practices, agroforestry, banana farming, citrus and shallow roots crops has been mentioned in Mbuyutende Shehia.

Figure 21: Improved (mixed) agricultural practices observed in Kaskazini-A

Most communities reported a lack of understanding on climate variability and its implications. The adaptation strategy here could be to increase information sharing with key stakeholders (farmers) with short-term and seasonal forecasting and early warning system (e.g. heavy rain or longer drier period). There is a need to make agro-meteorological services available and widespread, to share information through networks or mobile phones. The TMA has such information handy and is currently involved in awareness raising with communities on how to access and use this information.

Ecosystem-based options with wider cross sectorial benefits have been proposed, including soil and water conservation. These can build resilience as well as provide opportunities or synergies with low carbon activities (conservation agriculture, diversification, mulching, agroforestry), and are also no regret opportunities (e.g. reduces post-harvest losses). Furthermore, the use of rainwater harvesting and storage as a low-cost approach for water management, particularly for smallholder farmers, is a potentially important option. Many of the most promising options fall within a general definition of sustainable agricultural land management (SALM) practices, and these are considered a priority to build resilience, increase production and generate wider benefits for the islands.

Coastal resources

The Revolutionary Government recognizes that the mitigation of coastal impacts requires a holistic approach, with and consider integrated solution. The management dimensions identified in RGovZ (2010) for threat mitigation, and which are now under implementation, include:

- Integrated Coastal Zone Management (ICZM)
- Integrated Water Resources Management (IWRM)
- Land Use Management
- Shoreline Management Planning
- Solid and Liquid Waste Management
- Sanitation
- Capacity building Technology
- Law enforcement, legal review
- Alternative/Improved Livelihood
- Awareness-raising and education

The 2014 Government of Tanzania and World Bank Project provided a portfolio of prioritized actions; they include systemic and local actions. Those relevant to the Kaskazini-A District on Unguja Island are listed below. Systemic actions are actions directed towards improving the enabling environment for sustainable management of the development in the coastal zone. In this sense the systemic actions will be supportive for all local actions. However, no follow-up is available on which of these actions have already been implemented, and what the results have been. **It is therefore hard to measure the level of adaptive capacity in Zanzibar, and to assess the effects of CC-related policies and projects .**

Type	Action Title	Location
Systemic	Integrated Coastal Zone Management Framework for Zanzibar	Unguja and Pemba
Systemic	Integrated Spatial Planning	Unguja and Pemba
Systemic	Shoreline Management Policy Framework	Unguja and Pemba
Systemic	Information System as Decision Support for Coastal Development Management	Unguja and Pemba
Systemic	Primary and Secondary Education	Unguja and Pemba
Systemic	Overall Awareness Raising	Unguja and Pemba
Systemic	Integrated Review of Legal Framework for Coastal Development Management	Unguja and Pemba
Erosion	Beach erosion study for Zanzibar (Pemba and Unguja)	Unguja and Pemba
Sanitation	Sewage collection and treatment facility at Nungwi Village and hotel areas, Unguja	Unguja North
Waste Management	Regional solid waste collection and processing facility, Unguja North	Unguja North
Water Supply	Study, review and design of freshwater supply options for Unguja	Unguja North
Fisheries	Zanzibar fisheries sector review by fishery types and management areas	Over-arching
Fisheries	Zanzibar small pelagic fisheries support on Zanzibar	Over-arching

Fisheries	Support for Zanzibar fisheries monitoring, control and surveillance programme	Over-arching
Fisheries	Strengthening management of octopus fisheries on Zanzibar	Over-arching
Fisheries	Strengthening seaweed farming in Zanzibar	Over-arching
Fisheries	Semi-industrial offshore tuna fisheries support programme	Unguja North
Fisheries	Strengthening fish mariculture in Zanzibar	Over-arching

3.6 Interventions

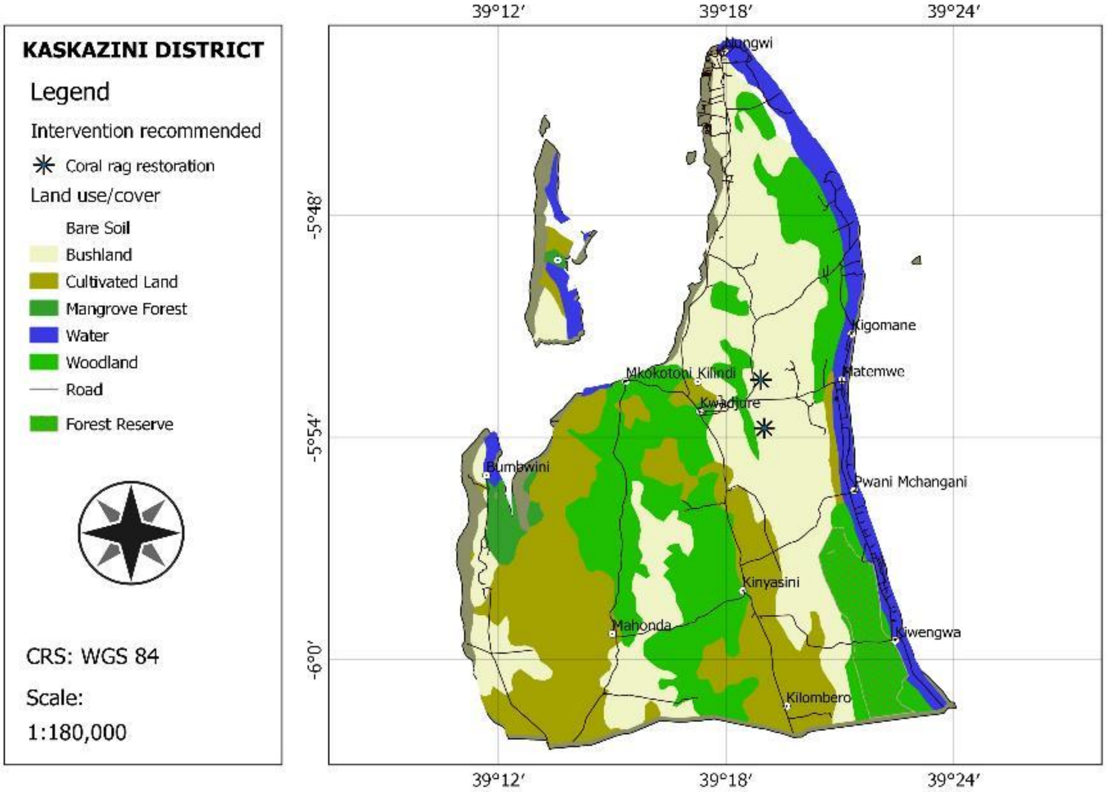
Table 13 summarizes the ecosystem level issues and impacts facing the community as recorded in the local stakeholder workshop, as identified in the multi-stakeholder workshop held in November, as well as suggested or desired interventions. Although most issues are linked directly to climate change, while some are only indirectly connected (e.g. exacerbated by climate change).

Table 13: Issues and interventions identified in multi-stakeholder workshop in Kaskazini-A

Issue		Intervention
Major issues identified	**Impacts to community**	▪ Afforestation with fruit trees and woodlots for firewood ▪ Updates to/improved enforcement of mangrove and beach by-laws and protection ▪ Improved seaweed farming ▪ Improved agricultural practices, banana and citrus farming, planting shallow roots ▪ Capacity building in water resources management (increasing availability and sustainability)
▪ Reduced forest area and cover (poor three growing conditions and success rate due to CC) ▪ Mild to severe drought alternating years ▪ Wetland areas drying up ▪ Dry conditions = increased incidence of forest fires ▪ Increasing pests and diseases in forests ▪ Drier conditions leading to reduced seedling/tree survival (esp. coconut); increased evapotranspiration ▪ Reduced quality and quantity of water (saltwater intrusion into shallow wells, low recharge capacity) ▪ Lack of piping connection exacerbates water shortage issues caused by CC ▪ Soil quality decrease (salinity)	▪ CC-linked adverse impacts to bees (esp. through reduction in forest cover), resulting in lack of beekeeping success ▪ Reduced productivity and production of timber ▪ Increase in crop pest and disease, livestock disease (pneumonia/ticks in cows and goats, mdondoo in poultry) ▪ Reduced fish production in mangroves; fishing livelihoods threatened. Fishermen lose time traveling into deeper seas. ▪ Reduced availability of NTFPs, firewood and wild fruits ▪ Food insecurity ▪ Increased health issues (cholera and malnutrition) ▪ Unreliable water access makes agricultural planning and activities difficult ▪ Lost time and income traveling farther distances for water (women disproportionately affected)	

As CSA interventions are already planned under a separate budget line, and as there are no rivers in the area, the study recommends **coral rag restoration and tree enrichment in select areas** of Kaskazini-A, based on expert observations and inputs of workshop attendants. Coral rag restoration is recommended particularly in and **around the Matemwe area, specifically Mahonda, Kinyasini and Mkokotoni** (i.e., in and around the scattered and degraded beige and green areas on the map.) These areas are sufficiently inland as to be protected from sea level rise and flooding risk, which increases the chances of these activities succeeding. Tree enrichment is proposed (at the specific request of district technicians) around the **Makonga caves.**

Figure 22: Recommended interventions in Kaskazini-A



For more information on this process, see Chapter 8.

4 MVOMERO, MOROGORO

4.1 Description of study district

Mvomero is one of the seven districts in Morogoro. Within the district, Melela has been selected as the target ward, however the study team visited Magali and Lubungo wards additionally. With respect to the EbARR project, relevant information on climate, population and area, and land use and land cover are given below.

Climate

Prior to climate change effects, the climate was described as varying from semi and warm tropical to cool high altitude tropical. Rainfall is described a bimodal, with a short rainy season between October and December (when predominantly eastern trade winds bring moisture from the Indian Ocean), and a long rainy season from March to May every year. Rainfall ranges between 700mm in lowland areas to 2300mm in high altitudes and adjacent areas. The elevations range from 300 – 2300m above sea-level. The temperature in the district ranges from 18 – 30° C, with the mean monthly temperature being 26°C.

Population and area

The total area of Mvomero is 7,325 km^2. According to the 2012 census, the district's population size is 312,109, and population density is 42.6 people per km^2. Economic activities, geographic condition and type of soil influence the population distribution.

The main economic activities are agriculture and animal husbandry (about 90%); 2.6% are engaged in forestry, fishing and related activities, a further 2% are engaged in trade and business, and 1.9% are in administration and education. The average individual annual income (per capita) in 2003/2004 for Mvomero district was estimated at TShs. 337,035.

Land use and land cover

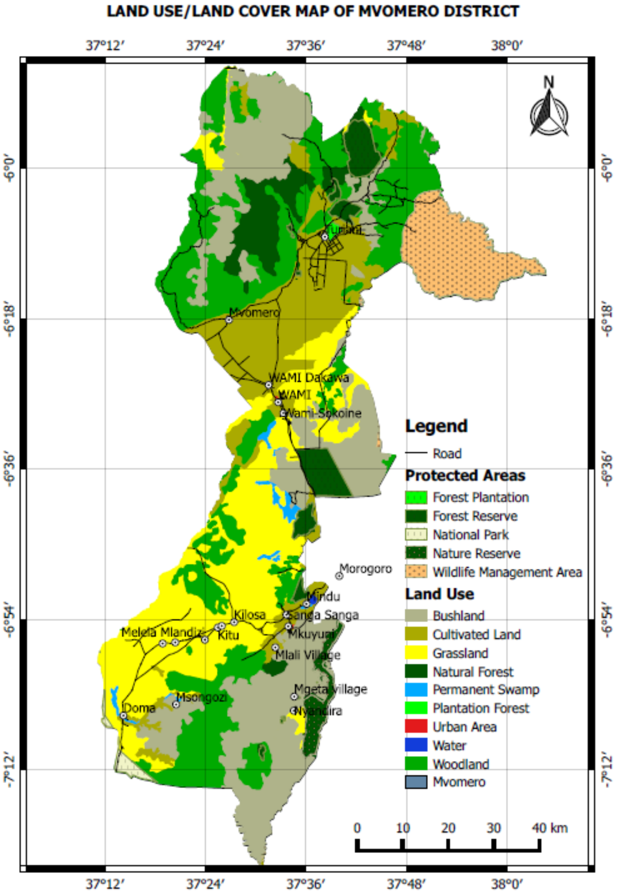
Within Mvomero district, three wards were visited and consulted as part of the VIA study; Lubungo, Melela and Magali. Of these wards, only Lubungo and Melela have land use plans in place. Figure 23 shows the current land use. Table 14 summarizes the land use changes that have occurred from 1996 to 2016. The main change is the reduction of woodland, forest and shrubland by a total of 153,180 ha, or 24.1% of the districts total area, and largely replaced by grassland, cultivated land and some scattered cropland. Also of note is the increase in permanent swamp and areas of inundation.

Mvomero has approximately 549,375 hectares of land suitable for agricultural activities but only 45% of this is cultivated. In practical terms this extent of agricultural land may not be available as it may involve further natural vegetation clearing. Since the arrival of livestock keepers in 1980s, land use conflicts between farmers and livestock keepers have occurred regularly. These are generally over the usage of water sources; pastoralists pass their herds through farms when taking them to water bodies (rivers and dams). Often, this results in large scale crop damage. Currently different measures have been taken by the District Council and the Regional Commissioner's office in educating and sensitizing these two groups (farmers and pastoralists) to enable them to manage the conflicts internally and effectively.

Table 14: Mvomero District: land cover/ use change detection, 1996 to 2016

Landcover Type	1996		2016		Rel. Change 1996_2016	
	Area (Ha)	Area %	Area (Ha)	Area %	Area (Ha)	Area %
Forest	42512.00	6.69	37065.00	5.83	-5447	-0.8571
Woodland	159410.00	25.08	82475.00	12.98	-76935	-12.1059
Bushland	155038.00	24.40	84240.00	13.26	-70798	-11.1403
Grassland	102173.00	16.08	166560.00	26.21	64387	10.1315
Cultivated Land	90343.00	14.22	138972.00	21.87	48629	7.6519
Scattered Cropland	54478.00	8.57	79245.00	12.47	24767	3.8972
Inundated Land	27329.00	4.30	30349.00	4.78	3020	0.4752
Permanent Swamp	3978.00	0.63	7964.00	1.25	3986	0.6272
Settlement	116.00	0.02	4043.00	0.64	3927	0.6179
Water	137.00	0.02	4601.00	0.72	4464	0.7024
Total Area	**635514.00**		**635514.00**			

Figure 23: Land use/land cover map of Mvomero district (2016)



4.2 Climate change projections for district

4.2.1 Temperature

Annual average temperatures have been increasing, a trend, which will continue. Using data from the Morogoro meteorological station, temperature projections for RCPs 4.5, 6.0, and 8.5, for 20 year time intervals (until end century) are summarized in Table 15 and shown in

Figure 24 below. The historical seasonal range in temperatures is shown in

Figure 25. The most likely increase is about 2.2°C by end century. **In addition to the increasing annual average temperatures, there is also a very apparent trend of increasing numbers of days per year > 35°C**, as shown in Figure 26. The highest historical temperature at Morogoro was 38.8°C. Most projections have maximum temperatures seldom exceeding 40°C by the end of century. Curiously, the trend of night-time minima warming much faster than day-time maxima observed for the other four districts, does not seem to apply in Morogoro.

Table 15: Median Ensemble Mean Annual Temperature Change Projections, °C

CMIP-5 data for Morogoro (Bias Corrected)

Station	Historical mean	RCP	2020-39	2040-59	2060-79	2080-99
Morogoro	24.79°C N=44	4.5	25.57	25.98	26.2	26.63
		6.0	25.51	25.81	26.42	27.06
		8.5	25.69	26.39	27.56	28.1

Figure 24: Historical and Projected Temperature Changes at Morogoro

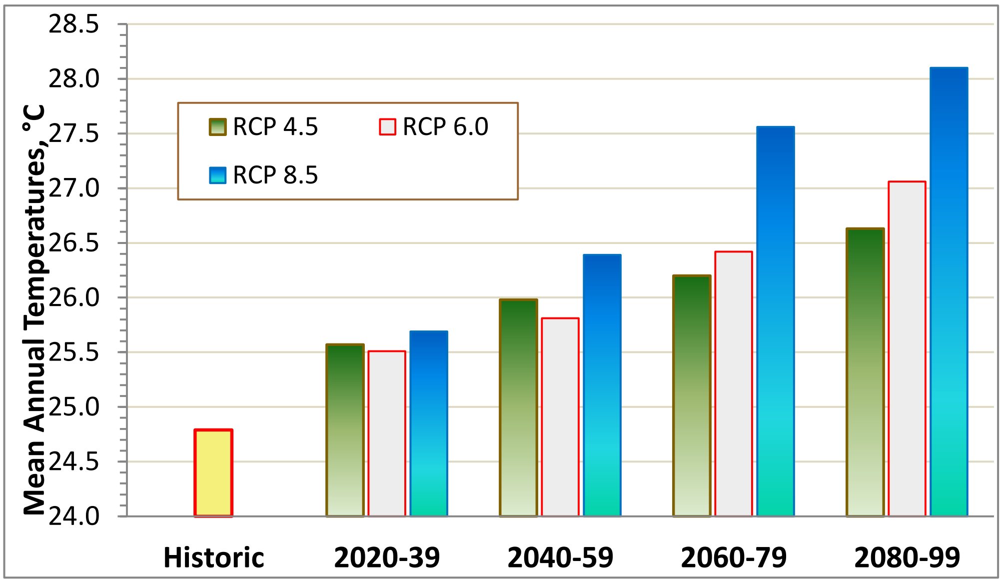


Figure 25: Seasonal Temperature Variations at Morogoro

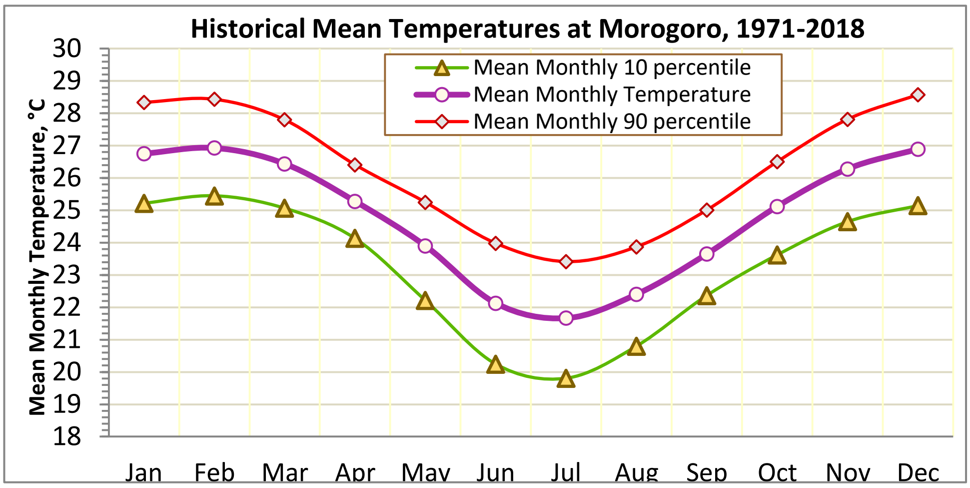
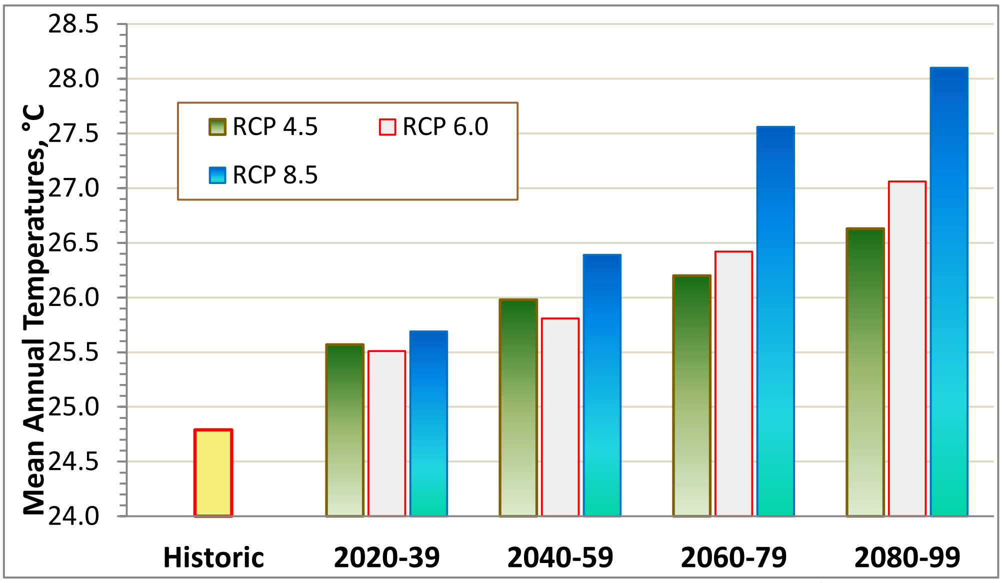


Figure 26: Historical Annual Days Exceeding 35°C in Morogoro



Note: The regression in the number of hot days at Morogoro has a statistically weak R^2 *value, but is nevertheless consistent with expected trends.*

4.2.2 Rainfall

Modelling indicates that **there will be an increase in annual mean rainfall, by approximately 2.4-5.6%** for the RCP 4.5, 6.0 and 8.5 scenarios, as summarized in Table 16. However, this computed gain in total rainfall is contradicted by both field perceptions of farmers, and by recent instrumental trends. The latter indicates a medium-term *decrease* in rainfall over the decade prior to 2018, which is most probably an artefact of the Indian Ocean Dipole (IOD) rather than of long-term climate change. The historical and projected mean annual total rainfalls for the 20 year time intervals until the end century are also shown in Figure 27.

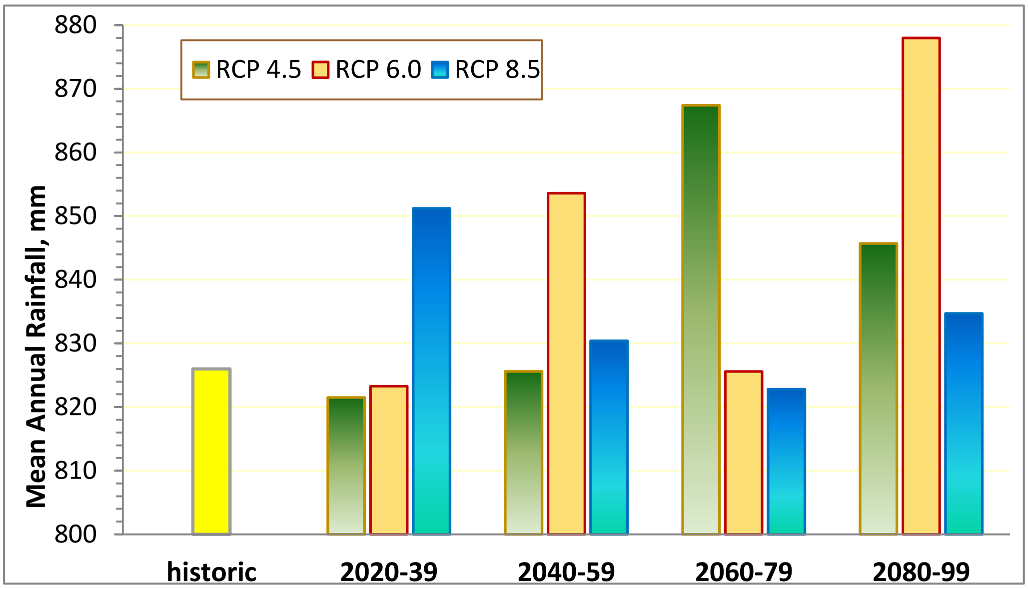
As in Zanzibar, not far to the east, **climate change is expected to have a relatively minor impact upon the rainfall variation in Morogoro** under any of the standard emissions scenario, or at any time-slice.

Table 16: Median Ensemble Mean Time-slice Rainfall Projections for Morogoro, mm

(CMIP-5 data for Morogoro, bias corrected)

Station	Historical mean, mm	RCP	Incremental Additions, mm			
			2020-39	2040-59	2060-79	2080-99
Morogoro	826	4.5	-5	0	41	20
		6.0	-3	28	0	52
		8.5	25	4	-3	9
			Projected Average Total Rainfalls			
		4.5	822	826	867	846
		6.0	823	854	826	878
		8.5	851	830	823	835

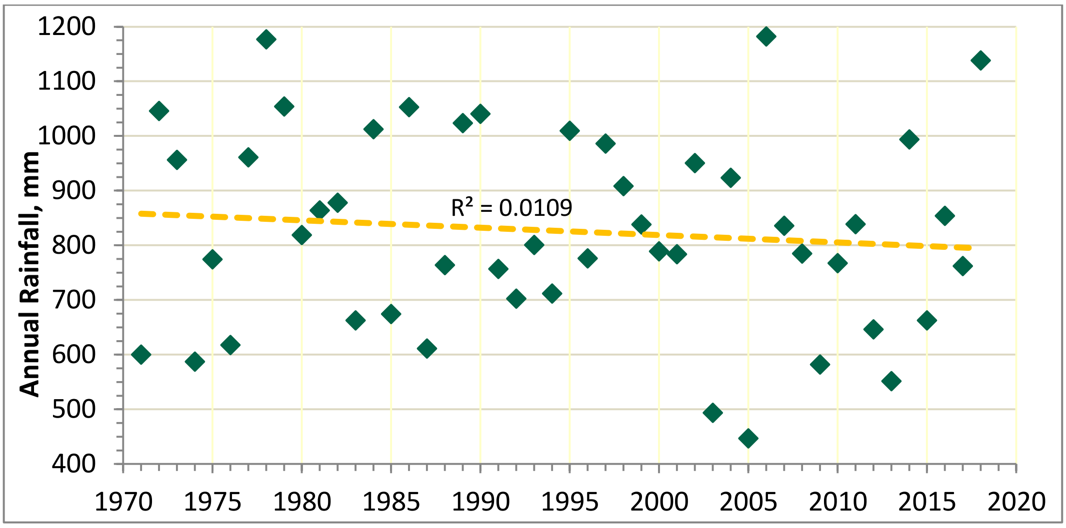
Figure 27: Historical and Projected Mean Time-slice Rainfalls at Morogoro



Caution: Some of these changes only appear to be large because of the false origin of the rainfall scale.

There is a large inter-annual variation in annual rainfall, which is clearly shown in Figure 28. While analysis appears to show a decrease in rainfall, it is clear that the scatter of data is too great to determine any reliable statistical trend. The apparent long-term decrease could easily be reversed by just one further data point.

Figure 28: Historical Annual Rainfall Variation at Morogoro



Of particular relevance to climate change impacts is the occurrence of periodic below-average dry and wet years and changes in the frequency of the occurrence of droughts. Figure 29 compares the historical mean rainfall with the 1:5 and 1:10 average return interval (ARI) wet and dry years. Table 17 also summarizes this data. This clearly shows the substantial difference between relatively wet and dry years, with 400 mm for the 1:5 ARI dry year compared to 1180 mm for the 1:5 ARI wet year. In the dry years, soil moisture will also be relatively low, so with the onset of rainfall, early falls will be taken up increasing soil moisture levels before water is available for crops. The runoff will also be greatly reduced.

Figure 29: Historical Wet and Dry-Year Rainfall Variability at Morogoro

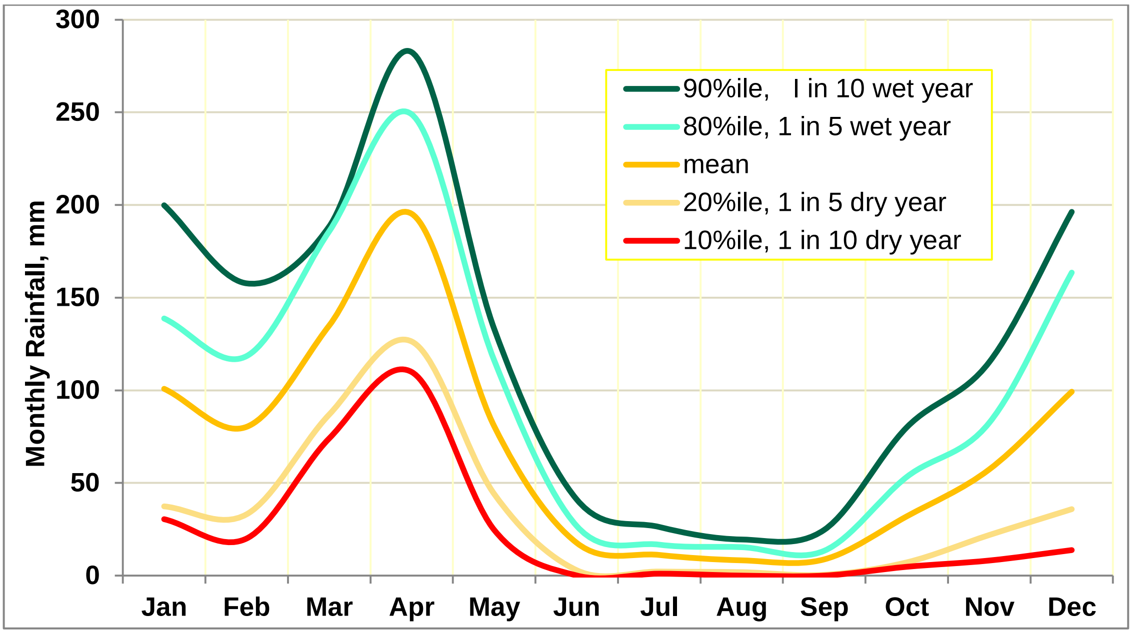


Table 17: Historical Wet and Dry-Year Contrasts in Rainfall for Morogoro, mm

MOROGORO	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
90%ile, I in 10 wet year	200	158	188	282	133	41	26	19	25	80	115	196	**1465**
80%ile, 1 in 5 wet year	139	118	186	249	116	27	17	15	13	53	82	164	**1180**
mean	101	80	135	195	81	18	11	8	9	32	57	99	**826**
20%ile, 1 in 5 dry year	37	33	87	126	44	3	2	2	0	7	22	36	**400**
10%ile, 1 in 10 dry year	30	20	74	110	25	0	1	0	0	5	8	14	**287**

4.3 Risk maps and risk analysis for district

Drought hazard

As per the climate projections, there will be 13% increase in drought probability. As seen in Figure 30, this risk is categorized as “near normal”, and is therefore not considered severe, particularly in the central part of the district, where the EbARR project sites are located (shaded green).

Flood risk

Figure 31 illustrates flood risk, which is classified as high across Sungaji, Hembeti, Mvomero, Kanga and Mtibwa wards, and in the southern tip of Kikeo. However, across the project wards of Melela and Mlali, flood risk is categorized as medium to low.

Erosion risk

The erosion risk across the project sites is between 6 to 10 tons per hectare per year, which is relatively low in comparison to the north of the district, and other EbARR project districts (Figure 32).

Figure 30: Drought risk for Mvomero

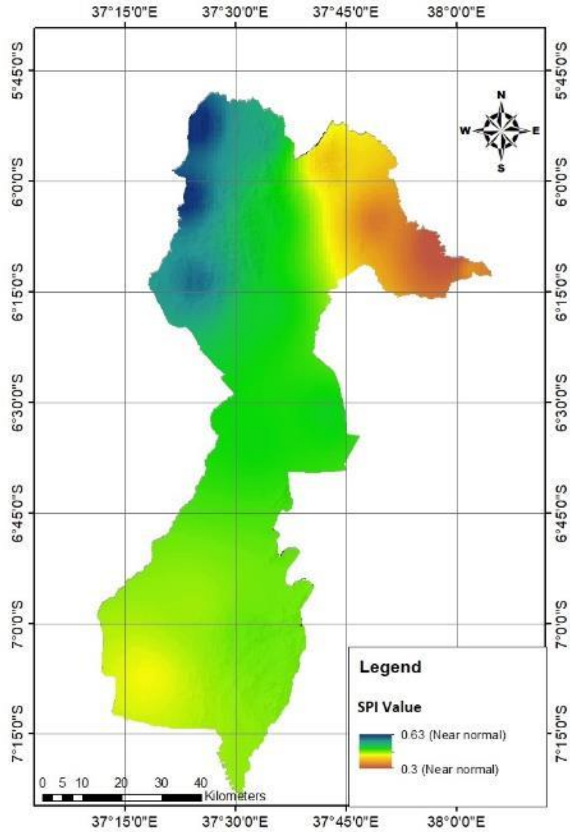


Figure 31: Flood risk in Mvomero

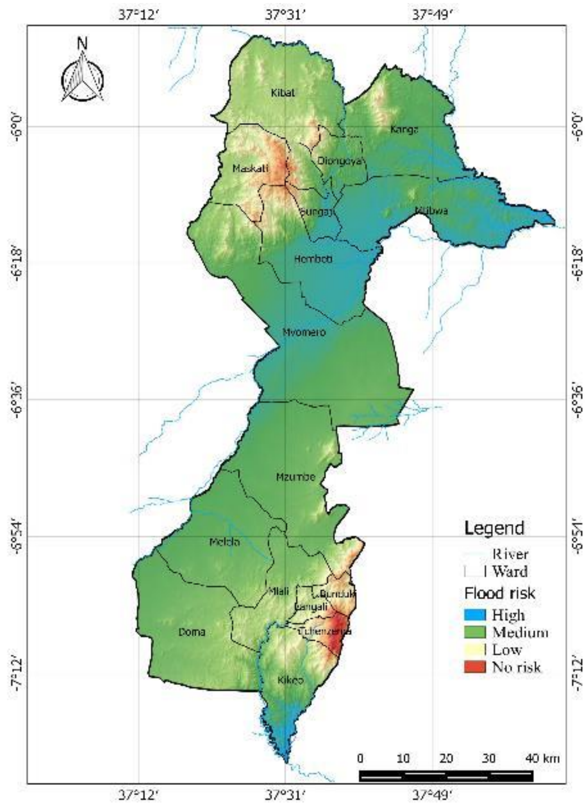
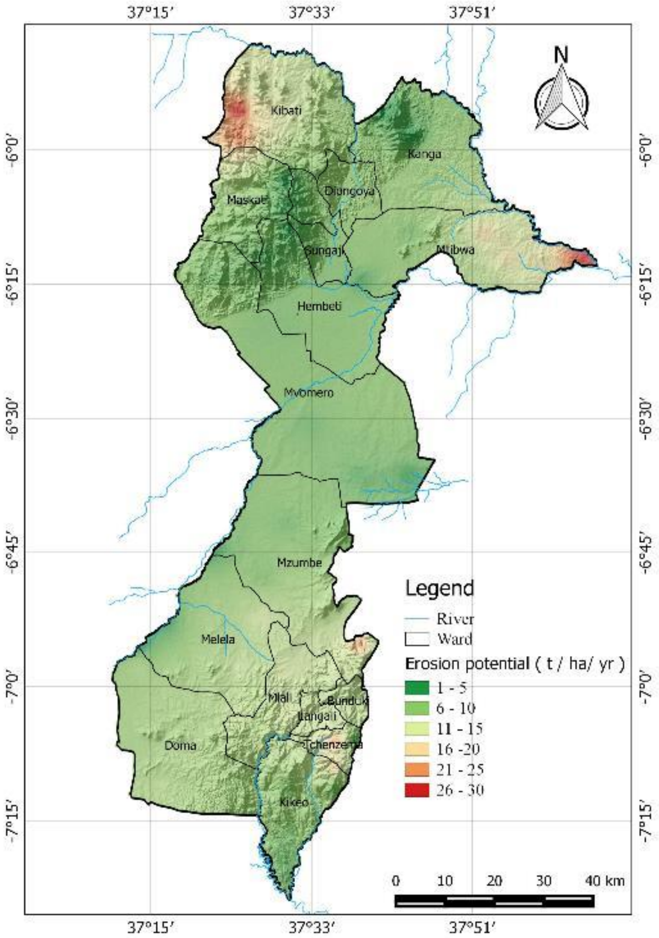


Figure 32: Erosion risk in Mvomero



4.4 Climate change impacts for the watershed in the context of current land use

The implications for climate change to the terrestrial ecosystems, specifically with regard to forests/woodland/bushland, general biodiversity and also water supply, are discussed below in the following sections.

4.4.1 Forestry

As mentioned above, the predominant land-use type in Mvomero is smallholder farming, consisting of crop production and livestock keeping mainly in the form of pastoralism. This land-use activity is causing heavy deforestation and forest degradation.

In 2010, Mvomero had 177,000 ha of tree cover, extending over 27% of its land area. In 2018, it lost 1.08kha of tree cover; this is equivalent to 230,000 t of CO_2 of emissions. This confirms the longer-term developments in the district that are equally alarming: from 2001 to 2018, Mvomero lost 20,200 ha of its tree cover, which is equivalent to a 9.6% decrease in tree cover since 2000, and a total of 4.08 million t of CO_2 emissions.

Groundtruthing done as part of this study revealed that most of the area deforested in Mvomero district (94 %) was converted into cropland for food crops. Groundtruthing done for the same study found a diversity of crops (13 crop types) planted on deforested areas, with bananas, cassava and maize being the most frequently planted crops. An earlier study also found these crops to be among the most planted in the area. Some crops like cardamom and cacao planted in Mvomero are shade tolerant (they need a proportion of forest cover to cultivate), whereas crops such as maize, beans, and others are shade-intolerant (i.e. they need 100% forest cover removal) (Mwampamba and Schwartz, 2011).

Small-scale crop farming could even be the main driver of deforestation in the iconic montane forest landscapes of Mvomero District. This is not surprising because agriculture is known to drive 83% of deforestation across the tropics.

Activities such as firewood extraction, charcoal production and timber harvesting might also have contributed to forest degradation. These activities are frequent drivers behind forest degradation in many African forest landscapes and known to be common in Mvomero District, too.

Climate change also has a huge impact on the remaining forests in Mvomero, confirming trends from other regions in Tanzania. It has been observed in Mvomero in recent years that some species are more vulnerable to climate change than others, with those species being particularly affected that:

- have a limited geographical range;
- are drought/heat intolerant;
- lie at boundaries of compatible climate regions at heat/drought tolerant limits;
- have low germination rates;
- have a low survival rate of seedlings; and
- have a limited seed dispersal/migration capabilities.

4.4.2 Rangeland

Range and shrublands in Mvomero are used by pastoralists for grazing purposes and as a source of medicinal plants. Rangelands are also impacted by other ongoing economic activities in the area, such as farming, mining and forestry.

Quantitative data, or even detailed qualitative information/studies on the quality and extent of rangelands in Mvomero district are lacking. The official district profile lists the area suitable for livestock as 266,400 ha; about 32% of total land area, with livestock grazing concentrated in the miombo woodland, and grasslands in the highland and mountain zones. However, the quality of the range resources available on this land is not described, nor is it clear what land use classification these fall under. It was found however that rangelands in Mvomero are perceived as quite attractive to pastoralists, simply because they are in better shape than those in neighboring regions. Therefore the district sees a lot of livestock in-flows from other areas, particularly during dry season. Similar to other regions however, LGAs in Mvomero categorize the majority of the area of grass, shrub and rangelands in the district as unproductive or unusable during dry season; this signals a massive pressure on depleting resources during dry periods.

Nomadic pastoralism is a significant threat to rangelands as it is difficult to engage or incentivize them to practice rangeland protection, or implement pasture establishment/weed control. Agricultural expansion, fires (climate change linked as well as human induced) and diseases brought in by wild animals further weaken their resilience.

Although land use plans exist for some villages in the target region, rangelands are not addressed in particular. Therefore, besides overarching national level legislations, there is no local level rangeland management plan to guide use and regeneration of these lands in Mvomero.

Climate projections show that climate change will have relatively minor impacts upon rainfall variation in this region. However, of the five EbARR regions, Morogoro is expected to have the second highest probability of drought starting 2040. The major climate change hazard for rangelands identified by stakeholders (both during the workshop and in expert interviews/questionnaires) matched this projection; i.e. that in the context of water scarcity, tied to increasing temperatures, instances of long dry spells and droughts have increased. The most commonly identified impact of this trend is a decrease in overall productive pasture area and quality of these pastures. Communities and livestock dependent on these range and shrublands for livelihood and survival are vulnerable to the shortage of water, particularly during dry season (seasonal impacts). In addition, as a result of longer drought periods in the past decade, charco dams, and seasonal and permanent water sources have become unreliable.

Rangelands are also vulnerable to the increasing occurrence of pests and diseases, which have been observed to become more resistant to higher temperatures, drought, and pastoralist intervention. New invasive, toxic species (Karanga gugu and Karoti gugu) have also been noted, which not only compete with native and other range species beneficial to livestock, causing these to decline in area, but also cause livestock illness or death. Other weeds identified include Solanum, Mexican poppy, Tephrosia, Indigogera, Sida, Datura stramoniu, and Devil’s horsewhip. Finally, rangelands were described as vulnerable to increasing temperatures, which is contributing to a decline in soil fertility.

After drought, stakeholders also identified flooding as a major threat. It is responsible for soil erosion and a suppression of native species in some areas in the district.

Besides ecological impacts, participants also identified social impacts of climate change, including land and resource conflicts between pastoralists, as well as farmer-pastoralist conflicts. This is the case when livestock are led into neighboring farms for sustenance, when rangelands are not providing sufficient feed, or even neighboring wards or districts. Family and social life are also strongly affected, as women face the burden of child rearing and supporting with livestock survival

4.4.3 Biodiversity

Mvomero forest cover is 196,165 ha, of which is 61,000 ha is government owned, village forest reserve is 97,000 ha and unreserved is about 36,000 ha. Mvomero is home to various types of vegetation that provide various ecosystem services. However, biodiversity is threatened by illegal activities, large presence of livestock with no proper allocation of grazing land, over exploitation of tree species due to poor law-enforcement and ever expanding demand from human and growing population.

Human activities and construction of houses near Uluguru Mountains has led to vegetation clearing, leaving the land exposed to soil erosion.

90% of the people in Mvomero district use wood fuel (fuel wood and *charco*al) for household domestic purposes. Most of the wood extraction is done unsustainably, leading to the disappearance of natural vegetation, forest degradation and deforestation.

With regard to identifying vulnerabilities in the face of climate change, due to the present rainfall pattern (unequal distribution) and the extent of deforestation and agricultural development, the lowlands are affected by floods during rainy seasons. Communities also practice burning vegetation. Bare soils result in a deterioration of normal soil micro-organisms, essential for soil fertility and healthy crop/vegetation growth, because of more extreme diurnal variations in soil temperature without a protective vegetative cover.

As a result, there is a reduced capacity of ecosystems to offer their usual quality of services in a reliable fashion. Stakeholder and community consultations also established the decrease in available water in the corridors of Mikumi, and as a result, elephants and other animals wander out of national parks or protected areas and encroach into villages, leading to human-wildlife conflict. Conflicts between farmers and pastoralists are also on the rise, in competition over grazing/farming rights and water sources (swamps, dams and rivers). These rivers are in fact said to be changing from permanent to seasonal (e.g. Melela and Kalolo).

Figure 33: Stream north of Morogoro that has transformed from permanent to seasonal

Socio-economic impacts further include farmers having to supplement incomes with charcoal making. Farmers may also encroach into new territory such as swamp and catchment area, for improved growing conditions. Finally, the incidence of new pests and diseases such as Viwavi jeshi vamizi is recorded to be increasing, and with no biological predators to control their spread, there has been a notable amount of crop destruction within the villages.

4.4.4 Water supply

Mvomero is centrally located in the Wami-Ruvu River Basin (see Basin map). The Ruvu River system drains a small area of the district in the south. The Kinyasunwe River, a major tributary of the Wami River, flows from the west of the basin though the cental Mvomero District, a flood prone area, joining the Wamu River, which flows along the northern boundary of the district. The Melela river system drains part of the southern highlands, into the Mkata river flowing north eventually into the Wamu River.

Water supply comes from the rivers, most of which have flowed throughout the year, dams, both deep and shallow wells, springs, water from the tap, and unprotected dug wells. Agriculture is largely dependent on rainfall, and some irrigation from rivers.

This summary of the current situation and challenges with water availability and supply comes from discussions with stakeholders in visits to Melela Village, the stakeholder workshop, the completed questionnaire from the District Technician (RUWSA), published information as referenced, and additional information supplied by the DT as requested by the VIA team.

With regard to identifying vulnerabilities, it is important to note that due to the present rainfall pattern, and the extent of deforestation and agricultural development, the lowlands are affected by floods, notably along the Kinyasungwe river floodplain, during rainy seasons. In addition, deforestation, agricultural and urban development has increased, with some landslides and erosion occurring during the rainy season. As pointed out in the Modelling report by Stanger (2019), for this project, the runoff is not directly proportional to the rainfall, so an increase of only 10% in extreme rain can, and almost certainly will, result in a much higher proportion of runoff, resulting in greatly enhanced quickflow (flash flooding). In addition, the erosive power of quickflow is approximately proportional to the fourth power of the runoff velocity, so a small increase in extreme rainfall will have a disproportionate impact upon hill-slope, soil and embankment erosion.

River banks are also eroded due to development, agriculture and a loss of vegetation, increased erosive velocities, stock access and trampling, and sedimentation in channels reducing hydraulic capacity resulting in over bank flows. Development should not occur within 60 m of water bodies. This is against the water sources management policy of 2009, which aimed to develop a comprehensive framework for sustainable development and management of the Nation's water resources. The current situation is also demonstrated in the results of the modelling exercise, with the most significant points being that temperatures have increased and the number of very hot days has increased, and that the annual rainfall pattern is for shorter and wetter rain seasons and drier and longer dry seasons. There is already a large inter-annual variation in rainfall and the district has regular years of below-average rainfall and above-average rainfall. For the population dependent on seasonal water availability in storages and even those rivers or tributaries reasonably close which may be ephemeral, in these dry years it can be difficult to find water, particularly of good quality. It is noted in UGovTz (2017), however, that in Mvomero District most of the rivers flow throughout the year. Finally, rainfall is becoming less reliable with more intense events, which increase their erosion and flooding potential.

The community has identified changes that have occurred across the district, which they consider to be due to climate change, including the drying of shallow wells during dry periods/droughts, the drying of *charco* dams for livestock watering (for the last two years), the prolonged dry period increasing competition on the use of impounded water, reduced water discharge from spring/river sources that were designed for village water supply schemes, an increase in the distance/time for collecting water for domestic uses (e.g. in Lubungo areas where Lubungo and Munga rivers have dried up due to deforestation), that the area previously had 7 water sources, but two have now dried up, and finally, that river banks are increasingly being destroyed or eroded by livestock, due to the increased animal population in the area.

The current number and type of water supply in rural areas for the population are summarized in Table 17, and for urban areas in Table 19 (UGovTz, 2017).

The majority of the supply sources are from groundwater, and less from rivers, dams and rainwater harvesting. However, it is uncertain at present time what percentage of the population across the 115 villages and 640 hamlets is dependent on the various sources. In 2002, there were a total of 260,525 dependents, of which approximately 53% obtained clean and safe water within a distance not exceeding 400m (see district profile). This percentage has since improved, but dams and rivers still remain for many the main supply.

Table 18: Number and Type of Rural Water supply

Source of water	*Charco*al Dams	Spring	Shallow wells	Rainwater harvest	Bore holes	River water	Piped schemes
Total	13	112	128	61	17	59	108

Sources: Mvomero District Council: 2016

Table 19: Number and Type of Urban Water Supply

Source of water	*Charco*al Dams	Spring	Shallow wells	Rainwater harvest	Bore holes	River water	lake	Dams	Piped schemes
Total	8	4	64	2	5	12	0	1	24

Source: Mvomero District Council: 2016

From the modelling results, it is clear that the longer and drier dry seasons will result in river sources of supply and dams becoming less reliable. Particularly during the periodic below-average years, these sources will dry out. With increasing temperatures (and with a larger population and increased demand), water demand will also increase. While rainfall will increase, it is offset by increases in evapotranspiration, but evaporation from water storages will increase, reducing the available volume for people and stock. Rainfall will occur in fewer more intense events, creating problems for agriculture and potentially increasing erosion. Aquifer recharge may also decrease, affecting groundwater supplies. The drying of shallow wells already observed is an indication that this will happen.

4.4.5 Agriculture

The major farming system in Mvomero is rice-maize based, or agro-pastoralism; the main cash crops are cotton, coffee, *simsim* (sesame), sunflower, sugarcane, banana and vegetables. Food crops are mainly maize, paddy, millet, cassava and pulses. Owing to the diversity in soil types and climates, the area is able to support various other crops. Livestock includes mainly cows, but many also keep goats, sheep and chicken.

Despite the generally high level of soil fertility in this region, some subsistence agricultural activities on the mountains (following vegetation burning and land clearing) is jeopardizing this. Farmers also cut trees during farm preparation, which in turn makes tracts of land barren, and thus susceptible to landslides and soil erosion during rainy season. Agriculture in the lowlands is another cause of flooding, since the river banks are disrupted during cultivation.

Faster evaporation and loss of water means that farming practices will need to change. Maize, generally being an easy and successful crop, is not performing well, sometimes resulting in food shortages in villages. Climatic change has also encouraged the spread of crop pests and diseases. No crops are grown in these areas nowadays without the use of pesticides. In addition to being harmful to the environment, these practices (alternative irrigation methods) also increase production costs. Overall, a decrease in crop production/yield and loss of crop/harvest has been reported. Indigenous seeds and crops are also being replaced by new, improved seeds to adapt to the changes, and thus, indigenous means of seed preservation is on the decline.

4.5 Ongoing adaptation efforts

Water

Water supplies for the community are improving with gradually more obtaining better quality water within 400m. The government has also introduced several ways of conserving and managing water bodies so as to make them safe for sustainable development, including actively discouraging agricultural activities around water bodies (less than 60m), establishing community-driven tree planting initiatives around water bodies (e.g. in areas around Mgeta River in Mgeta ward and Bunduki ward), and finally, trying to raise awareness on the health/disease risks of using the same water sources (dams and rivers) for both humans and livestock.

Forestry

Beekeeping is an alternative income activity and a versatile EbA measure; it is practiced in pockets in this district, particularly in Magali village.

Also, afforestation with trees such as cashew nuts and teak is ongoing.

- Cashew was done in the past with a group of people producing seedling and distributing to farmers and get paid by the Cashewnut Board of Tanzania
- Teak grows well here and has economic value

Biodiversity

There are several environmental, climate change and conservation related programs within the district and wider region. Morogoro is regarded as the 'national basket' because of its variability in ecological zones and suitability for various crops. What is required however is more effort towards streamlining various fragmented programs to maximize their impact.

Based on expert interviews and stakeholder consultations, it was found that there is interest in the following initiatives, which are likely to also be successful in the regional context. However, information on the level of progress of these initiatives is not available due to a lack of communication between LGAs and individual initiatives, as well as a lack of project progress documents. It is recommended that during EbARR project implementation, the team get in touch with these initiatives directly.

- Tree plantations along river banks (Mgeta river in Mgeta ward and Bunduki ward)
- Creation of buffer zones for elephant to pass; beekeeping and chilies to keep wildlife away from crops
- The TFCG project on sustainable charcoal should be covering Melela and Lubungo wards
- Promotion of and awareness on improved cooking stoves to be scaled up
- Sustainable land management through proper land use plans
- Protection of RUVU/WAMI basin in Mgeta and Mlali ward
- Using ash as a traditional method to reduce pests

Rangeland

Adaptive capacity of rangelands is lacking in the district, although the presence of regional, permanent rivers (Melela and Mkata) provides a good 'fall back'. The capacity of communities to perform weeding and management activities on range, bush and shrublands is lacking, as this is a highly labor intensive activity. Generally speaking, each ward has one livestock extension officer, who provides training to individual farmers on pasture establishment and management (for example, weeding is currently being practiced on 5000 ha of rangeland). Extension officers are restricted in their ability to reach villages due to inadequate funding for transport. Seeds are procured through the Ministry of Livestock and funded through the Mmovero district council.

Some pastoralists have knowledge on bush clearing, planting of pasture seeds and growing of corn as a feed alternative to decrease pressure on rangelands, as well as awareness regarding the impacts of bush encroachment. Rotational grazing, community-led bush clearing and pasture establishment supported by NGOs was also reported in scattered areas. However, in the absence of adequate planning and enforcement, land ownership confusion, issues erecting fences/use of paddocks, and problems with land demarcation, such knowledge is not widely put to use.

An IFAD funded project, *Potential Clusters for Joint Land Use Planning in Mvomero District*, began in 2018, and amongst others, encompasses the three EbARR project wards – Melela, Lubungo and Magali. While awareness about this project was lacking among stakeholders consulted, it is likely that as its implementation progresses, it will increase adaptive capacity of both LGAs and communities to build resilience to climate change and improve rangeland productivity through proper planning.

Other ongoing rangeland interventions in the district, which provide opportunities for the EbARR project to coordinate with include: (i) range management efforts at Wami-Sokoine in Dakawa ward (2500 ha under pastoral ownership) and (ii) establishment of land use plans taking into account rangelands in 85 villages within the district.

Besides the EbA interventions proposed, stakeholders identified the following interventions important for rangeland rehabilitation in the region: (i) introduction of improved breeds and reduction of livestock numbers by providing business models for alternative livelihoods; (ii) use of paddocks, (iii) development and enforcement of land use management plans, and (iv) conducting research on strains of efficient pesticides, insecticides etc.

Agriculture

Farmers' capacity to adapt in this region is judged to be relatively high, as it benefits greatly from government and international project funds.

However, stakeholders identified the following capacity development needs:

- General training e.g. Kilimo, IGAs, eco-management techniques (awareness and education as well)
- Facilitation or mediation of conflicts e.g. *vikundi vilivyopo*
- Beekeeping
- Improved stoves, VSLA/VICOBA
- Use of short rotation seeds e.g. cassava, to plant in the lowlands where is not too dry
- Contour planting with potatoes
- Use of drought-resistant crops (finger millet) and sunflower as an alternative crop
- Processing and marketing (value addition)
- Agroforestry/mixed cropping

Ongoing EbARR relevant programmes and projects in Mvomero district

The following relevant programmes should be taken into account by the EbARR project, either for lessons learned or as potential opportunities for convergence of activities.

- JICA (Smallholder irrigation program; 12 schemes planned over 2000-8000ha coverage)

- YEKOM (Water basin work).
- TFCG/SDC (forestry: sustainable *charco*al and CSA). This could be partners in forest conservation and sustainable charcoal production as they have the experience and have operated in the area.
- Govt. of Tanzania and World Bank (Provision of support to PADEP, TASAF and SEPS agricultural projects)
- PELAM Tanzania (Land use plans in Mela, Melela, Magali and Mlandizi wards).
- Sustainable Agriculture Tanzania (Pasture establishment, improved cattle breeding; Farmers & Pastoralists Collaboration (FPC), CSA Consultation). This NGO is conducting training and advising on sustainable agriculture and CSA techniques.
- National Artificial Insemination Center (NAIC - Livestock breeding improvement)
- UMADEP (Promotes Uluguru Mountain soil conservation)
- WARIDI USAID Project (water management and well digging for villages)
- World Vision (promotes community-initiated projects in water, education, health, and agriculture in the entire district).
- SURUDE (Foundation of Sustainable Rural Development; supports heifer production in trust loans)
- MOECO (Morogoro Environmental Conservation Organization; trains and promotes soil conservation in Mlali and Mvomero divisions)
- MVIWATA (supports farmers in agriculture and business and agriculture input supplies).
- ARI and other Farmer Training Centres (Cholima Agro –Scientific Research Centre)

Most of these organizations could be contacted to support the implementation of work in the associated villages as they work at the local community level promote development.

4.6 Interventions

Table 20 summarizes the ecosystem level issues and impacts facing the community, as identified in the multi-stakeholder workshop held in November, as well as suggested or desired interventions. Although most issues are linked directly to climate change, some are only indirectly connected (e.g. exacerbated by climate change).

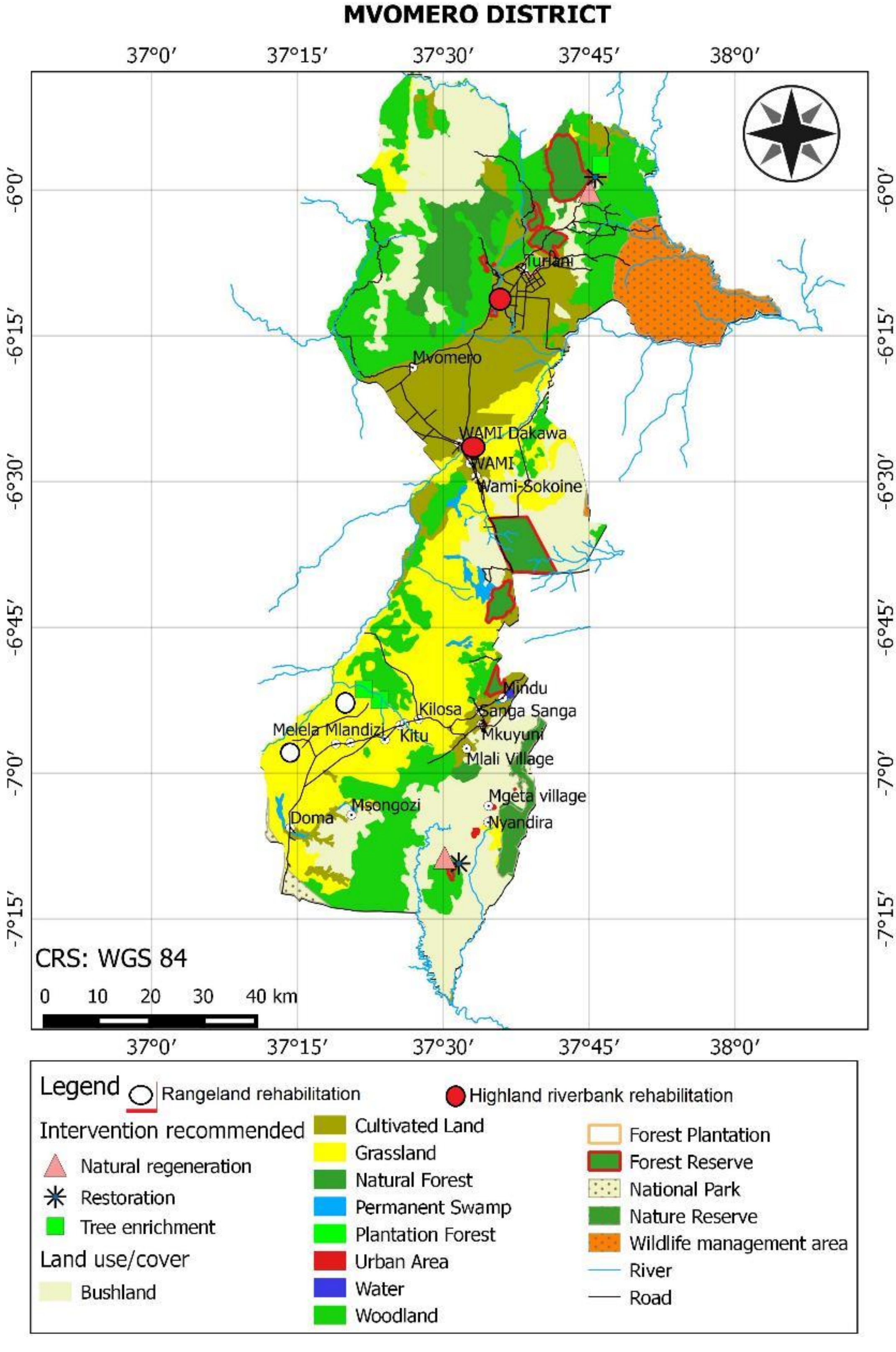
Table 20: Issues and interventions identified in multi-stakeholder workshop in Mvomero

Issue		Intervention
Major issues identified	**Impacts to community**	
▪ Longer drought periods ▪ Increased incidence of flood events ▪ Reduced natural regeneration of forests ▪ Reduced water availability (esp. in Mikumi corridors), affecting wildlife due to less rainfall and transformation of permanent rivers into seasonal (esp. Kafumu, Melela and Kalolo – reduced water discharge from springs); drying up of shallow wells and charco dams ▪ Destruction of river banks due to livestock facing water shortage and due to heavier rains (erosion) ▪ Increased incidence of pest and disease (Viwavi jeshi vamizi) and toxic weeds	▪ Conflicts between wildlife and communities, and between farmers and pastoralist (over reduced water, decreasing grazing area etc.) ▪ Crop destruction/lowered productivity due to insufficient rains, pests and reduced soil fertility = increased costs of production ▪ Invasive species in grazing area reduces feed for livestock; reduced livestock productivity due to lack of pasture and water ▪ Increase in illegal activities (e.g. more cutting, pastoralists and farmers pushed into new un-degraded lands and forest areas) ▪ Shifting livelihoods (from cropping and livestock to charcoal production, which in turn causes more deforestation) ▪ Additional burden on women (water access and more farm work)	▪ Develop land use plans ▪ Afforestation with valuable species (esp. cashew and teak), and along river banks ▪ Sustainable charcoal production ▪ Improved cooking stoves & alternative energy sources ▪ Creation of buffer zones ("crossings") for wildlife ▪ Pasture establishment or use of paddocks ▪ Enforcement of land management by-laws ▪ Reduce number of livestock using improved breeds ▪ Awareness raising schemes on conservation ▪ IGAs (beekeeping, vegetable gardening) ▪ Water provision (bore holes, drill wells and charco dams) ▪ Rain water harvesting training

Based on expert observations and inputs of workshop attendants, the study recommends (see Figure 34):

1. Forestry related measures
    a. tree enrichment with valuable species in northeast and southwest Mvomero
    b. natural regeneration in northeast and southeast Mvomero, where human activities are encroaching into established woody areas
    c. reforestation in degraded lands in northeast and southeast Mvomero in deforested patches
2. Rangeland rehabilitation around the project villages
    a. Demarcation of managed areas near water sources
    b. Pasture establishment
    c. Pest and weed control
3. Riverbank restoration in highland areas (marked with red dots)
    a. Tree planting for soil stabilization and to reduce run-off
    b. Engineering works to stabilize water course

Figure 34: Recommended interventions for Mvomero district



5 SIMANJIRO, MANYARA

5.1 Description of study district

Simanjiro is one of the six districts of Manyara region. It is bordered to the north by Arusha and Kilimanjaro regions, to the south-east by Tanga region, to the south by Kiteto district, and to the south-west by Dodoma region. No land use plans were reported in the potential project villages visited in Orkesumet ward.

Climate

The district lies at an altitude between 560m and 2,123m above sea level. It has a bimodal rainfall pattern with a short rainy season from November to December, and a long rain season from February to May. Most households plant during the long season, with each planting an average of 1.3 ha. Prior to climate change, the district was described as having semi-arid climate with an annual rainfall ranging from between 650 and 700mm. The wettest months are March and April while the driest are July and August (Pittiglio et al., 2012). Temperatures range between 13 and 30°C with May and July being the coldest months and hot months lasting between August and February (Homewood et al. 2009).

Population and area

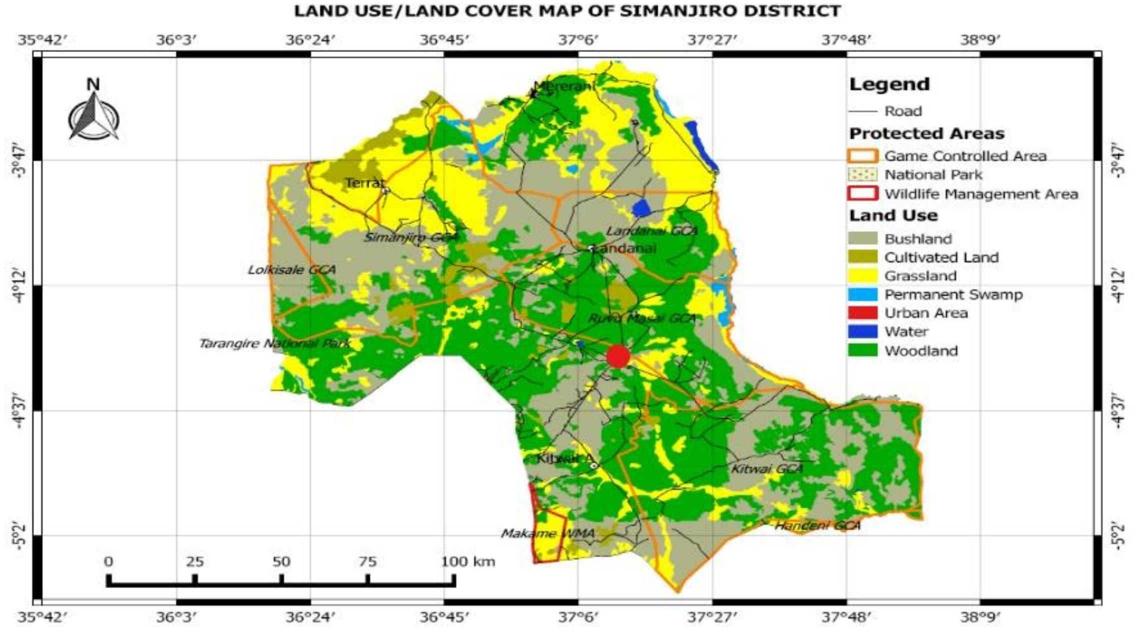
The district has a population of 178,693 according to the national census of 2012.The population has poor literacy with the majority having only a primary level of education. Average household size is 7-9 people. The recent main source of food and income is crop production and livestock rearing. The population engaged in agriculture in Manyara was 97.7%, according to the national sample census of agriculture, although the actual number of crop growing households is smaller (3%) compared to other districts, with almost half the population living off-farm incomes. The district is 90% Maasai, with other tribes being the Chaggas, Arusha and Meru.

Land use and land cover

Current land-use is shown in Figure 35, and land-use changes from 1996-2016 are summarized in Table 21. The main changes has been the large scale loss of woodlands (106,633 Ha) and bushland (85,919 Ha), which together are approximately 9.55% of the district. This has been replaced by cultivated and scattered cropland of approximately 9% of the district area. Settlements have also increased from 209 Ha in 1996 to 3524 Ha in 2016. Forest has increased in area by 1301 Ha. This is likely due to tree planting activities in Simanjiro by MWEDO, which is conducting large scale tree planting using species such as *Sinna siamea* or other fast-growing agroforestry tree species.

In the past, the district contained more wildlife and livestock than humans, but with human population growth, immigration, farming and conservation on the rise, this trend has shifted. Grazing land is swiftly shrinking, make it hard for the area to continue sustaining large numbers of livestock.

Figure 35: Land use and land cover in Simanjiro, 2019



Note: Orkesumet marked in red

Table 21: Land use and land cover change, 1996-2016

Landcover Types	1996		2016		Relative Change 1996-2016	
	Area (Ha)	Area %	Area (Ha)	Area %	Area (Ha)	Area %
Forest	1411.00	0.07	2712.00	0.13	1301	0.0645
Woodland	602845.00	29.90	496212.00	24.61	-106633	-5.2880
Bushland	541285.00	26.84	455366.00	22.58	-85919	-4.2608
Grassland	278143.00	13.79	283223.00	14.05	5080	0.2519
Cultivated Land	77546.00	3.85	238322.00	11.82	160776	7.9730
Scattered Cropland	388278.00	19.26	408621.00	20.26	20343	1.0088
Innundated Land	105963.00	5.25	107917.00	5.35	1954	0.0969
Permanent swamp	15145.00	0.75	14993.00	0.74	-152	-0.0075
Settlement	209.00	0.01	3524.00	0.17	3315	0.1644
Water	5678.00	0.28	5613.00	0.28	-65	-0.0032
Total Area	**2016503.00**		**2016503.00**			

Livestock keeping is the dominant economic activity of the Maasai, who have recently taken up cultivation as a strategy to cope with decrease pasture land and quality. An increasingly important segment of the cultivating population is being formed by small-scale agriculturalists that are moving into drier zones, as space in wetter agricultural areas runs out. In 2002-2003, after the creation of the new Manyara Region, non-pastoral communities progressively moved into Simanjiro, an area that had been inhabited primarily by Maasai pastoralists for hundreds of years. Typically, agriculturalists sub-lease plots from Maasai, who do not have the necessary skills, or know-how to cultivate large portions of their land. These outsiders are also often hired by the Maasai to cultivate in key areas in an attempt to secure it against conservation, other protected area expansion, or other external land acquisition threats.

The Maasai peoples' livelihood strategies were disturbed during the *villagization* program in the 1970s, and in some cases have resisted government conservation expansion. Structural adjustment in 1985 and land use tenure arrangements saw some land alienated for commercial farming, conservation and mining (Homewood et al. 2009).

5.2 Climate change projections for district

5.2.1 Temperature

Annual average temperatures have been increasing, a trend which will continue to end of the century. Using data from the Arusha meteorological station, temperature projections (for RCPs 4.5, 6.0, and 8.5 for 20 year time intervals) are summarized in Table 22 and shown in Figure 36. In addition to the increasing annual average temperatures, there is also an evident trend of increasing numbers of days per year > 33°C, as shown in Figure 38. Projected temperatures on a mean monthly basis are shown in Figure 37, for 2050 and 2090, and for RCPs 4.5, 6.0 and the worst case 8.5. The most likely increase of about 1.7-2.1°C, relative to recent historical temperatures, is about average for a tropical to the sub-tropical environment.

Figure 36: 20-year time-slice temperature projections for Arusha

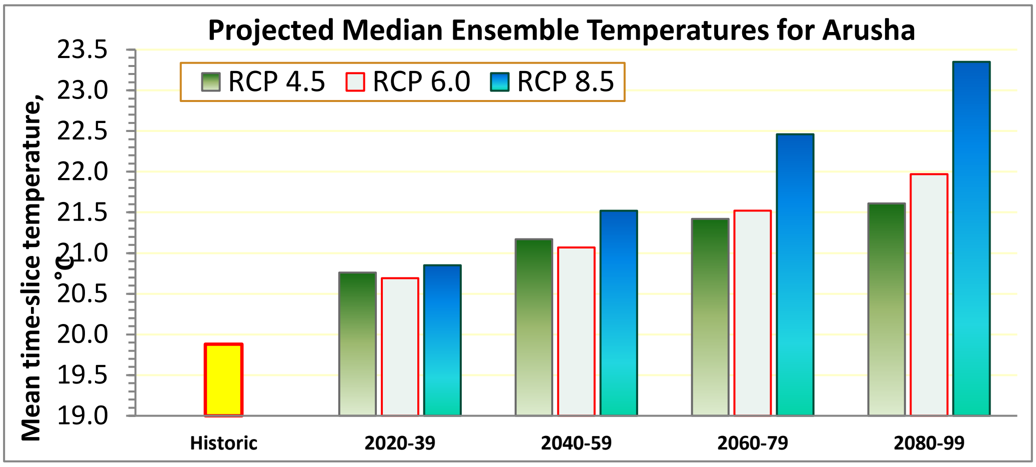


Figure 37: Seasonal Mean Temperatures at Arusha: Historical vs. Projected

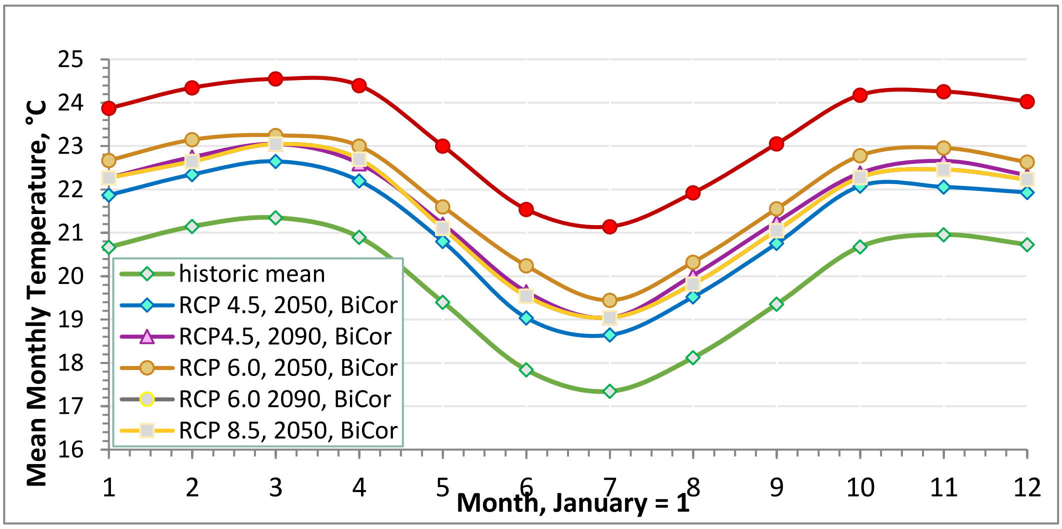


Table 22: Median Ensemble Mean Annual Temperature Change Projections, °C

Station	Historical mean	RCP	2020-39	2040-59	2060-79	2080-99
Arusha	19.9°C N=54	4.5	20.8	21.2	21.4	21.6
		6.0	20.7	21.1	21.5	22.0
		8.5	20.8	21.5	22.5	23.3

(Figures from the modelling report, rounded off)

Figure 38 illustrates the historically increased frequency of hot days in Arusha. Currently, the available data do not justify anything more than a linear approximation. Nighttime temperatures will also increase, as shown in Figure 39. In common with most regions, the increase in night-time minima is roughly three times the rate of increase in day-time maxima.

Figure 38: Increasing frequency of hot days in Arusha

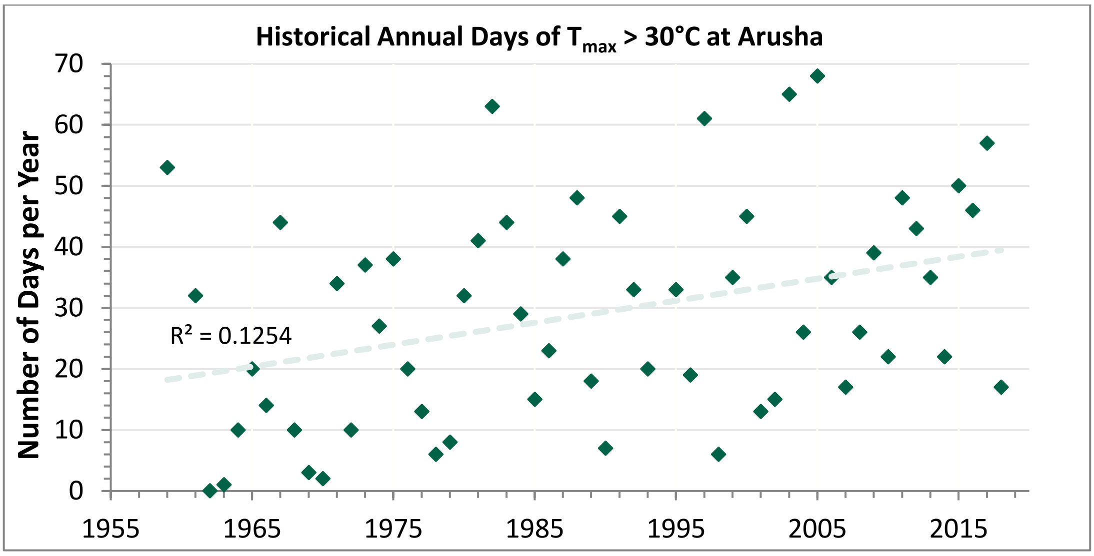
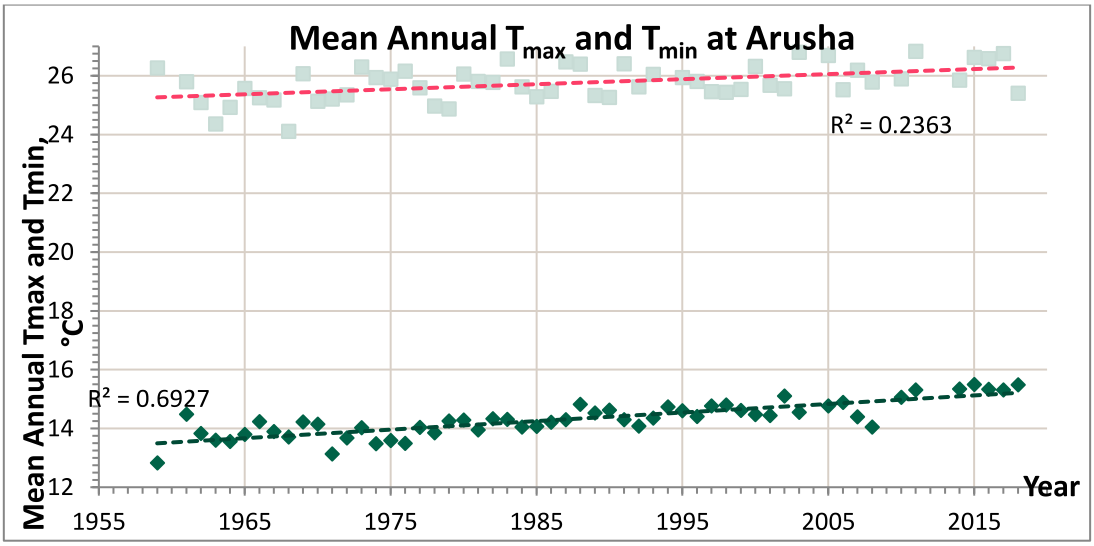


Figure 39: Historical Drifts in Night-time Minima and Day-time Maxima



5.2.2 Rainfall and evapotranspiration

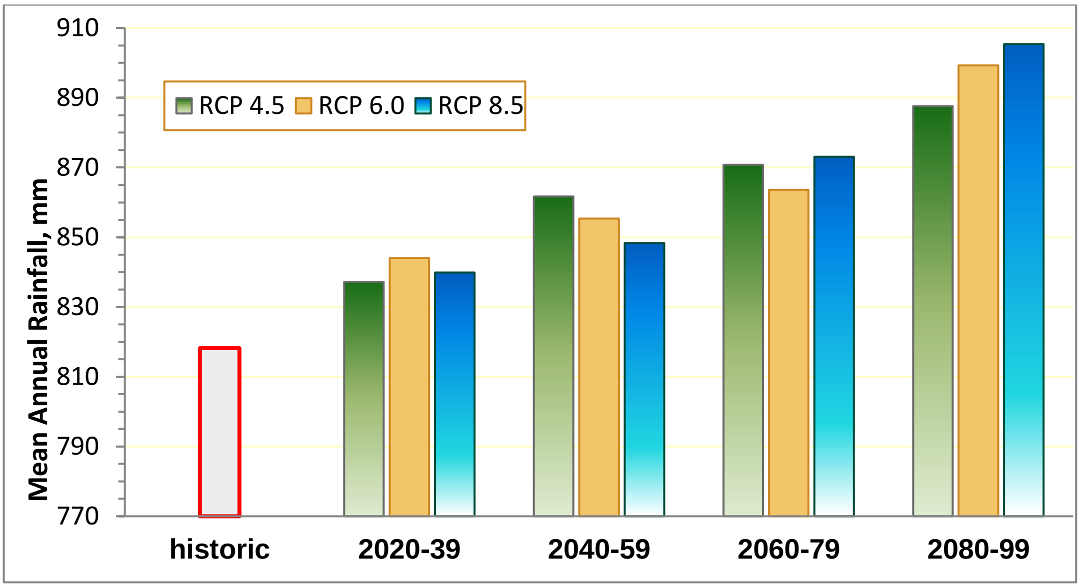
Modelling indicates that there will be an increase in annual mean rainfall, by approximately 8.5-10.5% for the RCP 4.5, 6.0 and 8.5 scenarios, as summarized in Table 23. However, this computed gain in total rainfall is contradicted by both field perceptions of farmers, and by recent instrumental trends. The latter indicates a medium-term *decrease* in rainfall over the decade prior to 2018, which is most probably an artefact of the IOD rather than of long-term climate change. The historical and projected mean annual total rainfalls for the 20 year time intervals until the end of the century are also shown in Figure 40.

Table 23: Median Ensemble Mean Time-slice Rainfall Projections, mm

CMIP-5 data for Arusha (Bias Corrected)

Station	Historical mean, mm	RCP	Incremental Additions, mm			
			2020-39	2040-59	2060-79	2080-99
Arusha	818	4.5	19	44	53	69
		6.0	26	37	45	81
		8.5	22	30	55	87
			Projected Average Total Rainfalls			
		4.5	837	862	871	888
		6.0	844	855	864	899
		8.5	840	848	873	905

Figure 40: Historical and Projected Mean Time-slice Rainfalls at Arusha



Note: The above-projected rainfalls are all bias corrected for Arusha met station.

Other vital points from the modelling are:

- The data for Arusha is for 59 years of record and there is no significant evidence of a change in the onset of the long-rains.
- It is expected that there will be fewer and heavier rainstorms during the rainy season. However, there is as yet no statistically convincing evidence of this trend in the data.

- Evapotranspiration rates will increase from a historical average of 4.0 to 4.2 mm per day for RCP 6.0, which is the most likely scenario. Although this increase greatly reduces the benefit of increased rainfall, there is still likely to be a small increase in effective rainfall.

Rainfall is variable, ranging from drought conditions to floods. Even within these extremes, there are below-average and above-average rainfall years. For Arusha, Figure 41 compares the historical mean rainfall with the 1:5 and 1:10 average return interval (ARI) wet and dry years. This data is also summarized in Table 24. This clearly shows the substantial difference between relatively wet and dry years, with 359 mm for the 1:5 ARI dry year compared to 1227 mm for the 1:5 ARI wet year. The wet year would also have more effective precipitation values.

Figure 41: Historical Annual Rainfall Distribution at Arusha

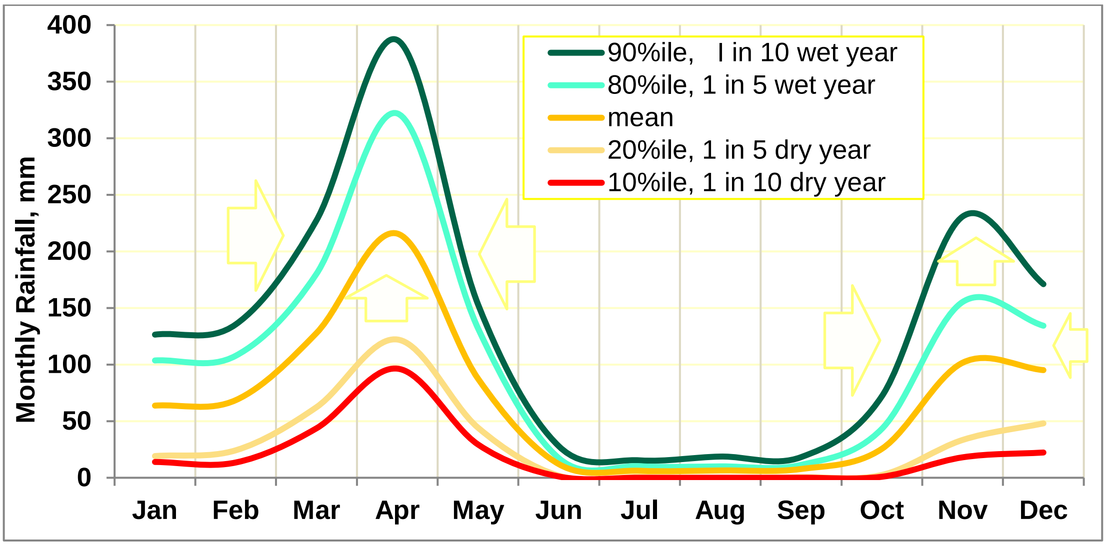
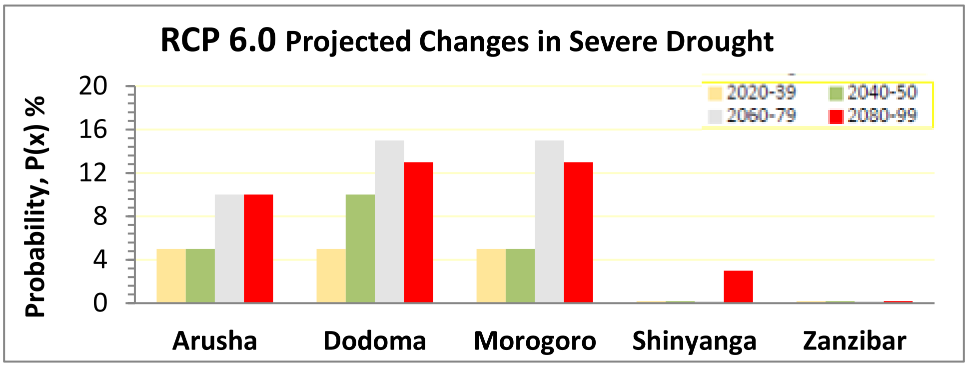


Table 24: Historical Wet and Dry-Year Contrasts in Rainfall at Arusha, mm

ARUSHA	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
90%ile, I in 10 wet year	126	135	227	387	153	28	15	19	18	72	231	171	**1584**
80%ile, 1 in 5 wet year	104	108	180	322	132	17	10	10	11	43	155	134	**1227**
mean	64	69	128	216	88	12	6	6	8	26	102	95	**818**
20%ile, 1 in 5 dry year	19	24	62	122	44	2	1	0	0	2	33	48	**359**
10%ile, 1 in 10 dry year	14	13	44	96	29	1	0	0	0	1	18	22	**239**

With climate change, the wet seasons will become wetter and the dry seasons will be longer, as the trend arrows in the figure above indicate, and drier. Rainfall in the wet seasons will be more irregular, less frequent and more intense. There is an increase in drought probability, which is illustrated for RCP 6.0 in Figure 42, where a small increase of about 3% is indicated for 2080-99. With RCP 8.5, the less likely RCP scenario, this increases to between 5-10% over the next 80 years.

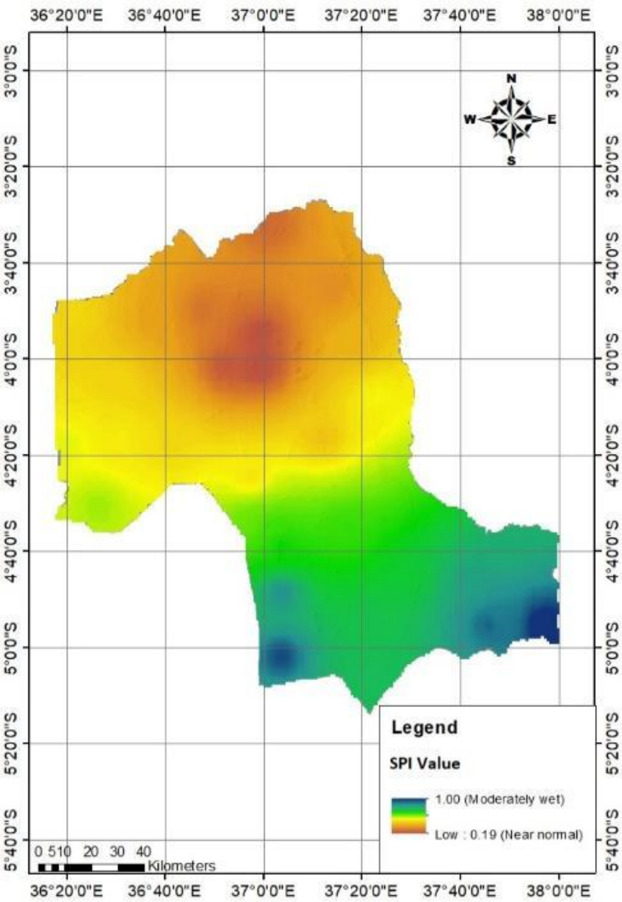
Figure 42: Ensemble Median Estimates of Increasing Drought Probability, by Location



5.3 Risk maps

Drought

Figure 43: Simanjiro District drought hazard map



According to climate projections (Figure 42), there will be 10% increase in drought probability. As seen in Figure 43, this risk is categorized as "near normal" around Orkesumet, and is therefore not considered severe compared to other parts of Tanzania. The south and southeast of the district faces an extremely low probability of drought. Any project interventions targeting water access and drought would, therefore, have their highest impact when implemented in and around the brown areas.

Flood

Figure 44: Flood risk in Simanjiro (Orkesumet marked in yellow)

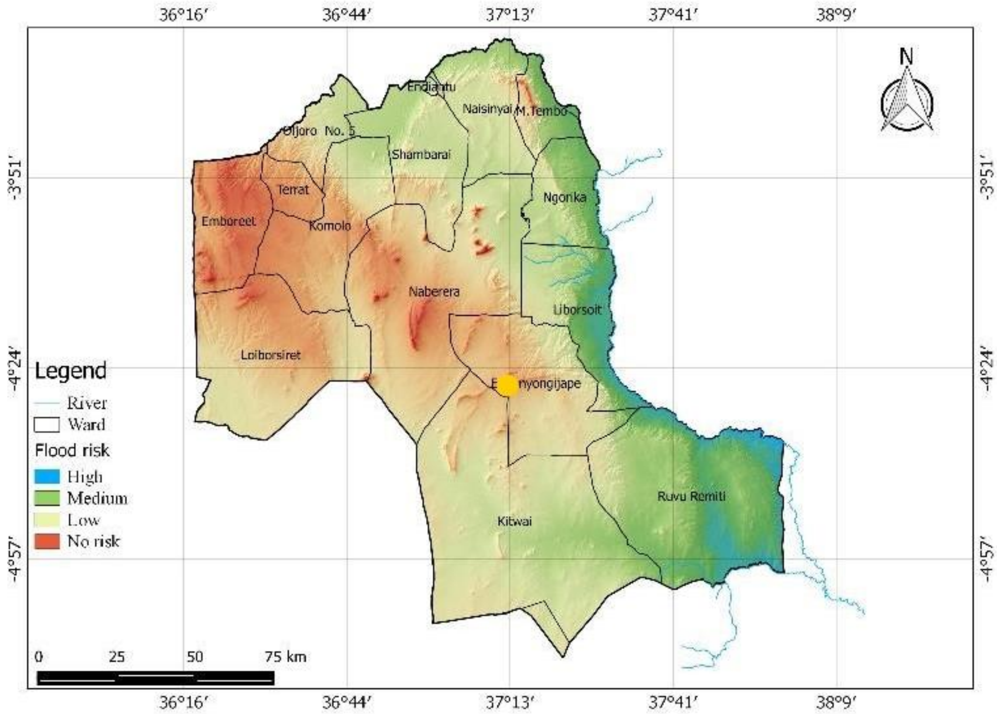
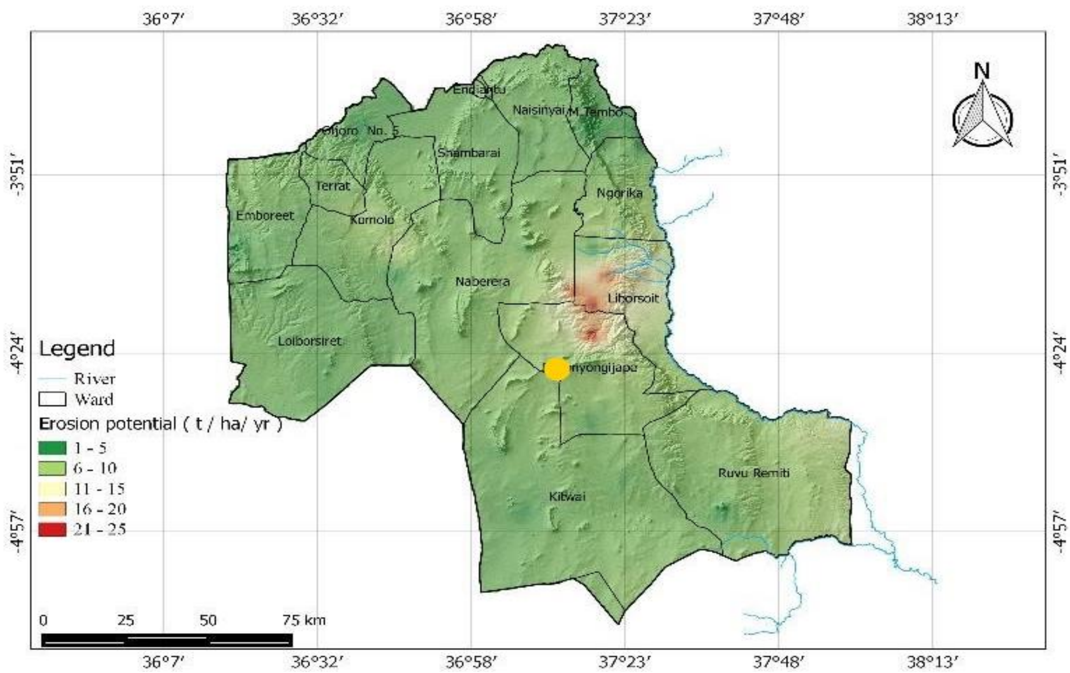


Figure 44 illustrates flood risk, which is classified as high across Liborsoit and Ruvu Remiti wards. Orkesumet (marked in yellow), Emboreet, Terrat, Komolo, Loiborsiret, Naberera and Endonyongijape wards are positioned in the highland areas and thus not prone to risk flooding. The remaining wards are categorized as medium to low risk, but some with small parts facing no risk.

Erosion risk

Figure 45: Erosion risk in Simanjiro



Erosion potential on Simanjiro is highest in the areas shaded in red (16-25 tons per hectare per year) covering some areas in Orkesumet ward (as well as non-EbARR sites such as Liborsoit and Endonyongijape wards; Orkesumet is marked in yellow on the map). These areas are important for planning EbA measures to reduce erosion and erosion linked damages. The rest of the wards in the northern and southern part indicate medium to low erosion potential.

5.4 Climate change impacts for the watershed in the context of current land use

5.4.1 Forests and woodlands

In 2010, Simanjiro had 9.560 ha of tree cover, extending over 0.48% of its land area (Global Forest Watch, 2019). As per the same source, Simanjiro lost 289 ha of tree cover between 2001 and 2018, equivalent to a 7.2% decrease in tree cover since 2000, and 52.1kt of CO_2 emissions.

Overall, a substantial decrease in tree cover has been observed in recent years.

At the level of individual tree species, it can be observed that some tree species are more affected by climate change than others, especially those that already have a limited geographical occurrence and those that already lie at the boundaries of their distribution area. The germination and survival rate of such species is getting lower to the extent that the species eventually disappear from the region. Also, with the disappearance of certain insects and mammals, some species lose the usual distribution channels for their seeds.

5.4.2 Bushland, shrublands and rangelands

The rangelands in Simanjiro represent an ecologically diverse, semi-arid system, characterized by low plant productivity and high precipitation variability, including frequent drought. Rangeland managers in the region (as well as across the country) have rather limited financial and social capital, modest infrastructure, and few options to diversify livelihoods beyond livestock grazing – although many are now turning to cropping and alternative means of gaining incomes. The general trend is also that these communities particularly around Orkusemet ward are isolated from major urban centers and governing institutions.

The study has looked at rangelands at the district level, because of its landscape approach, and the fact that rangelands extend far beyond administrative boundaries. Specific ward level information in also not available in this district. The area of usable or productive rangeland in Simanjiro is 1,011,000 ha. A further 346,000 ha of rangeland is classified as ‘unusable’ due to invasive species, weeds and Tsetse infestations. The Baseline Survey indicated a loss of land cover from between 1996 to 2016 in Simanjiro of about 106,633 ha of woodland and 85,919 ha of bushland, which have been converted to other land use such as agriculture and settlement area.

Within the district, 19 out of 56 villages have land use and management plans, which govern rangeland use as well. Most villages have also demarcated their rangeland areas locally and generally, community enforcement of these by-laws (either formally or informally agreed) is judged to be high.

Rangelands in Simanjiro are mainly used by pastoralists for livestock grazing. A rotational grazing system based on seasonal variations is practiced in many villages. I.e., rangeland may be divided into three categories; (i) land for calves and a small number of cattle near-permanent residential areas; (ii) land reserved for grazing during the rainy season, in areas where there is no water infrastructure in place; and finally (iii) land for grazing during dry periods, situated near water bodies that regenerate during the rainy season. The main water sources for livestock (as well as humans) are boreholes, *charco* dams (as seen in Figure 46, the design is not optimal, and there is not enough vegetation on the boundaries to stabilize the land and water source), and one river.

Figure 46: Charco dam in Orkesumet used by livestock and humans

Besides climatic threats, rangelands are threatened by agricultural expansion, charcoal making, mining activities, wildlife, human-induced fires and a vast number of livestock.

LGAs and workshop participants identified unreliable weather as the greatest issue facing pastoralists and rangelands; this is confirmed by the findings of the projections report (although trends in the report are acknowledged to be statistically weak). As a result of climate change and increasing temperatures, the persistence and expansion of weed-infested areas (specifically, Ipomea and Partheniu, species) as well as natural fires have increased. Some invasive species are poisonous to livestock (carrot weeds), and their expansion is changing pasture types and causing a decrease in pasture quality. Common livestock diseases in the area are foot-mouth, tick-borne diseases (said to kill more cattle than any other) trypanosomiasis, anthrax and black quarter.

Changed precipitation patterns also cause large scale soil erosion in times of heavy rainfall, and in dryer periods, a severe shortage of rain and water result in further deterioration of rangeland quality and resilience. As water infrastructure in the district is poor (manmade dams exist, but are old and do not conserve water well for longer periods), livestock is also impacted.

Maasai livestock is however generally believed to cope well with the current changing weather patterns and climatic variability. The Maasai believe their indigenous species can withstand water and pasture scarcity, as well as diseases.

5.4.3 Biodiversity

Simanjiro falls under the Maasai steppe in the Tarangire ecosystem. The area plays a crucial biodiversity conservation role considering its wildlife habitat value. The Simanjiro plains serve as an important grazing area for wildlife during the rainy season. The district is characterized by two agro-ecological zones, semi-arid midland consists of elevated to flat areas in low altitudes land and bushed Maasai Steppe. The semi-arid midland slowly merges into bushy grassland area covered plain mixed with bush. The Simanjiro plains support commercial farming, rain-fed agriculture, for grazing of livestock, tourism, small-scale medicinal plant extraction and wildlife.

Information on the current situation and challenges was obtained from the baseline survey, field notes from various experts and the field visit in Simanjiro and from stakeholders' workshop meeting all conducted from 17-18 November 2019. Simanjiro is home to a biodiversity hotspot bordering Tarangire National Park ecosystem. However, there are no wildlife management areas, forest plantations and national forest reserves in the district.

Climatic modelling data show that the evapotranspiration rate will increase from its historical average and that annual average temperatures have been increasing and will continue to increase. For Simanjiro, which has experienced devastating droughts in the past, this is a major climate signal. Stakeholder discussions confirmed that they are facing hotter summers, as well as significant changes to rainfall (unreliable onset and cessation, in some cases, reduced amount leading to a decrease in rainy days). These have induced a number of effects to communities' livelihoods and natural resources management, including recurrent drought, extended dry spells, shortened growing season, shifting rainfall seasons, as well as the emergence of human diseases such as malaria. This will affect biodiversity and ecosystem function and reduce its capacity to provide goods and services, and simultaneously increase pressure on natural resources, wildlife and perhaps increase natural resource use conflicts. Temperature increase and change in rainfall pattern as reported above will further impact vegetation cover as well.

5.4.4 Water supply

Siminjiro District is partly in the Lake Eyasi Basin in the west, but mostly in the Pangani River Basin (see Basin map). The Pangani River and tributaries is the only major river and flows along the eastern Boundary. As mentioned earlier, this semi-arid district consists of the elevated flat bushed Maasai Steppe and the bushy grassland and bush covered plains. It is a dry landscape and the main surface water is the Pangani River.

Even without climate change, challenges with water availability and supply comes from discussions with stakeholders in visits to Irkujit Village, Langai Village, and Mkumbi and Jitegemee hamlets in Orkesumet Village (2019), the stakeholder workshop (November 2019), the completed questionnaire from the District Technician (RUWSA), published information as referenced, and additional information supplied by the DT as requested by the study team.

Of the 71 villages in the district, 52 have boreholes. For these 52 villages, there are a total of 71 functional and 18 non-functional boreholes (specific numbers for Orkesumet not available). There are 18 villages that do not have any supply and one village which has a non-functional gravity source (RU). Cropping was found to be largely dependent on rainfall, but there is some irrigation using water from rivers, and tap water using gravity to deliver the water to the crops.

The most common distance from the source of drinking water was between 1 and 2 km, with dams/rivers, protected wells, piped water and uncovered rainwater catchments as the main source of drinking water.

In Irkujit Village, overall, the water sources do not suffice for human and livestock needs. The main issue mentioned is water scarcity for both human and livestock needs, especially during the dry season. There are two *charco* dams. These are rather shallow, and not very large; sometimes they dry up before the subsequent rainy season. There is no water raft or fence surrounding the dams, and cows trample the banks and base, which constitutes a serious health hazard. There is no dug well or borehole, and the village depends on swamps and temporary dams. During periods of water shortage, the nearest viable source can be up to 5 hours one way. The distance to water for humans affects women most, as women labour to fetch water every day with donkeys. A donkey can carry up to 60 litres (possibly sufficient for one household for one day). The biggest dam is used by four villages and usually dries out, when people have to travel to the nearest village to request water for cattle.

In Langai Village, the water reservoir (*charco* dam) is used by six villages of the three wards. Residents take turns to use it (rotation) to conserve water levels during the dry season. Small dug wells exist around and below the dam. Two *charco* dams exist and are recharged by rainfall. One has dried out, while the other remains functional, however, it is not sufficient for year-long supply and additionally has a breached wall. Women generally walk about 6km one way to reach the dam.

Figure 47: Breached wall observed at one charco dam

In Orkesumet village (within Orkesumet ward), many villagers report having received environmental conservation training, following a drought in 2017, which wiped out the harvest. In terms of water sources, Jitegemee and Mkumbi were not included initially in the water pipeline planned in the area, but are now considered. The intention is to provide water supply for domestic use, but some plan to use it for their vegetable gardens. Another source is boreholes. The one near Simanjiro South School had the capacity to produce 7,500 L/hr, until it went dry in 2018. The borehole at Narosoito (Orkesumet ward) had the capacity for >10,000 L/hr, but now produces a maximum of 1,100 L/hr. Of note is that the minimum not only occurs in drought periods but also in the summer (wet) periods.

The current situation, as described above, is clearly apparent in the modelling with regards the inter-annual variability, which would account for the water scarcity. The extent of the dry season is apparent, particularly in below-average years. In the 1:5 ARI dry year, there is only an average of 359 mm of rainfall compared to 1,227 mm in the 1:5 ARI wet year. It is during the below-average rainfall years that water sources are less reliable. In the 1:10 ARI dry year, which is approaching drought conditions, there is only an average of 239 mm of rainfall. Only a portion of this would be effective rainfall (about 70%) because of very low soil moisture levels in dry conditions and there would be much less runoff if any unless rain occurs as a short intense event.

In the consultations and workshop, it was generally perceived that current trends would continue. The wet seasons will be shorter and wetter, and rains will occur in fewer and more intense events. Bank and soil erosion will increase, causing further downstream sedimentation issues.

As pointed out in the Modelling report by Stanger (2019), for this project, the runoff is not directly proportional to the rainfall, so an increase of only 10% in extreme rain can, and almost certainly will, result in a much higher proportion of runoff, resulting in greatly enhanced quickflow (flash flooding). In addition, the erosive power of quickflow is approximately proportional to the fourth power of the runoff velocity, so a small increase in extreme rainfall will have a disproportionate impact upon hill-slope, soil and embankment erosion.

The dry season will be longer and drier, increasing the unreliability of storages such as *charco* dams, and reducing groundwater recharge speeds. The higher temperatures will increase evaporative losses. In below-average rainfall years, a longer dry season will mean long periods with no water at all, unless sought from long distances.

With less water, there will be increased sanitation issues with humans and livestock in closer contact with decreasing water sources. As is already occurring in some places, many boreholes, which are the main water source for the area, will dry out due to decreased groundwater availability, while above-ground resources will be less reliable due to drying out and facing recharge failure. Rates of groundwater recharge will reduce, and distances travelled to fetch water will increase. The increasing number of very hot days will affect health overall.

As much of this activity is done by women, their ability to participate in income generation and other meaningful activities will decrease. Economics activities and other natural resources that rely on the water will be affected on the whole.

5.4.5 Agriculture

Communities reported using farming as a means to cope with the decrease in pasture availability and quality; it is being adopted even by the Maasai who are not traditionally farmers. These farmers use local seeds and no specific farming techniques (e.g. water conservation, soil management etc.) The yields reported is not proportional to farm size; they are much lower than the standard given local context and relatively fertile, loamy soils. Farmers grow a variety of crops including maize, sorghum, sunflower, groundnuts, paddy, onions, finger millets, pigeon peas, cassava and potatoes.

As wet seasons will become wetter and dry seasons will be longer and drier in the future, agriculture will be significantly impacted. The district suffered major drought events in 1986 and 2011. Rainfall in the wet seasons will be more irregular, less frequent and more intense. There is an increase in drought probability. These impacts are vivid through to farmers, the yield has been compromised and drought has been seen to destroy entire crops in the past. This means that it is hard for farmers to plan when to plant or what to plant. Rural families have an average household size of 7-10 people and one *boma* could have up to 50 people, to feed one family requires about 20-30 kilos of maize per week. Usually, they tend to farm using family and extended family thus farm size depends on the effort and capacity to farm. Harvest is generally about 10-12 bags per acre, but communities reported to harvest only around 2-3 bags per acre.

Communities reported an increase intensity and severity of livestock and crop pests and diseases. These affect various primary sectors for food and income for local communities such as agriculture and livestock keeping.

The erratic rainfall and increase temperature and drought periods have mentioned taking a toll in the agriculture sector. The occurrence of new pest and diseases have in some cases destroyed farms. Extension workers are available to advise farmers, but technicians reported that many are unwilling to follow this advice.

5.5 Ongoing adaptation efforts

Water

It is clear that in addition, *charco* dams are needed to adapt to the changing future rainfall patterns and water availability. Villagers themselves identified a location for a potential new *charco* dam and pointed out those that require renovations. While tree planting would help the water cycle in general, water scarcity and prolonged drought has impaired attempted initiatives, hence a little has been done so far.

RUWSA has conducted rainwater harvesting trials in the following seven villages: Naisinyai, Loswaki, Loiborsiret, Gunge, Olbil, Olchoronyori, and Lorkale. The trials involved the following steps:

- Constructing 5 m^3 ferro-cement tanks, supplying and installing 1 3000L plastic tank, all at public institutions.
- Training persons from model villages on how to install the gutter system and tanks.
- Training over five days of a community member on the advantages of rainwater harvesting, type of harvesting and different construction materials.
- There is a forward plan for an additional 20 villages to eventually have boreholes (details not supplied).

Information on the success or progress of these trials were not made available to the VIA team. It is understood that locally, the intention is to upscale these trials if deemed successful. Rainwater harvesting in planned under a separate EbARR budget line. It is up to the MoA to decide on the out-scaling of these activities.

Forest

As a mechanism for climate change adaptation, the indigenous people do not cut down trees but rather use fallen dried woods from trees for firewood.

Beekeeping is practiced in some areas in this district, as an alternative income generation and EbA activity. Some afforestation and reforestation for commercial and conservation purposes is also taking place in some areas but no information was available on their process or results.

Rangelands

In Simanjiro district, it was reported that two EbA practices relevant to pasture and livestock are practiced to some degree by households, namely, crop residue creation and integrated crop-livestock management. Other ongoing interventions include the formation of (joint) village rangeland committees and a district rangeland committee, awareness creation on invasive species and how to control them, tsetse control, education on ecological benefits of reducing livestock numbers, research on invasive weeds, sustainable pasture management, as well as the establishment of pasture demo plots for harvesting seeds for rangeland improvement.

Overall, the district has 26 extension officers, from which only one rangeland specialist is available to support rangelands and livestock across 18 wards. LGAs have communicated a lack of available funds to implement rangeland interventions and limited knowledge on sustainable rangeland management.

Agriculture

The pastoralist of Simanjiro have ways to adapt by reducing livestock numbers or migrate all together to search for pasture and water. Communities have complex social networks that allow the sharing of land and preserve certain area to take livestock during dry conditions. However, their adaptive capacity has been challenged due to an increased demand for land and other land use changes brought by climate and human activities. The pastoralist land for grazing has changed because of change in land use and this has affected livestock mobility which was in the past used as an adaptation mechanism to deal with climatic stresses. The pastoralist in Simanjiro reported to have decrease the cow herds as a coping strategy but also forced to travel far to search for pasture.

While the District Council receives TMA weather predictions, communities reported not receiving these notices, and are thus not able to make weather-informed agricultural decisions. In addition, some farmers mentioned having received training on improved farming techniques from extension officers, but the majority of stakeholders consulted reported that they do not practice them, and stick to traditional means and knowledge. Most of the training are costly to implement and farmers in Simanjiro are not cultivating for business rather subsistence and their main activity is livestock keeping.

In Simanjiro district, five EbA practices were reported to have been in use, which are the following:

- mulching, crop residues, minimum tillage, cover crops, crop rotation and terraces;
- crop diversification/intercropping;
- integrated crop-livestock management; and
- use of drought resistant crop varieties were also reported.

These interventions are relevant for climate change and have adequate capacity to mainstream climate change adaptation in their plans. This should continue to be practiced and scaled up to cover a bigger area and increase adoption rate.

5.6 Interventions

Table 25 summarizes the ecosystem level issues and impacts facing the community. These issues and desired interventions were identified in the multi-stakeholder workshop held in November. Although most issues are linked directly to climate change, some are only indirectly connected (e.g. exacerbated by climate change).

Based on expert observations and inputs of workshop attendants, the study recommends two EbA interventions around Orkesumet ward, the target ward for EbARR in Simanjiro district: (i) tree enrichment in degraded, thinning forest areas to the north west of the ward, and (ii) rangeland rehabilitation in the degraded patches around the ward, including zone demarcation, pasture establishment and pest and weed control (see Figure 48).

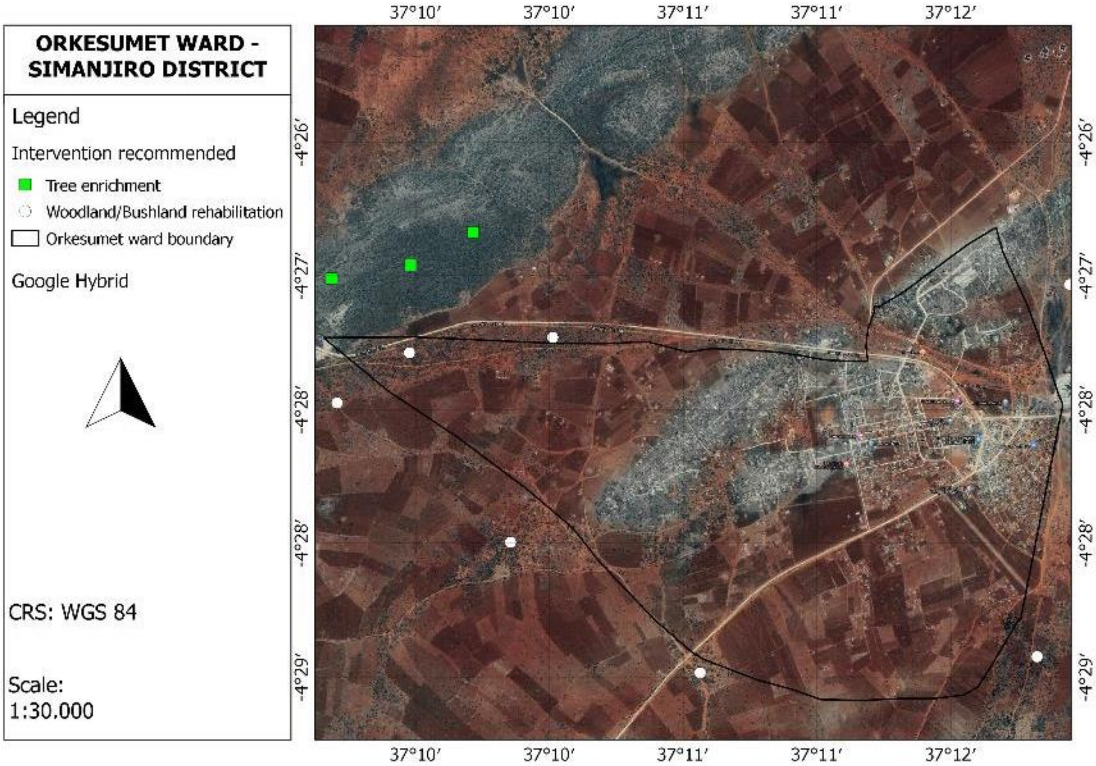
RUSWA and LGAs also suggested that new charco dams be built under the EBARR project, at Langai and Irkujit. As these areas fall outside the original scope of the project plan, maps are not available. We have however secured the following coordinates:

- Langai *Charco* dam (Endonyongijape ward) with E 37.14' 097'' S 04.18' 358'' coordinates
- Irkujit *Charco* dam (Endonyongijape ward) with E 37.11' 781'' S 04.30' 906'' coordinates

Table 25: Issues and interventions identified in multi-stakeholder workshop in Simanjiro

Issue		Intervention
Major issues identified	**Impacts to community**	
▪ Overall environmental degradation, disappearance of natural vegetation and viable pastures due to increased temp, reduced reliability of rain. ▪ Shorter growing seasons in agriculture ▪ Increasing pests and diseases ▪ Increase in extreme events (floods, erosion, fires and drought) ▪ Decrease in soil fertility due to higher temperatures (damage to micro-organisms)	▪ Lack of water leading to over-exploitation of bore holes and ground water, which is not recharging fast enough ▪ Change in agricultural practices (using different crop types and seed varieties, planting on a delayed/shorter schedule) ▪ Increased cost of living and cost of agricultural production ▪ Old dam infrastructure, frequently drying out water sources and poor pasture cause livestock deaths; pastoralist livelihoods impacted ▪ CC reduces area of quality pastures, leading to farmer-pastoralist land conflicts over scarce, fertile, non-degraded lands	▪ Reduce water contamination from livestock ▪ Erosion control on Pangani river banks ▪ Tree planting ▪ Drill borewells for water supply, new charco dams ▪ Combat pest and disease (using baits/dips, education) ▪ Undertake water table study ▪ Develop village land use plans and strict enforcement of by-laws and demarcated zones ▪ Natural woodlands conservation ▪ Planting stabilizing riparian vegetation around charco dams

Figure 48: EbA interventions proposed for Orkesumet, Simanjiro



6 KISHAPU, SHINYANGA

6.1 Description of study district

Kishapu is one of the eight districts in Shinyanga region. Within the district, Kiloleli ward has been selected as the target ward. With respect to the EbARR project, relevant information on climate, population and area, and land use and land cover are given below.

Climate

Prior to climate change occurring the District was described as having a semi-arid dry climate characterized by flat, gently undulating plains (Monela, 2005) with little rainfall and temperature ranging from 22^{o}C to 30^{o}C.

Population and area

Kishapu has a population of 272,990 people (2012 census); 35,500 households which 89.5% are in rural areas. The population growth rate of over 2.9%. The main activity is agriculture (78.5% of the population); with few pastoralists, mining, forestry and agroforestry as well as fishing with 97% of households involved in smallholding agriculture. Kishapu is estimated to have the poorest supplies of improved water sources in the region.

Land use and biodiversity

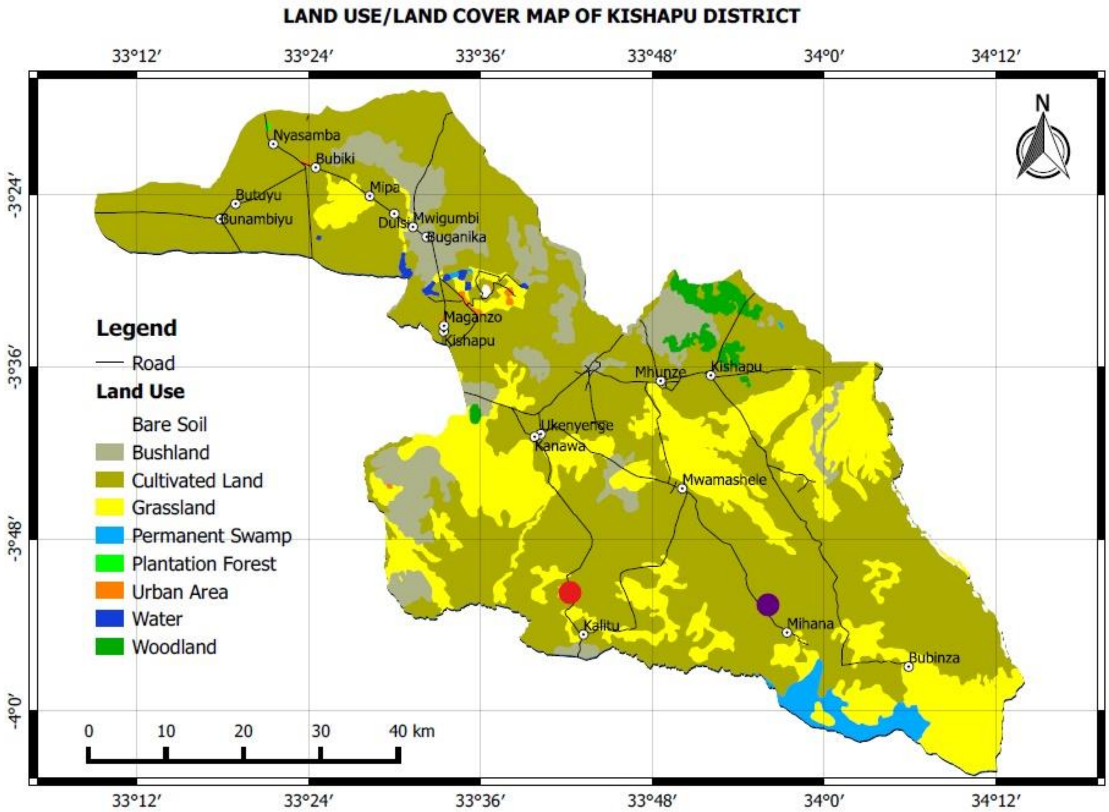
The current land-use of the Kishapu District is shown in Figure 49, and the changes in land-use between 1996- 2016 summarized in Table 26. Unlike the other mainland districts in the study, Kishapu has little forest, woodland and bushland, together totaling 625 ha, which is a very small 0.14% of the district area. Over the twenty year period this has reduced from a total of 0.31% in 1996. As noted in the section below, Shinyanga region used to be covered with dense acacia scrub and miombo woodland, but by 1985 much of the landscape had been transformed into an open-bush savanna. The majority of the area is cultivated land and scattered cropland, totaling 93.2%. The proportion of cultivated land has increased over the 20 years.

Table 26: Change in land use and land cover (1996-2016)

Land Cover Types	1996		2016		Relative Change 1996_2016	
	Area (Ha)	Area %	Area (Ha)	Area %	Area (Ha)	Area %
Forest	50.00	0.01	314.00	0.07	264	0.0617
Woodland	265.00	0.06	189.00	0.04	-76	-0.0178
Bushland	1104.00	0.26	122.00	0.03	-982	-0.2297
Cultivated Land	291624.00	68.21	356167.00	83.30	64543	15.0957
Scattered Cropland	113546.00	26.56	46592.00	10.90	-66954	-15.6596
Innundated Land	11371.00	2.66	9979.00	2.33	-1392	-0.3256
Permanent swamp	7650.00	1.79	7593.00	1.78	-57	-0.0133
Settlement	472.00	0.11	5677.00	1.33	5205	1.2174
Water	792.00	0.19	737.00	0.17	-55	-0.0129
Total Area	426874.00		427370.00			

Communities reported that historically land is under pressure due to an increase in livestock and crop production which increase land degradation. The degradation has caused severe cover degradation, deforestation, scarcity of wood fuel and severe soil erosion and thus cause food insecurity. On the other hand, the land is becoming scarcer due to an increased population and the expanding mining activities that rendered arable land useless (Kangalawe, 2006).

Figure 49: Land use and cover map for Kishapu (2019)



Kiloleli is marked in red, and Lagana ward is marked in purple

A number of households practice both animal husbandry and farming but the main activity is cultivation. The traditional land use type is the practice called *Ngitili*, which is an in-situ conservation system which involves close access on an area of standing vegetation from the beginning of the rainy season and opening it up for grazing at the peak of the dry season during extremely dry weather. This practice is used as a mechanism to adapt and in preserving the environment from land degradation and as a way to securing firewood, fodder, building poles and grazing pasture due to prolonged dry season (Mkwama, 2016).

6.2 Climate change projections for district

6.2.1 Temperature

The data used is from Shinyanga meteorology station, which has 24 years of unbroken temperature data. This is too short a record to detect the onset of any significantly increasing temperature change. Both Shinyanga and Kishapu are about 150 km south of Lake Victoria, and hence at about the southernmost limit of climatic influence from the Lake. However, modelling indicates temperatures will increase. The temperature projections for the 20 year time intervals are tabulated in Table 27 and shown in Figure 50. The seasonal variation and projections for 2050 and 2090 are shown in Figure 51.

Table 27: Median Ensemble Mean Annual Temperature Change Projections, °C

CMIP-5 data for Shinyanga (Bias Corrected)

Station	Historical mean	RCP	2020-39	2040-59	2060-79	2080-99
Shinyanga	24.6°C N=32	4.5	25.6	26.1	26.3	26.5
		6.0	25.5	25.9	27.0	27.0
		8.5	25.7	26.5	27.5	28.4

Figure 50: Projected median ensemble temperature changes

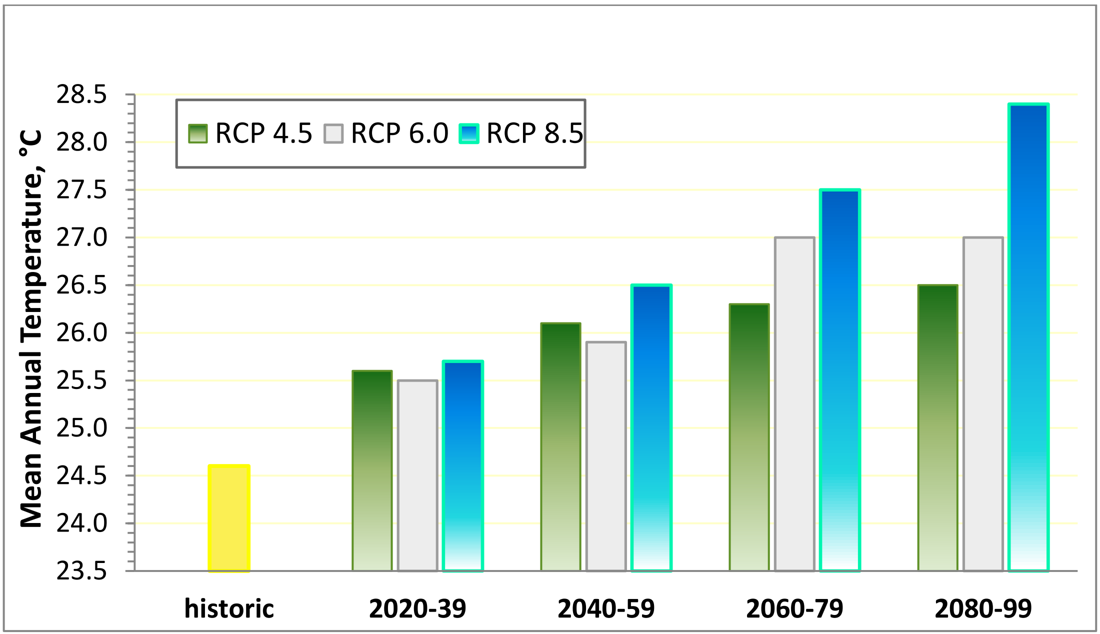
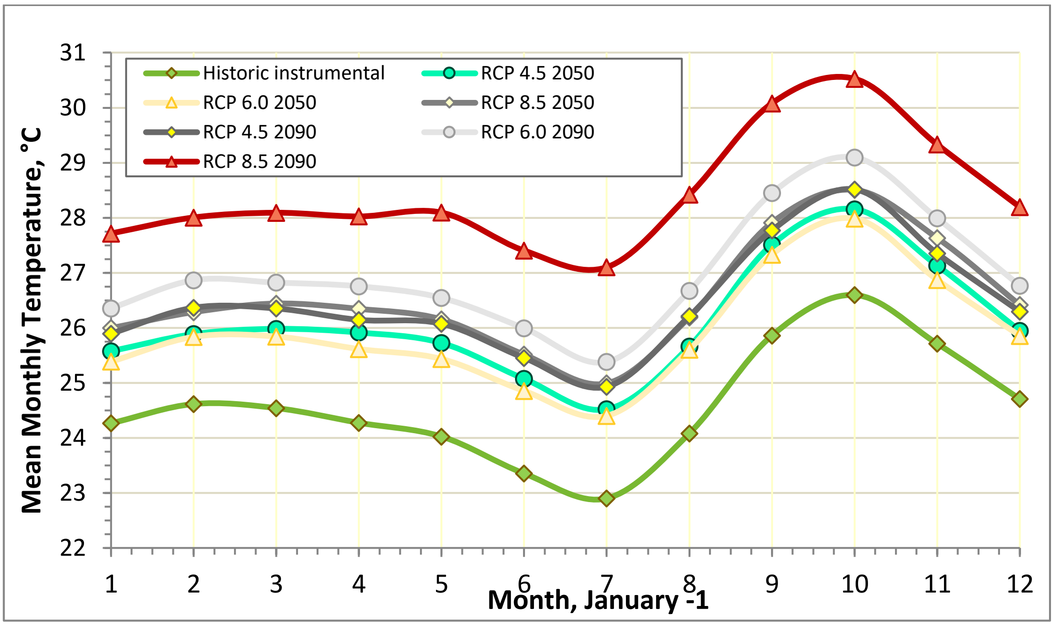
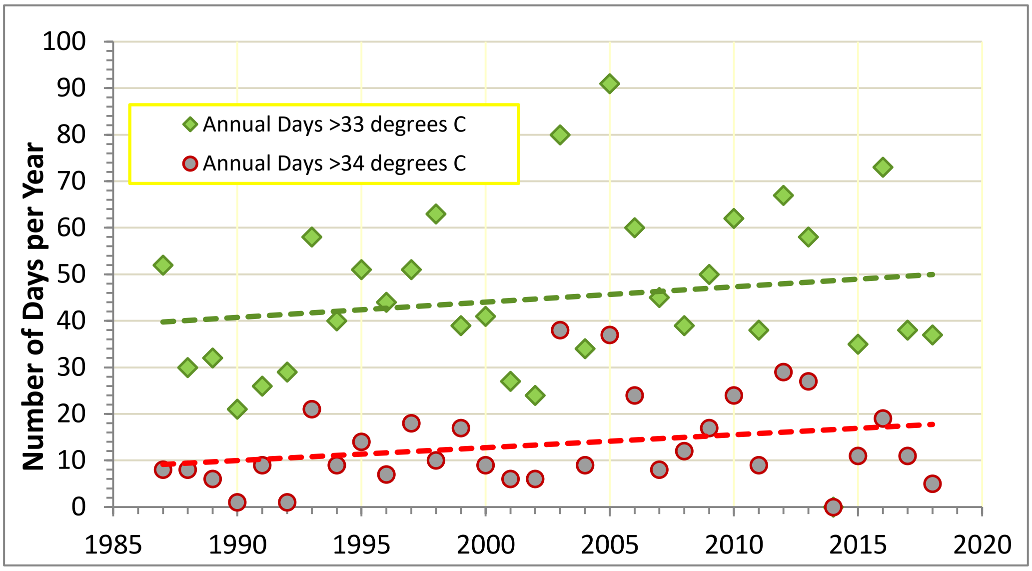


Figure 51: Historical and Projected Seasonal Temperatures at Shinyanga



There will be an increase in the number of hot days, and will most probably be greater than the linear trends shown in Figure 52. This is because, over the relatively short time-series of data available, the Indian Ocean Dipole (IOD) depression of temperatures between 2008 and 2018 has been disproportionately represented.

Figure 52: Historical Frequency of Hot Days at Shinyanga 1987-2018



Across the 34-year rainfall record for Shinyanga there is no statistically valid evidence of a change in the onset of the Long-rains

6.2.2 Rainfall

The modelling projection is for the annual mean rainfall to increase by approximately 11% by end century, as summarized in **Table 28**. The recent trend, shown in Figure 53, has been for a decline, but this will not continue, according to models. The projected rainfall for the 20-year intervals is also shown in Figure 54. Although the rainfall record at Shinyanga is of high quality, the limited time-series, of only 33 years, is too short to discern any meaningful shift in the onset of the long rains.

Table 28: Median Ensemble Mean Time-slice Rainfall Projections, mm

CMIP-5 data for Shinyanga (Bias Corrected)

Station	Historical mean, mm	RCP	Incremental Additions, mm			
			2020-39	2040-59	2060-79	2080-99
Shinyanga	818	4.5	14	24	65	92
		6.0	28	37	75	92
		8.5	29	17	76	96
			Projected Average Total Rainfalls			
		4.5	832	842	883	910
		6.0	845	855	893	910
		8.5	847	834	894	914

Figure 53: Historical annual rainfall at Shinyanga

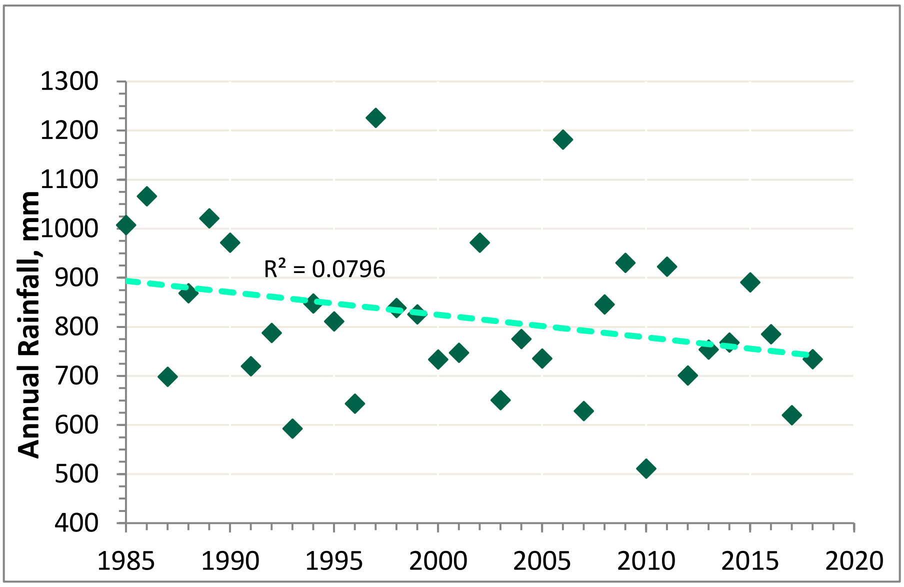
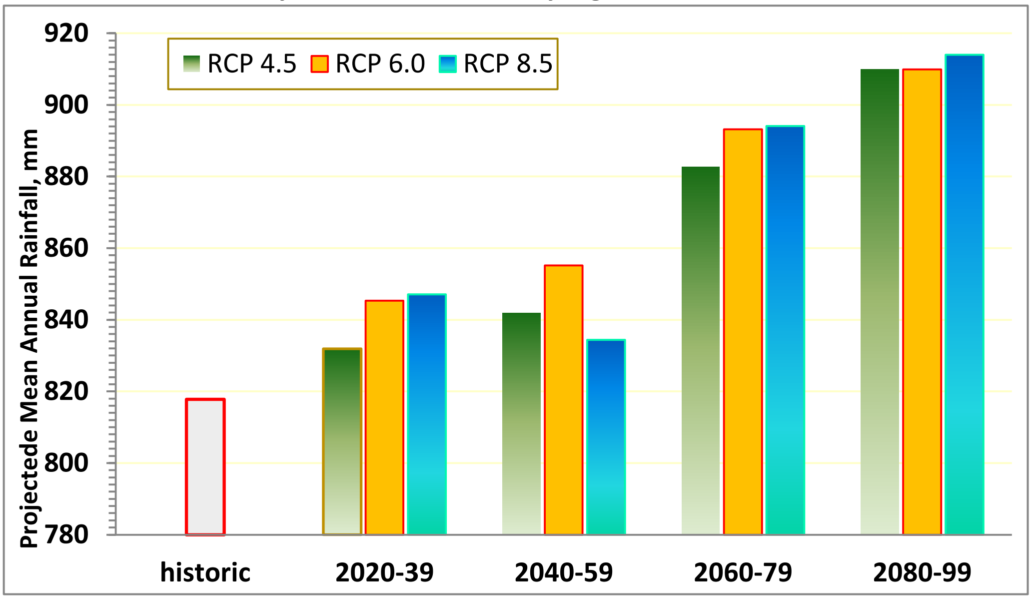


Figure 54: Historical vs. Projected Rainfall at Shinyanga



Evapotranspiration rates will increase from a daily average of ET_0 of 5.0 to 5.3 by 2080-2089 (RCP 6.0), which will offset the increased rainfall.

Today, the inter-annual variation in rainfall produces regular below-average and above-average rainfall years. This variation is shown for 1:5 and 1:10 average return interval (ARI) dry and wet years in Figure 55 and tabulated in Table 29. This shows the marked difference in rainfall between the wet and dry conditions, with, for example, only 467mm in a 1:5 ARI year, compared to 1106 mm in the wet year. This difference is even greater when effective precipitation is considered. Also, in dry years, there is a long dry season of approximately 6 months. Modelling indicates that the wet seasons will be shorter and wetter with fewer, more intense, rainfall and the dry seasons will be longer and drier. With regards to serious droughts, modelling indicates no increased probability for RCP 6.0, until 2080-99 when there is a small increase of 3%.

Figure 55: Historical Wet and Dry-Year Rainfall Contrasts Rainfall at Shinyanga, mm

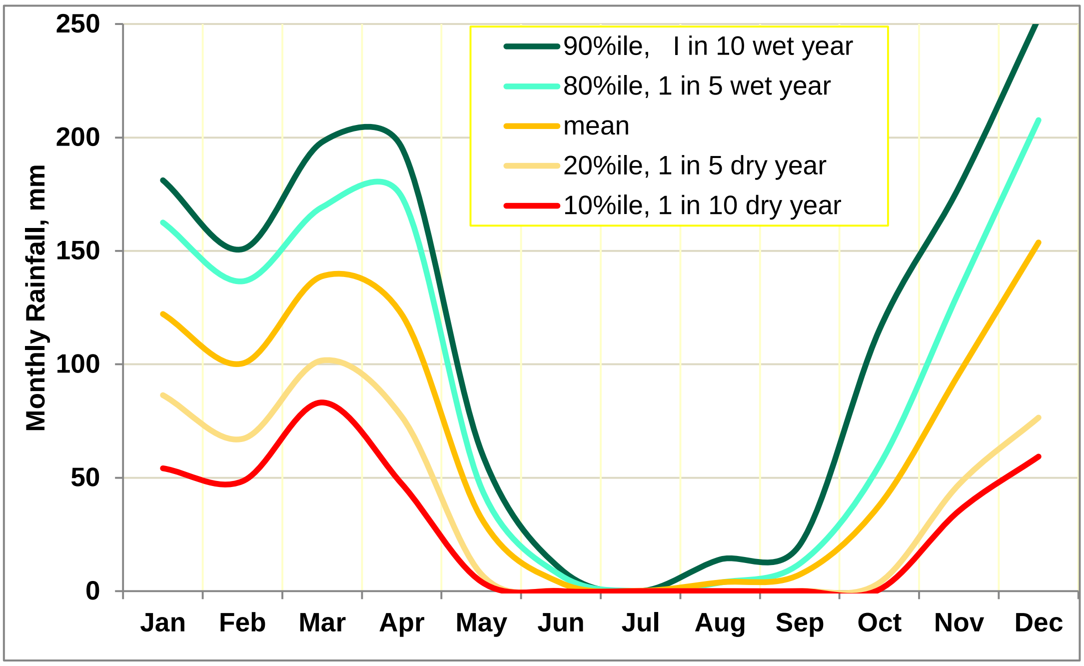
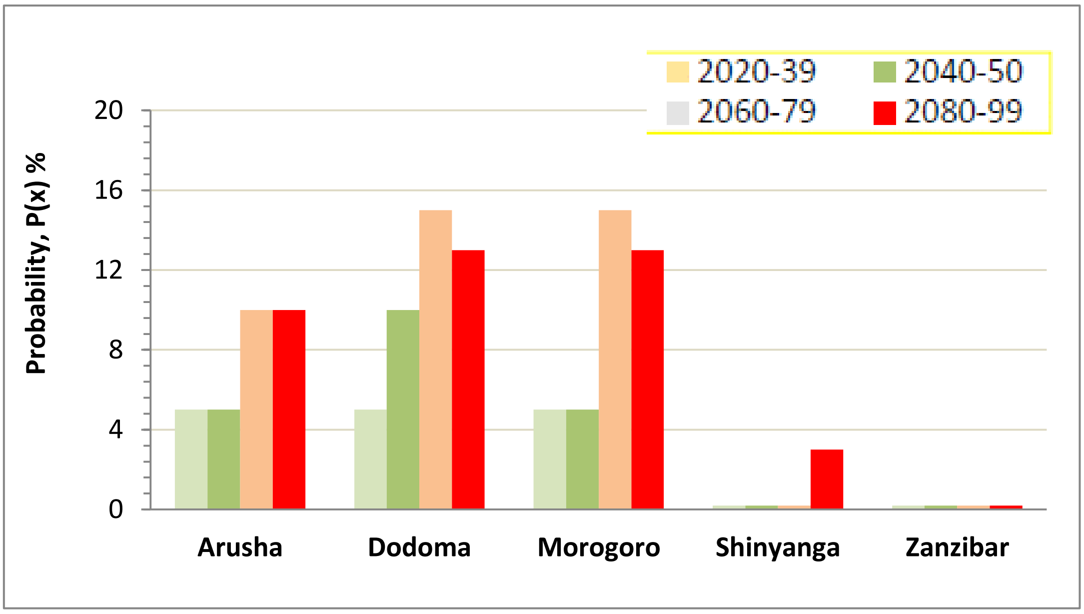


Table 29: Historical Wet and Dry Year Rainfall Contrasts at Shinyanga, mm

SHINYANGA	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
90%ile, I in 10 wet year	181	151	198	196	62	10	0	14	20	115	178	253	**1377**
80%ile, 1 in 5 wet year	163	137	169	174	46	7	0	4	12	55	132	208	**1106**
mean	122	100	139	122	32	4	0	4	7	38	96	154	**818**
20%ile, 1 in 5 dry year	86	67	102	77	7	0	0	0	0	4	47	77	**467**
10%ile, 1 in 10 dry year	54	48	83	47	4	0	0	0	0	1	35	59	**333**

Figure 56: RCP 6.0 Projected changes in severe drought

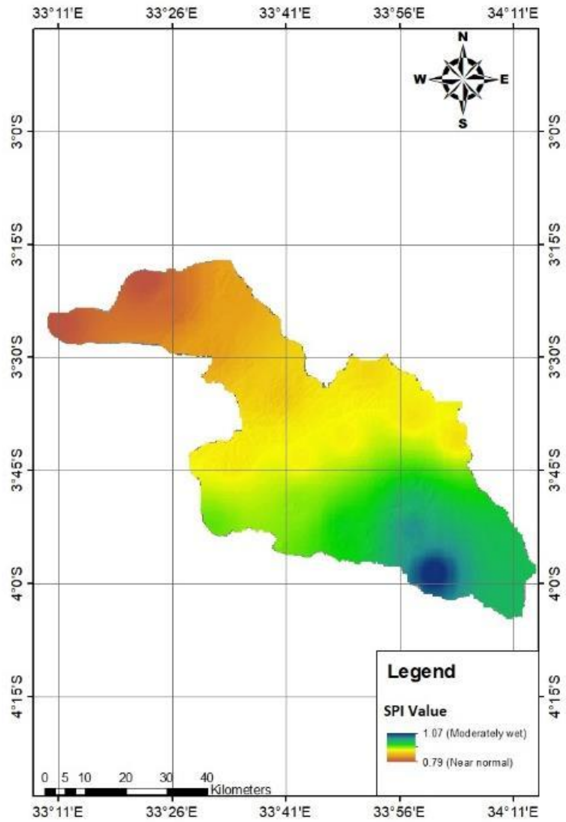


6.3 Risk maps

Drought

According to climate projections, there will be 3% increase in drought probability. As seen in Figure 57, this risk is categorized as "near normal", and is therefore not considered severe, particularly in the northern part of the district. The southern parts of the district (where Lagana and Kiloleli are located; refer also to Figure 1 for regional references on drought probability) face an extremely low probability of drought. Any project interventions targeting water access and drought would, therefore, have their highest impact when implemented in and around the brown areas.

Figure 57: Kishapu District drought hazard map



Flood risk

Figure 65 illustrates flood risk, which is classified as high across the southern wards of Mwamalasa, Masanga and Lagana, and moderately high for Kiloleli, Ngolifa, and Itilima – all these wards fall within the lowland area with a network of rivers running across. The northern wards are situated in the highland areas and are thus not at risk from flooding. The rest of the wards are categorized as medium to low risk.

Erosion risk

Erosion potential on Kishapu is high in the areas shaded in red (4-5 tons per hectare per year, Figure 59). Southwest and northeast Lagana are categorized as high risk, whereas the rest of the ward and all of Kiloleli ward are classified as low to medium risk only. Red areas are important for planning EbA measures to reduce erosion and erosion linked damages. Generally, most of the district area indicate medium to low erosion potential.

Figure 58: Flood risk in Kishapu

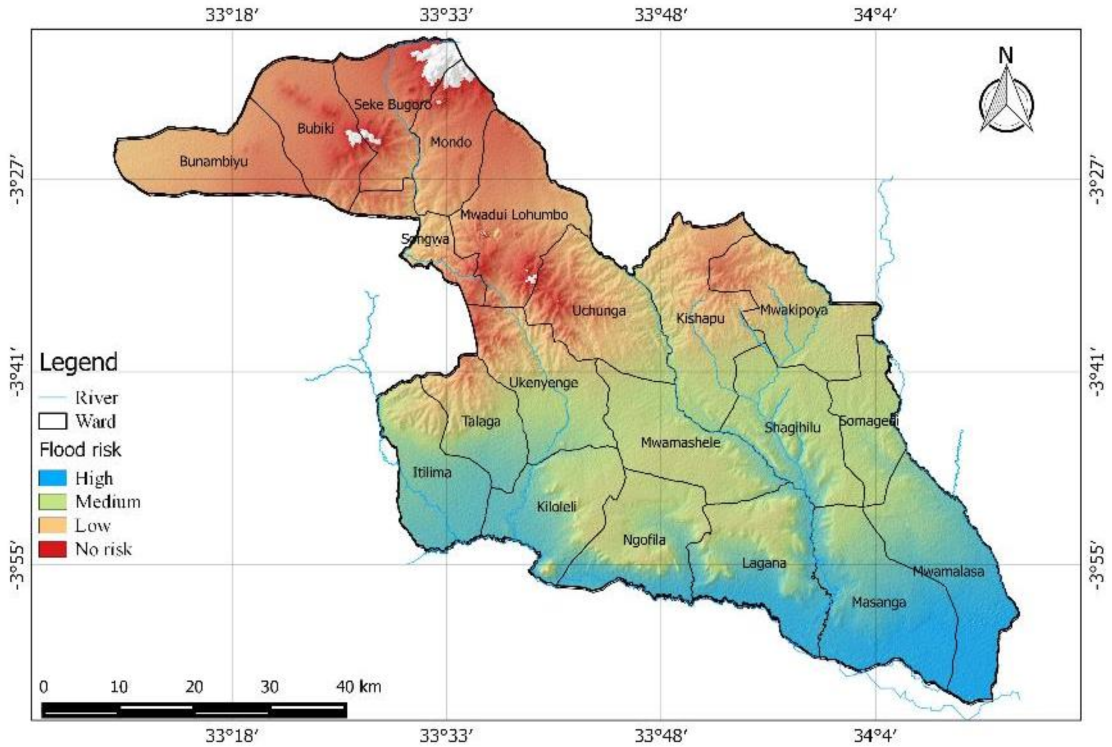
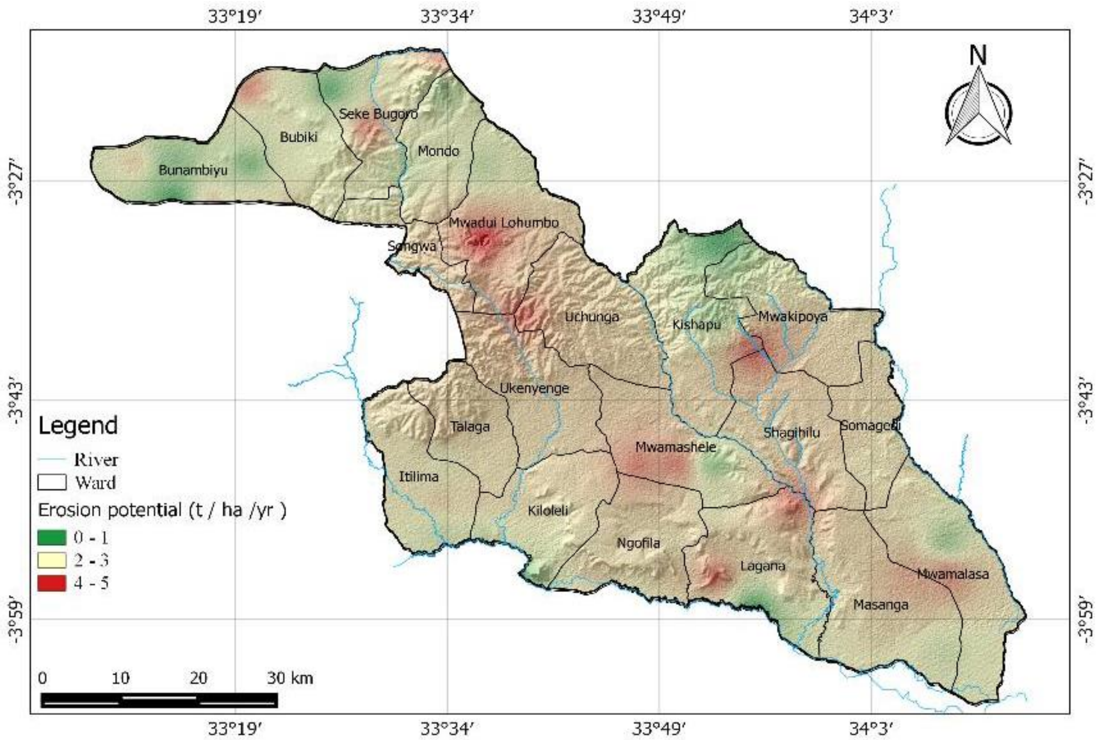


Figure 59: Erosion risk in Kishapu District



6.4 Climate change impacts for the watershed in the context of current land use

6.4.1 Forests and woodlands

In 2010, Kishapu had only 124 ha of tree cover, which is equivalent to a mere 0.030% of its land area. From 2001 to 2018, Kishapu lost 26 ha of tree cover, which is an alarming 34% decrease in tree cover since 2000 (Global Forest Watch, 2019). Current land use map for the area shows that most of the land in Kiloleli and Lagana are cultivated land, with small scattered areas of tree cover (see Figure 49).

An important factor has been drought, which has been leading to a decline of natural forests (e.g. Mihama and Ikonda forests) and the cutting down of trees for timber, charcoal making and curing tobacco, as alternative sources of income. In dry years there is a long dry season of approximately 6 months. Modelling indicates that the wet seasons will be shorter and wetter with fewer, more intense, rainfall and the dry seasons will be longer and drier. Also, the diversity of tree species has been reduced, with a few species becoming rarer and rarer (e.g. *magwata, misingisa, mipogoro, miponda*).

The reduced tree/forest cover has intensified soil erosion, and the increased occurrence of drought events has led to local desertification.

An overall loss of biodiversity can be observed above all in insects, but also wild animals including game.

6.4.2 Rangelands, bushlands and grasslands

Kishapu has approximately 370,247 ha of rangelands, 10% of which is degraded to the point of being "unusable". These lands are used by the community, as part of a communal system. There are no land management plans in place in the consulted villages of Muguda and Kiloleli (Kiloleli ward), and Mihama and Beledi (Lagana ward). This has been identified as a strong reason for the deterioration of rangelands in the district. Other threats include pastoralists with permanent residence in neighboring villages, as well as agricultural expansion.

Stakeholders identified the major climate change impact on rangelands in Kishapu to be the decline of pasture in terms of size, and its ability to accommodate available livestock (a decrease in carrying capacity of the land), most likely as a result of prolonged drought periods and the resultant lack of water. Species of weeds competing with plants and shrubs on rangelands that are beneficial to livestock are also observed to be increasing in prevalence.

6.4.3 Biodiversity

Shinyanga region used to be covered with dense acacia scrub and miombo woodland, but by 1985 much of the landscape had been transformed into an open-bush savanna. During the 1920s and 1930s, large areas of land were cleared of bush and trees as part of a tsetse fly and *quelea quelea* bird eradication programme (HASHI-ICRAF, 1997). Deforestation and bush clearing continued as large blocks of land were converted into fields for the production of cash crops like cotton and rice. Overgrazing became a serious problem as the area of rangeland declined, and matters were made worse when many people from traditional villages were relocated in the 1970s to newly created settlements under the government's Villagization Act. The programme's aim was to bring rural families closer to social services, but it meant the abandonment of houses, farms and – most significantly – their *ngitilis*. The Sukuma have long relied on these enclosures (“*ngitilis*”) of acacia-miombo woodlands to provide them with dry-season fodder for their cattle, as well as firewood and other essential products. By 1985, this traditional system of land management had virtually disappeared, and a mere 1,000 hectares of *ngitilis* remained.

There are variations in species composition between the districts, but two major vegetation types can be distinguished in Shinyanga, namely: bushland (with: Acacia, Dalbergia, and Combretum bushlands) in eastern Shinyanga; and regrowth miombo woodland in the western part of the region. Generally, the regrowth miombo vegetation has higher stocking, basal area, volume production, and tree species diversity compared to the bushland. Regenerants are generally few, and the two most regenerating species, Dichrostachys cinerea and *Omorcapum trichocarpum*, are indicators of degraded areas. Grass and herb cover is also generally low and is dominated by grass species, which is another indicator of degraded sites. The dominant tree species in terms of volume per hectare are: *Acacia tortilis, Acacia tanganyikensis, Acacia senegal, Acacia mellifera, Acacia kirkii, Acacia seyal var. fistula, Acacia drepanolobium, Acacia sieberiana,* and *Acacia polyacantha*. Non-Acacia species include: *Commiphora africana, Dalbergia melanoxylon, Combretum zeyheri, Cordia sinensis, Pterocarpus angolensis, Diplorhynchus condylocarpon* and *Albizia harveyi*. Other wood species include Terminalia Catapa, *Acacia polyacantha*, *Acacia Senegal*, *Acacia indica*, *Balanites aegyptiace,* and *Senna siamea.* Grass species include *Pennisetum mezianum*, *Pennisetum stramineum*, *Chroris roxburghiana* and *Sporobulus angustifolia*, *Chlorisguyana* and *Cenchrusciliaris* (Kishapu District Profile, 2013).

Major climate impacts according to key informants has been the eruption of animal-related diseases; migration of wild animals; extinction of biodiversity; a decline of tourist activities; change or destruction of biodiversity and ecosystems; change of animal behavior, animal (esp. insect) diseases; change of human behavior, for instance in the incidence of resource conflicts and farming regimes (i.e. planting season/schedules and harvesting time).

6.4.4 Water supply

Kishapu is located in the Lake Eyas Basin (see Basin map), but with a small area in the north within the Lake Victoria Basin. The majority of the area is drained by the Pangani River and tributaries which enters Lake Eyasi ouside the district to the east. The southern boundary of the district is the Manonga River, which has as major tributaries the Negezi and Nkumba Rivers. The Nkumba River, which flows through the Kiloleli Ward, originates in an area of northern highlands. As noted above, the district has had major land use changes since 1985, when it was mostly dense *Acacia scrub and Miombo woodland.*

Kishapu does not have a perennial river, which makes water supply erratic and not safe for drinking. Most rivers flow for only a few days per year and then dry up. Communities depend on standing pools of rainwater for domestic use and livestock needs during the wet season and dig shallow pits in the riverbeds during dry season.

In the district, agriculture (cropping) is the main economic activity, with stock keeping. It is mostly rainfall dependent, with very little irrigation (>2.0%) (United Republic of Tanzania, 2007), which is also assumed to be generally the case.

The current situation is also demonstrated in the results of the modelling, with the most significant points being:

- While there has been no statistically significant change in the annual rainfall volume, the pattern is for shorter and wetter rain seasons and drier and longer dry seasons. There is already a large inter-annual variation in rainfall and the district has regular years of below-average rainfall and above-average rainfall. For the population dependent of seasonal water availability in storages and even those rivers or tributaries reasonably close which may be ephemeral, these dry years can be difficult to find water, particularly of good quality. Rainfall is becoming less reliable with more intense events, which increase their erosion and flooding potential. As pointed out in the Modelling report by Stanger (2019), for this project, the runoff is not directly proportional to the rainfall, so an increase of only 10% in extreme rain can, and almost certainly will, result in a much higher proportion of runoff, resulting in greatly enhanced quickflow (flash flooding). In addition, the erosive power of quickflow is approximately proportional to the fourth power of the runoff velocity, so a small increase in extreme rainfall will have a disproportionate impact upon hill-slope, soil and embankment erosion

- Temperatures have increased and the number of very hot days has increased, which will be a heat stress risk, particularly when longer distances are involved to obtain water.

The community has identified changes that have occurred, which they consider to be due to climate change, including:

- Drying up or disappearance of water resources (e.g. Rivers Manonga, Tambo and Tungu) leading to:
  - Decline of water availability for domestic use
  - Increased distance for the search of water
- Eruption of waterborne diseases due to poor water quality
- Impacts on livestock due to lack of water and pasture which forces them to travel long distances of up to 2km in searching for water
- Increased truancy rates in schools, esp. for girl children
- (Drought) leads to low or under-productivity and low crop yields
- Soil erosion, due to bare soils, deforestation and stock trampling
- Increase in temperature

At the present time, the majority of the population obtains its water supply for domestic supply from rivers and harvesting in dams. In 2007 this was approximately 72%, with other sources being boreholes with hand pumps (14.1%), protected wells (1.3), unprotected wells (8.4), pipe-borne treated water (2.9) and pipe-borne untreated water (0.2%) and rainfall (0.8%) (PMO-RALG, 2007). No up to date data has been available as yet, but it is assumed that while improvements are continuously being made, the general picture would be the same.

From the modelling, the implications of future climate change are summarized as follows:

- The longer and drier dry seasons will result in surface river sources of supply and dams used by the majority of the population becoming less reliable. Particularly during the periodic below-average years, these sources will dry out.
- With increasing temperatures (and with a larger population and increased demand), water demand will increase. While rainfall will increase it is offset by increases in evapotranspiration, but evaporation from water storages will increase, reducing the available volume for people and stock.
- Rainfall will occur in fewer more intense events, creating problems for agriculture and potentially increasing erosion.
- Aquifer recharge may decrease, affecting groundwater supplies which are currently used, and it’s potential as a future resource to replace the increasingly more unreliable surface water sources.

6.4.5 Agriculture

Farmers in Kishapu grow sorghum, maize, legumes, finger millet and sunflower. Main farming style is shifting cultivation which is predominantly rain-fed. Intensive cultivation is practiced on sweet potatoes, groundnuts and cotton with rice grown in a certain part of alluvial soil. Livestock production is limited due to land degradation caused by increased pressure on fragile lands, increased crop production and unpredictable rainfall. The district has a high proportion of households receiving crop extension service (51%). Within Shinyanga, Kishapu has the largest area planted per household (3.4 ha).

Key issues can be summarized as follows:

- Unreliable rainfall for agriculture and inadequate rains in dry periods.
- Inadequate supplies for people and stock in dry years.
- People and stock accessing the same water, which has serious sanitation issues.

The current situation is also demonstrated in the results of the modelling, with the most significant points being:

- While there has been no statistically significant change in the annual rainfall volume, the pattern is for shorter and wetter rain seasons and drier and longer dry seasons. There is already a large inter-annual variation in rainfall and the district has regular years of below-average rainfall and above-average rainfall. For the population dependent on seasonal water availability in storages and even those rivers or tributaries reasonably close which may be ephemeral, these dry years can be difficult to find water, particularly of good quality. Rainfall is becoming less reliable with more intense events, which increase their erosion and flooding potential.
- Temperatures have increased and the number of very hot days has increased, which will be a heat stress risk, particularly when longer distances are involved to obtain water.

Communities narrated that dry season in Kishapu is always very harsh, the soil is hard to cultivate, pastures become very poor, and availability of water for domestic use and livestock become acute. This is because the rain distribution is unequal and unpredictable which makes rainfall a source of water for various usages unsustainable. Generally decreasing rainfall trend (1985 to 2016 time series); early cessation of rainfall in April, shortens crop cycles hurts productivity.
An increasing trend in temperature perpetuate situation and make most of Kishapu areas high drought resistance. Higher temperature can increase evapotranspiration that in turn can have an effect on moisture for the crops adversely affecting pasture productivity for livestock, and leading to a shortage of water for both crops and livestock hampering yields and productivity. Water sources are drying up, thus adversely affecting smallholders' farmers and agro-pastoralist whose livelihoods largely depends on the rain-fed farming system.

During the discussion, farmers reported the increase in pests such as stalk borers *Calideadregii* locally called *somi* and cutworms *Agrostis ssp.* locally known as *gegesha*, attacks maize and sorghum especially during dry periods, destroying crops and hurting yields. Soil erosion was also repeatedly mentioned, associated with destroyed vegetation cover and thus soil fertility.

6.5 Ongoing adaptation efforts

Forests

The *ngitili* system – practiced in Shinyanga – was developed by villagers as a means of ensuring dry-season fodder reserves by carefully managing an area of standing vegetation (i.e. grasses, trees, shrubs and forbs) from the onset to the end of the rainy season. Notable success of restoration of some 350,000 ha of *ngitili* lands in Shinyanga region has been managed through an indigenous natural resource management system and supported by the HASHI project and others – benefitting 2.8 million people in over 800 villages since the 1980's. Ngiitili and agroforestry practices are widely adopted across Shinyanga region, but no evidence was found in the study that this is necessarily the case in Kishapu. A very rough expert estimate is that 50% of communities around Shinyanga practice agroforestry or a mix of agroforestry and other techniques.

Pioneering work by EcoAgriculture Partners and the Landscapes for People Food and Nature Partnership (LPFN) in raising awareness, developing capacity and supporting restoration through integrated landscape management approaches has occurred. Also noted is an increased adoption by farmers of Farmer Managed Natural Regeneration (FMNR) in association with work of the LEAD Foundation, World Vision, ICRAF and the EverGreen Agriculture Partnership. Innovation work by the Ujamaa-Community Resources Team (UCRT) in collaboration with local communities, Village authorities and the Ministry of Lands to secure land rights through Certificates of Customary Rights Occupancy" (CCRO), in northern Tanzania in areas of pastoralism and traditional hunting / gathering communities was also reported.

Experience of forest restoration activities in Shinyanga illustrates the importance of working with local people. In the past, the state-imposed its own solutions, which often failed. The survival rate of trees planted in state-sponsored communal wood lots, for example, was less than 20% in the region. The government's HASHI project has not only involved local people in the whole process of landscape restoration, but it has also built on local institutions instead of creating new ones. Villages have been encouraged to pass their own by-laws to protect communal *ngitilis*, and traditional village guards monitor activities in the *ngitilis*. Allowing traditional Sukuma institutions and village governments to oversee restoration efforts has given villagers a sense of ownership and investment in the project's outcome and has helped ensure region-wide success.

Biodiversity

Traditionally farmers have devised methods to cope with the impacts and have been successful in some effort include agroforestry. Efforts by ICRAF (World Agroforestry Center) have seen the adoption of agroforestry techniques in reducing the effect but also in fixing soil nitrogen.

The District disaster management committee has conducted training on climate change in collaboration with Relief to Development Society (REDESO).

Farmers have applied drip irrigation techniques to help trees grow. The techniques involve filling water in a bottle then turning the bottle upside-down on each tree, water from the bottle comes out slowly allowing the availability of moisture around the tree for longer times. A one and half little bottle could be replaced every three to four days. Key informants see the method as efficient and cost-effective compared to conventional irrigation and thus could reduce the effect of deforestation.

Adaptation gaps were identified and the following measures were suggested by LGAs and workshop participants, to build capacities.

- Conservation and management of the natural vegetation through traditional Ngitili and coppicing system of miombo regeneration (*Kisiki* initiative)
- Replacement of the natural vegetation (where destroyed), e.g. through reforestation using agroforestry trees which could be used as fodder and to improve soil fertility and crop yields. An example of such trees includes *Gliricidia*, *Calliandra* and *Leucaena*. In addition, *Faidherbia albida* and an acacia-like tree could be used as they shed leaves during the early rainy season when farmers are planting crops in fields and once the dry season begins the trees sprout new leaves thus coincide with the time when most crops are at last stage of development. *Leucena leucocephola*, *Tamarindus indica, Moringaolifera* and *Grevillea robusta* could also be used to improve soil fertility and animal feeds.
- Practice environmentally friendly technologies when using the forests (firewood collection and charcoal making, this could also include the promotion of more efficient cooking stoves)
- Capacity building and awareness-raising on the importance of biodiversity
- Enactment of by-laws for the protection and management of the natural vegetation

Rangelands

Most rivers in the area are seasonal, which reduces the adaptive capacity of the communities and rangelands during dry periods; water is however available during rainy seasons. Stakeholders also found that inadequate knowledge among pastoralists on pasture production and management also impacts the capacity to rehabilitate rangelands. Another key area of awareness that is lacking is an understanding among pastoralists on the need for livestock "harvesting", i.e. the selling of some heads to invest in other productive assets.

Two extension officers (one for livestock and one for agriculture) are available for the district. They do not, however, have the capacity to deal with rangeland issues on a widespread basis because they cover a vast area and have limited resources for travel and capacity development.

Stakeholders identified the following areas of improvement in this regard:

- Construction of dams, reservoirs and deep water wells for human and livestock use
- Maintenance and improvement of water catchment areas for humans
- Capacity building and awareness-raising on the production and management of pasture
- Rainwater harvesting for humans
- Removal of weeds and invasive species on rangelands

Agriculture

Farmers in Kishapu have reported practicing mixed farming in response to frequent crop failure which is also associated with prolonged drought in the study area; the common crop combination, in this case, is maize with cassava, groundnuts (*Arachis hypogea*) and cowpeas (*Vignaunguiculata*). Despite knowing about poor soil fertility farmers reported not to use manure in their farm mostly because of the costs associated.

Adaptation techniques have been employed by farmers and it is up for the EbARR project to scale-up its usage and adoption instead of re-inventing the wheel.

Climate change-related programmes and projects in the target region, relevant to EbARR

- REDESO: Village Community Banks (VICOBA) with activities such as women empowerment, promotion of agricultural activities (millet, sweet potatoes and sisal), fish farming, afforestation

- TCRS (Tanzania Christian Relief Service) Climate Change Adaptation and Mitigation projects including reforestation/tree planting and woodlots establishment, farming techniques/Gardening, water conservation and harvesting, Livelihood and food security, Water and Sanitation
- TATEDO: Improved cooking stoves and using less firewood

6.6 Interventions

Table 30 summarizes the ecosystem level issues and impacts facing the community, as identified in the multi-stakeholder workshop held in November, as well as suggested or desired interventions. Although most issues are linked directly to climate change, while some are only indirectly connected (e.g. exacerbated by climate change).

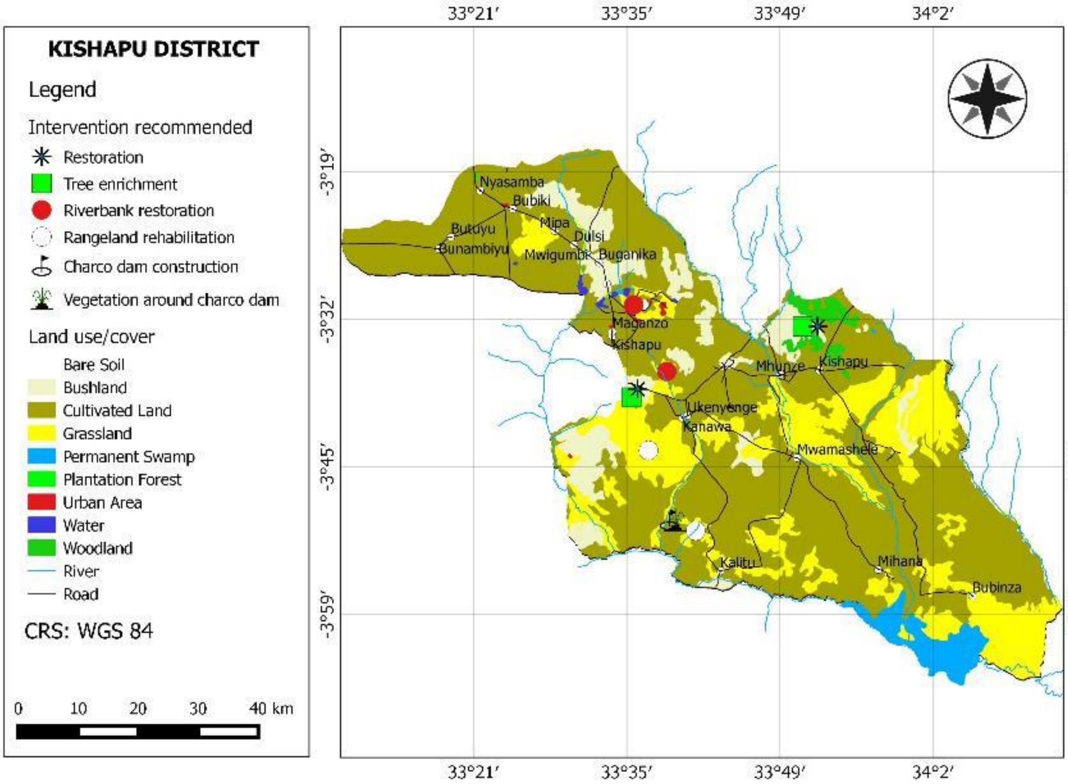
Table 30: Issues and interventions identified in multi-stakeholder workshop in Kishapu

Issue		Intervention
Major issues identified	**Impacts to community**	▪ Growing drought resistant crops (millet, sisal, mango) ▪ Capacity building on use of pesticides and access to materials ▪ Awareness raising on limiting livestock numbers ▪ Demarcation of rangelands ▪ Distributing pasture seeds ▪ Establishment of small ranches (livestock enclosures) ▪ Establishment of cattle dips ▪ Construction of water reservoirs or dam within Manonga river ▪ Deep water well construction ▪ Kiloleli reservoir rehabilitation ▪ Tree planting and conservation ▪ Alternative energy sources ▪ Establishment of tree nurseries, beekeeping and tree farms ▪ Rainwater harvesting
▪ Recurrence of drought, decreased water availability. Manonga, Tambo and Tungu rivers disappearing. ▪ Increase in pest, weeds and disease (esp. stroke borer and cut worms; ticks and worms affecting livestock) ▪ Decrease in healthy pasture extent and quality ▪ Mihama and Ikonda forests declining ▪ *magwata, misingisa, mipogoro, miponda* tree species on the decline ▪ Desertification ▪ Loss of biodiversity ▪ Increased animal migration	▪ Lower crop productivity harming agricultural livelihoods due to lack of water, increased erosion and higher temperatures ▪ Women under pressure to travel farther to fetch water ▪ Eruption of water borne diseases ▪ Truancy in schools, particularly among girls ▪ Livestock productivity decreasing but numbers are increasing ▪ Reliance on alternative income (timber and charcoal, causing more deforestation) ▪ Decline in wildlife, habitats and protected areas due to climate change impacts, leading to a decline in tourism and associated livelihoods	

Based on expert observations and inputs of workshop attendants, the study recommends four categories of EbA interventions around Kishapu district (see Figure 60):

1. Reforestation and tree enrichment in degraded areas
2. Rangeland rehabilitation in and around Kiloleli ward
3. Highland riverbank restoration north of Maganzo and south of Kishapu ward (due to slope considerations, this is highly recommended upstream, around Kishapu ward, rather than downhill at the target wards)
4. Charco dam construction near Kiloleli, with riparian vegetation boundaries

Figure 60: EbA interventions recommended for Kishapu district



7 MPWAPWA, DODOMA

7.1 Description of study district

Mpwapwa District is one of seven districts in Dodoma Region. The study team visited Nghambi ward during both the first and second project missions. With respect to the EbARR project, relevant information on climate, population and area, and land use and land cover are given below.

Climate

Most of the district is predominantly arid with spontaneous mountain chains especially in the southern and western parts, lying between 915 to 1,200 meters above sea-level.

Prior to the effects of climate change, the district was described as having a dry savannah type of climate characterized by the average temperature of 27^0 C. Short rain season starts December to April ranging between 600-700 mm per annum which is relatively adequate compared to other districts in the region. The mountainous areas Kiboriani, Wotta, Lufu, Mbuga and Mang'aliza receive heavy rains up to 1,200 mm per annum.

Population and area

Mpwapwa had a population of 305,056 according to the National Census 2012, with an annual growth rate of 2.1%. The district covers a total area of 7,379 km² (18.1% of the total area of Dodoma Region).

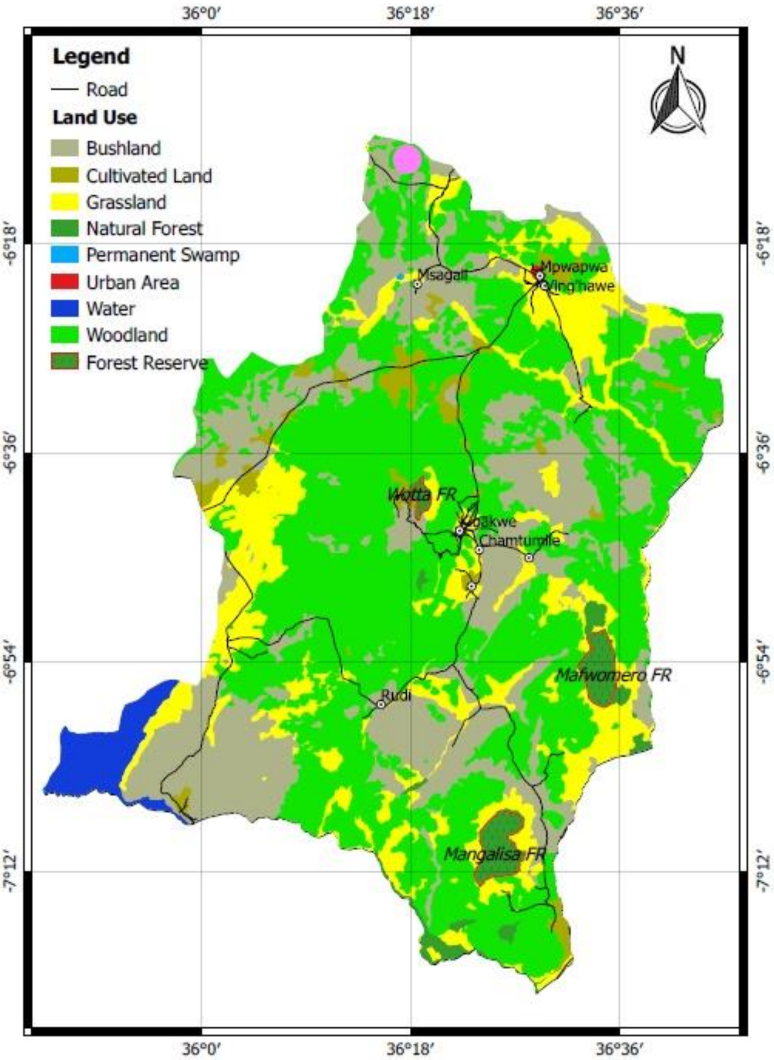
The major ethnic groups are Gogo, Kaguru, Tiriko and Hehe. There are few pastoral ethnic groups like Wamang'ati and Wamasai who migrate into the District, especially on the southern plains around Mtera dam and Ruaha River. There are 8 rivers of which three are seasonal and five are permanent. About 90% of the people in Mpwapwa District depend on agriculture as their primary economic activities/employment and source of income. Other employment opportunities are small and medium scale businesses (7%), small scale industries (1%) and office works (2%).

Crop production contributes about 50% of the district's wealth and livestock keeping about 40% of the same. In 2011/12, the district GDP was estimated at Tshs. 64,495.1 million. Per capita income was estimated at Tshs. 217,180.00.

Land use and biodiversity

Current land use is shown in Figure 61 and changes in land use from 1996 to 2016 is summarized in Table 31. There have been major changes in that period. In 1996, approximately 54.5% of the district was Forest (2.31%), woodland (29.45%), bushland (6.19%) and grassland (5.61%). By 2016, forest and woodland had decreased in area, but shrubland and grassland have increased. The total is approximately the same at 52.7%, but with forest (2.25%), woodland (18.6%), shrubland (12.8%) and grassland (19%). The other significant change is the increase in cultivated area from 2.8% of the district to 19.6% (124,645ha increase), but scattered cropland decreased by 230, 250 ha.

Figure 61: Land use and land cover in Mpwapwa, 2019



Nghambi is located in the north (marked in pink)

Table 31: Change in land use and land cover (1996-2016)

Land Cover Types	1996		2016		Relative Change 1996_2016	
	Area (Ha)	Area %	Area (Ha)	Area %	Area (Ha)	Area %
Forest	17128.00	2.31	16704.00	2.25	-424	-0.0572
Woodland	218398.00	29.45	138223.00	18.64	-80175	-10.8122
Bushland	45873.00	6.19	95060.00	12.82	49187	6.6332
Grassland	41599.00	5.61	141141.00	19.03	99542	13.4240
Cultivated Land	20519.00	2.77	145164.00	19.58	124645	16.8093
Scattered Cropland	386894.00	52.18	156644.00	21.12	-230250	-31.0510
Innundated Land	4729.00	0.64	30633.00	4.13	25904	3.4934
Permanent Swamp	66.00	0.01	8704.00	1.17	8638	1.1649
Settlement	421.00	0.06	1326.00	0.18	905	0.1220
Water	5895.00	0.79	7923.00	1.07	2028	0.2735
Total Area	741522.00		741522.00			

7.2 Climate change projections for the district

The key findings of the modelling study relating to changes in temperature, rainfall and evapo-transpiration are summarized below.

7.2.1 Temperature

Annual average temperatures have been increasing, a trend which will continue. Temperature projections are summarized in Table 32. In addition to the increasing average yearly temperatures, there is also a pronounced trend of increasing numbers of days per year > 33°C, as shown in Figure 62. This trend is expected to continue for many decades to come. Only two days in the 60-year record have exceeded 35°C, and none have yet attained 40°C. Nighttime temperatures are increasing and the overall rate of warming of night-time minima is 2.3 times the rate of warming of day-time maxima, as shown in Figure 63.

Table 32: Median ensemble mean annual temperature change projections, °C

CMIP-5 data for Dodoma (Bias Corrected)

Station	Historical mean	RCP	2020-39	2040-59	2060-79	2080-99
Dodoma	22.94°C N=59	4.5	23.83	24.33	24.56	24.78
		6.0	23.76	24.13	24.67	25.22
		8.5	23.95	24.73	25.71	26.65

Figure 62: The growth in annual days exceeding 33°C

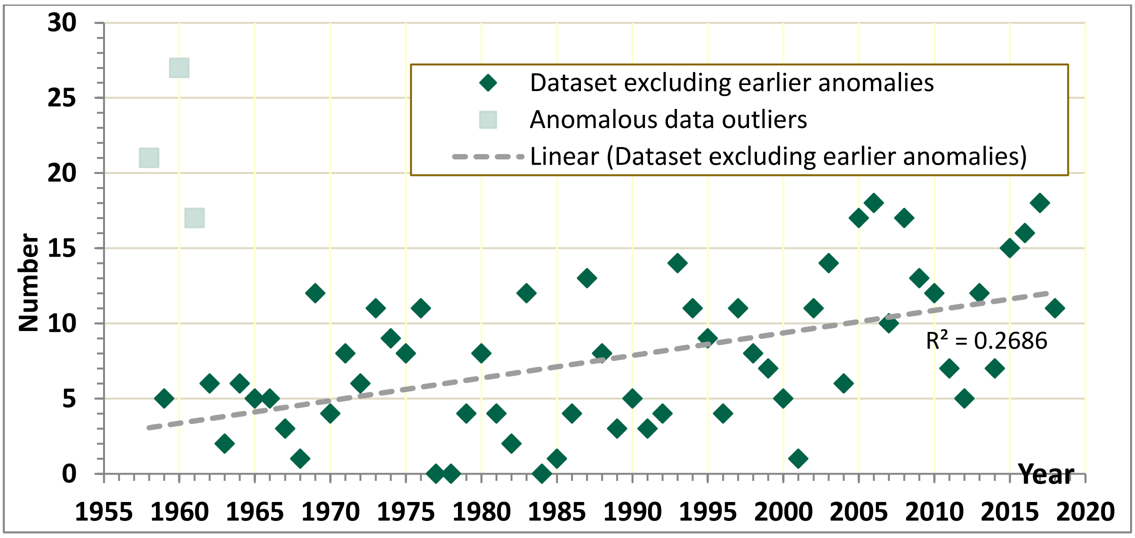
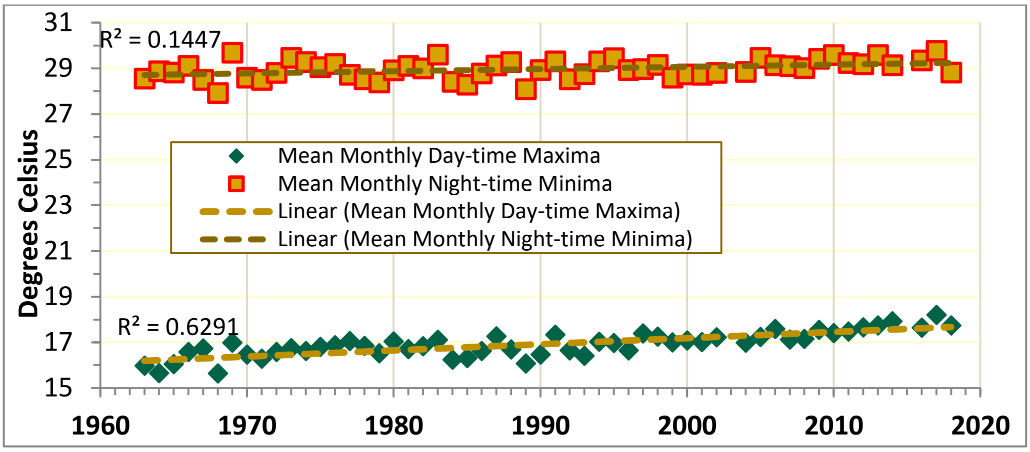


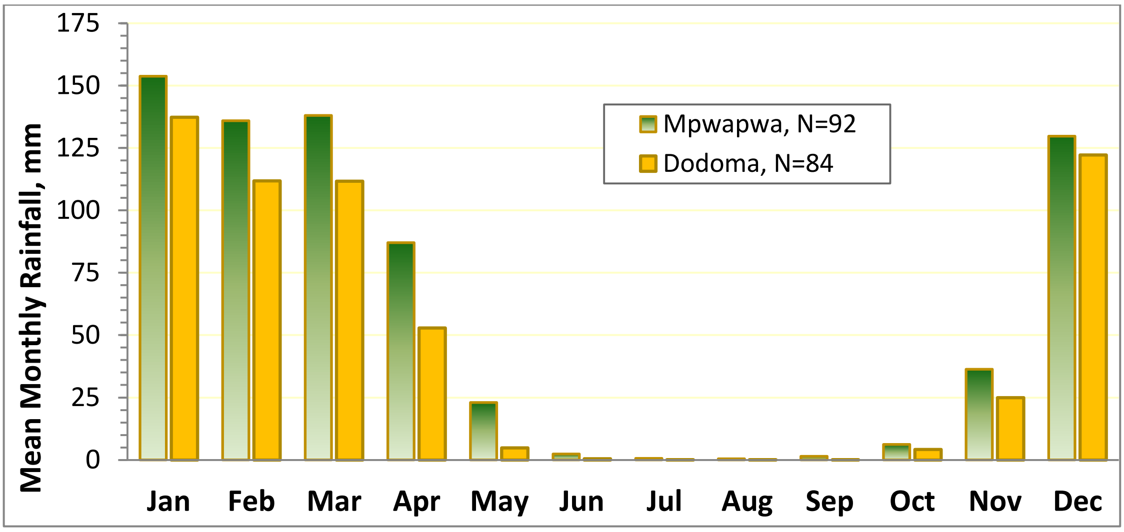
Figure 63: Historical mean annual Tmax and Tmin variations at Dodoma



7.2.2 Rainfall/Evapotranspiration

The district is predominantly arid, with rainfall that is highly variable, ranging from droughts to devastating floods. These floods are mainly a result of storm water from the upper catchment areas. It varies within the district, which is apparent when the data from the two meteorological stations, at Mpwapwa and Dodoma, used in modelling are compared, as in Figure 64, which shows the distinctly bimodal historical monthly rainfall pattern. It is also noted that most of, and while the rain season (Dec-April) typically receives 600-700 mm per annum, in mountainous areas there can be much heavier rains, up to 1200 mm annum.

Figure 64: Historical mean monthly rainfall at Mpwapwa and Dodoma



Rainfall will progressively become more variable with climate change. Dodoma's historical inter-annual variability is 29.4%. Although difficult to accurately project, and it is assumed that this will increase to 43-44%, but the timing is uncertain. What is certain is that the wet seasons will be shorter, wetter and the dry season longer and drier. Overall, however, the rainfall total will increase slightly, as summarized in Table 33.

Table 33: Median ensemble mean time-slice rainfall projections, mm

CMIP-5 data for Dodoma and Mpwapwa (Bias Corrected)

Station	Historical mean, mm	RCP	Incremental Additions, mm			
			2020-39	2040-59	2060-79	2080-99
Dodoma	570	4.5	-10	-15	30	2
		6.0	7	28	12	32
		8.5	10	-9	-7	30
			Projected Average Total Rainfalls			
		4.5	560	555	600	572
		6.0	577	598	582	602
		8.5	580	562	563	600
Mpwapwa	710		Incremental Additions, mm			
		4.5	-7	-8	29	24
		6.0	-4	13	6	38
		8.5	12	-11	5	33
			Projected Average Total Rainfalls			
		4.5	702	701	738	733
		6.0	705	722	715	747
		8.5	721	698	714	742

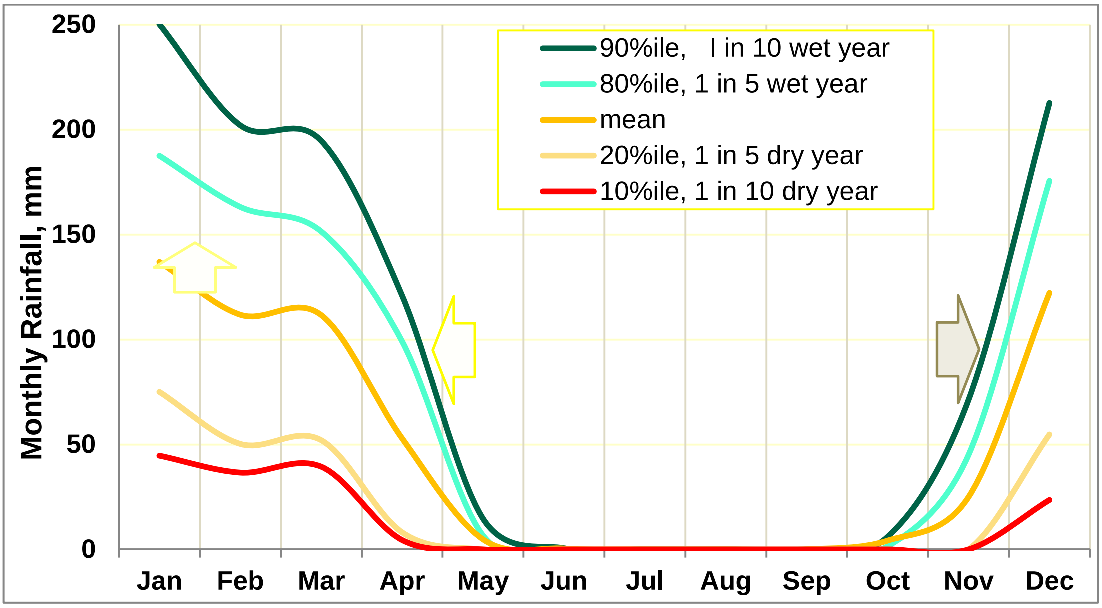
However, the variation in available water from year to year is a more meaningful indicator. Figure 65 shows the historical rainfall distributions for Dodoma for periodic wet and dry years, which are also tabulated in Table 34.

Table 34: Historical Wet and Dry-Year Contrasts in Rainfall at Dodoma, mm

DODOMA	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
90%ile, I in 10 wet year	250	202	195	121	15	1	0	0	0	6	71	213	**1073**
80%ile, 1 in 5 wet year	188	163	151	99	7	0	0	0	0	2	45	176	**830**
mean	137	112	112	53	5	0	0	0	0	4	25	122	**570**
20%ile, 1 in 5 dry year	75	50	52	8	0	0	0	0	0	0	0	55	**240**
10%ile, 1 in 10 dry year	45	37	39	4	0	0	0	0	0	0	0	24	**149**

Using wind run, temperature, relative humidity and estimates of sunshine hours, potential changes in evapotranspiration have been estimated, which indicate a change in the annual daily average from 5.1 mm to 5.4 mm for RCP 6 during 2040-59, and up to 5.7 mm during 2080-99. This increase in water loss effectively cancels out the projected increase in rainfall. The dry season already has essentially zero rain, but as temperatures increase, so also will the soil moisture deficit, so at the break of the rainy season, the runoff is likely to be less than the historical discharges.

Figure 65: Wet and Dry Year Historical Rainfall Distributions for Dodoma



In East Africa, approximately two-thirds of rainfall occur in cumulus cloud bursts, rather than in drizzle or from cold fronts, which occurs in many other regions. This leads to what is known as the East African Paradox, where rainfall may increase in relatively torrential short bursts, but because of temperature loss and rapid runoff, effective precipitation decreases.

7.3 Risk maps

Drought risk

According to climate projections, the wet seasons will be shorter, wetter and the dry season longer and drier and likely variable across the district. As seen in Figure 66, the risk is categorized as "near normal" to "moderately dry" for Nghambi (generally from the northeastern to south-western part of the district), and is therefore not considered severe. Comparatively, the south-western part is much drier than the northeastern part which seems to face an extremely low probability of drought. Any project interventions targeting water access and drought would, therefore, have their highest impact when implemented in and around the brown areas.

Flood risk

Figure 67 illustrates flood risk, which is classified as high across parts of Rudi, Malolo and Kimagai wards. The areas in red are categorized as no risk as they are the highlands. The rest of the areas are categorized as medium to low – including Nghambi.

Erosion risk

Erosion potential in Mpwapwa is high in the areas shaded in red (29-42 tons per hectare per year) covering some areas in Mtera, Mlunduzi, Chitemo, Wotta, Kingiti and Kibwakwe wards. These areas are important for planning EbA measures to reduce erosion and erosion linked damages. **However, the risk is categorized as low for Nghambi.** The rest of the wards in the northern and southern part indicate medium to low erosion potential. See Figure 68.

Figure 66: Mpwapwa District drought hazard map

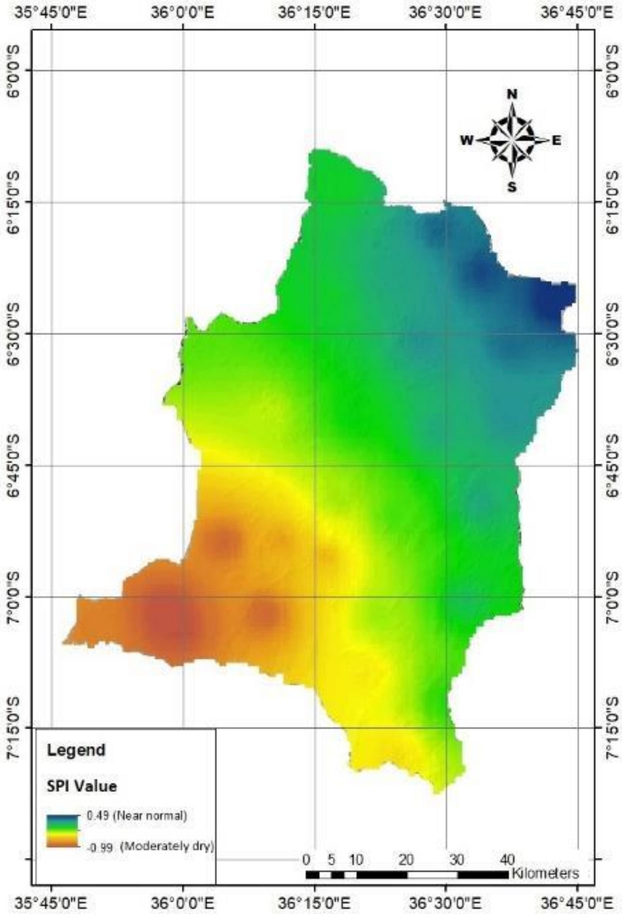


Figure 67: Flood risk in Mpwapwa

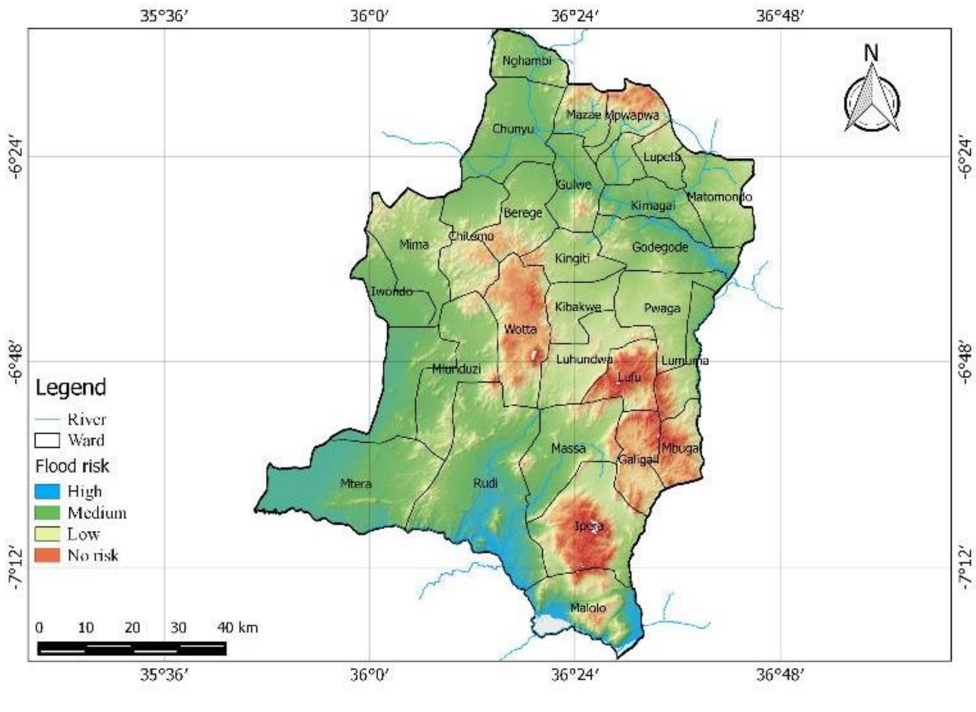
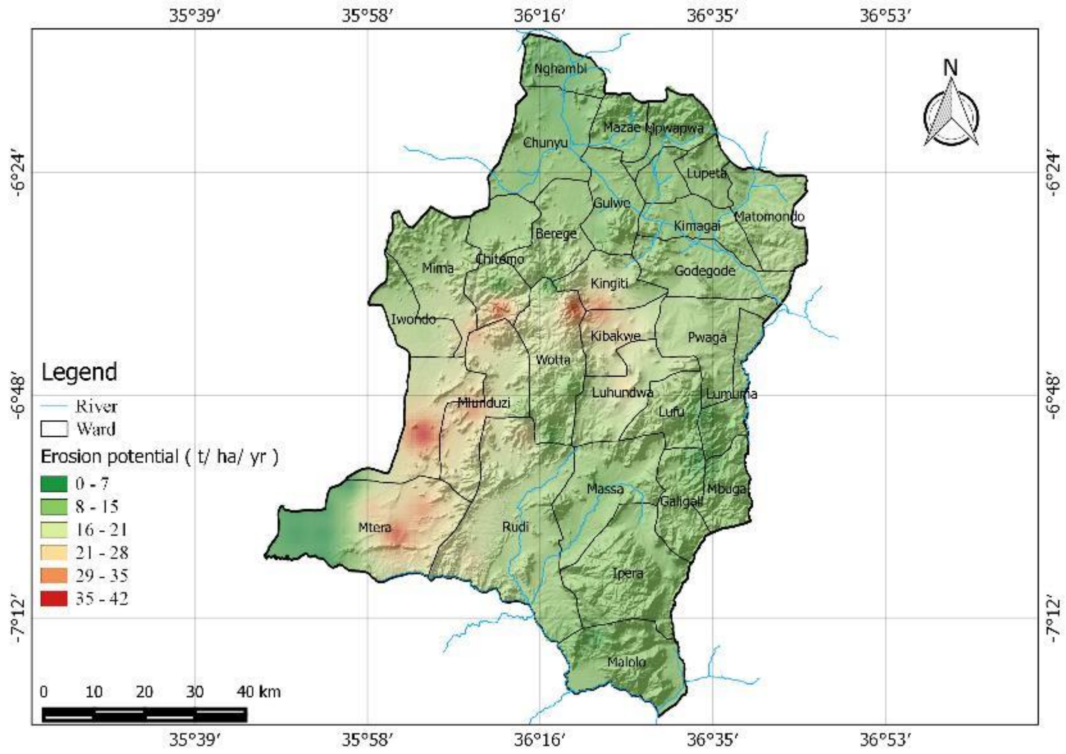


Figure 68: Erosion risk in Mpwapwa



7.4 Climate change impacts for the watershed in the context of current land use

7.4.1 Forests and woodlands

In 2010, Mpwapwa had 87,400 ha of tree cover, extending over 12% of its land area. There are scattered woodland areas across the western side (highlands) of Nghambi. From 2001 to 2018, the district lost 5,940 ha of tree cover, equivalent to a 7.4% decrease in tree cover since 2000; in 2018 alone, it lost 603 ha of it, this is the equivalent to 105,000t of CO_2 of emissions (Global Forest Watch, 2019).

Between 2001 and 2018, 1.13 million t of CO_2 (62,900 t per year) was released into the atmosphere as a result of tree cover loss in Mpwapwa.

Repeated droughts are also observed to cause a decrease in - and in some cases disappearance - of vegetation, as well as the drying up of water sources (e.g. *sungura*, *mgae* and *mtema changele* etc.) Other species affected that have been mentioned during the interactions with villagers and local authorities include *misani, miheme*, and the medicinal plants *mitembwe, mikakatika*

7.4.2 Rangelands, bushlands and grasslands

The area suitable for livestock production and grazing (free-range) in Mpwapwa district is 262,000 ha (35% of total land area). Of this area, 38% is classified as “degraded” or “unusable”. There is currently no overarching rangeland management system in place in the target district, and management of these resources is done according to the National Livestock Policy and National Land Use Planning Commission Act. Land use plans were developed at the national level with collaboration with local authorities (*mkuribita*) for 16 villages across Mpwapwa district – LGAs consulted could not pinpoint which of these fall within Nghambi. However, they are not properly implemented or enforced. The main non-climate threats faced by rangelands in Mpwapwa are pastoralists with permanent residence in or around the district, farmers driving agricultural expansion, human-induced fires and general land degradation due to spread of settlements.

The quality and extent of range, bush and shrublands in Mpwapwa are deteriorating for numerous reasons, including recurring drought, the expansion of toxic, weed-infested areas (Solanum, Jimson weeds, milkweeds, Makongwa and Nightshade weeds) and increase in pests and diseases (e.g. Trypanomiasis-Ndigana Kali). Climate signals such as increasing annual temperatures and highly variable rainfall, as shown in the climate projections report, will have significant negative impacts on rangelands. Water unavailability during the dry season is another major factor, which in turn has adverse social impacts such as water conflicts and migration. Environmental degradation on higher altitudes (especially along the hill ranges in the district) has adverse impacts on soil and general health of rangelands and pastures.

Figure 69: Vast tracts of degraded and disappearing shrub and bushland

Such tracts of land – either cleared for agriculture, or overgrazed - are visible across the whole district as well as other project regions.

7.4.3 Biodiversity

Mpwapwa is surrounded by the Rubeho mountain chain of forest ecosystems. Rubeho forms part of what is known as the Eastern Arc Mountains that run from Taita Hills in Southern Kenya all the way to Udzungwa passing North and South Pare, West and East Usambara and North and South Nguru then Ukaguru and Uluguru. Rubeho Mountain ecosystem covers an area of 156,532ha, spanning Kilosa and Mpwapwa districts. In Mpwapwa, it consists of three national forest reserves (Mafwemela, Wotta and Mangaliza) and nine Village Land Forest Reserve (VLFRs) namely Ipondelo, Ndege, Mbikimkiwa, Mbuga, Galigali, Bulu, Chemchem, Isoliwaya and Kiyegea.

Rubeho has montane and sub-montane forest lowland, woodland characteristics. The forest ecosystem is rich in biodiversity. The Rubeho ecosystem provides service to the community in terms of water for irrigation, hydro-electric power at Lummamu Roman Catholic Mission Centre, water for domestic use, benefits from tourism and research, firewood and non-wood products.

The mountain ecosystem has two vertebrates endemic to Rubeho mountains: the patridge *Xenoperdix obscurata* and the frog *Arthroleptis nikeae*. Other species include Abbott' duiker that is categorized as Vulnerable to extinction by IUCN. Furthermore, twelve Eastern Arc endemic vertebrate species and 22 vertebrate species within ranges that include the Eastern Arc, the coastal forest and/or the southern have also been recorded from this area.

Rubeho, like many other areas in Mpwapwa is facing threats including illegal logging, charcoal production, population increase, uncontrolled fire. The effect of climate change will exacerbate the situation because these non-climatic stress factors contribute to a greater vulnerability to climate change impacts such as recurrent drought and floods that have direct significant negative effects on communities' livelihoods and natural resources, including the availability of and access to ecosystems goods and services. This was evident from communities' reports and from the fieldwork.

Results of baseline and interview with communities reported that natural resources adjacent to their villages are degraded.

Major impacts were observed or reported:

- Drought and water scarcity because people have destroyed and have moved into catchment areas
- A decrease in forest cover
- A decrease in wild animals and microorganisms e.g. Dik Dik and tortoise
- Migration of people due to drought
- The disappearance of some species (*Mikobura*)

The impact was confirmed by the modelling results showing changing rainfall patterns (fewer but more intense storm events), and with greater intensity exacerbating the existing flooding situation. Moreover, discussions with meeting participants confirmed that major changes have been a decreased amount and change pattern of rainfall and temperatures which have resulted in uncertainty in some families and decrease crop production and livestock.

The effect was also seen in bare land of Mpwapwa with no vegetation cover at all in some areas and communities admitted to moving up the mountain to search for forest products and open new land for agriculture, thus perpetuate deforestation and forest degradation.

7.4.4 Water supply

Mpwapwa District is partly in the Wami Ruvu Basin and partly in the Rufiji Basin to the south. The Kinyasunwe River, a major tributary of the Ruvu River, flows through the northern section of the district, including Nghambi Ward. In the south, the Great Ruaha River flows along the southern boundary of the district, into the Rufiji River.

Agriculture and livestock (pasture) are the main economic activities, employing approximately 90% of the people, and in this predominantly arid region, these activities are mostly dependent on rainfall. The land suitable for agriculture is approximately 223,000 Ha, but only approximately 142,300 Ha is cultivated (63%). Water is the limiting factor. Even the well-known Msagali Irrigation Scheme, located elsewhere in Dodoma region, (Figure 70) is dependent on rainfall (NEMC, 2016). There is little irrigation and watering is mostly by hand (RUWSA, 2019). The area suitable for grazing is approximately 262,000 Ha.

Figure 70: Msagali irrigation scheme

For the Mpwapwa District general rural population, the water sources are boreholes, springs, improved wells and shallow wells which serve about 170,000 of the total rural district population of 320891 (53%). Mpwapwa urban is served by the Urban Water Supply and Sanitation Authority (MPWUSSA), an agency established in 2002 with an urban coverage of 69% (RUWSA, 2019).

The district has 33 boreholes, 124 shallow wells (using hand pumps) and 28 water springs and their current condition (November 2019) is summarized in Table 35 below. More specific information on Nghambi is not available. In addition, there are 43 rainwater-harvesting tanks and currently, seven new water projects are underway (bores). As can be seen in the table, a proportion of the water supply sources are non-functional, particularly the shallow wells.

Table 35: Water Supply Sources in Mpwapwa, November 2019

(Source: Mpwapwa District Profile)

Na.	Source	Built Number	Functional	Non-functional sources
1	Boreholes	43	33	10
2	Springs (Gravity)	32	29	3
3	Shallow wells pumping by hands	144	44	100
4	Improved springs	28	25	3

According to the Mpwapwa District Water Profile provided by (RUWSA, 2019), the district has 109 villages, of which 36 do not have a water supply or an inadequate supply. Currently, projects are underway to supply water to seven of the 36 villages, leaving 29 without a water supply such as a bore or well. These villages, which include those in Nghambi, need to obtain water from seasonal rivers or from temporary dug wells (RUWSA, 2019). There are eight rivers, three are seasonal and five are more permanent with pools (NEMC, 2016). During very dry/drought periods, these villages without supply need to get water from nearby villages with a supply, which can be about 5 to 12 km away (RUWSA). Stock watering occurs at rivers or in the charco dams.

Apart from the effects of climate change, river hydrological patterns have been altered by anthropogenic activities, particularly deforestation. The DC (in NEMC, 2019) indicated that storms and floods are now major challenges facing the district every year during the rainy season, which originate in upper catchment areas outside the district. These floods impact on the community, with villages flooded, and downstream river systems degraded. Flooding also results in the loss of agricultural land. The main areas of concern are the Mbori and Mzase River basins[7]. With the changes that have already begun, with a trend towards shorter rain seasons, higher rainfall intensity, with cleared forests, runoff rates increase, resulting in significantly increased erosion potential (see climate projections report for more information). Eroded material from highlands during the storm events is carried downstream and deposited along watercourses, reducing hydrologic capacity, contributing to flooding and further bank erosion. Damage to infrastructure also occurs. In 2015, railway lines near Gulwe Railway station were washed away by flooding in the Mzase River (NEMC, 2016). It was also noted in NEMC, (2016) that damage caused by the floods is mainly manifested in the Mbori and Mzase riverbeds and basin, where there are massive gullies as a result of erosion and sedimentation.

As pointed out in the Modelling report by Stanger (2019), for this project, the runoff is not directly proportional to the rainfall, so an increase of only 10% in extreme rain can, and almost certainly will, result in a much higher proportion of runoff, resulting in greatly enhanced quickflow (flash flooding). In addition, the erosive power of quickflow is approximately proportional to the fourth power of the runoff velocity, so a small increase in extreme rainfall will have a disproportionate impact upon hill-slope, soil and embankment erosion (see Figure 71).

Figure 71: Sedimentation and severe bank erosion along a watercourse

[7] Note: the study team tried to develop on similar information for all project districts. However, the team is only really able to generalize for the other mainland districts, as this type of information was not provided during consultations. The various Water Resource plans that were requested were also not provided. Due to restrictions on time and budget, as per the scope of the assignment, the team did not have the opportunity to visit and assess important parts of the basins in person.

The degradation of the rivers that has been occurring is a result of:

- Forest clearing for building materials, firewood/charcoal making, agricultural development, village/urban development
- Poor farming practices upstream;
- Increased irrigation upstream making less water available for the environment;
- Wildfires and fire caused by ‘slash and burn’ practices
- Agricultural activities on the river banks (vegetable/horticulture) and on the river bed
- Livestock grazing and watering along rivers, which damages the protective vegetation cover, tramples the banks; this also is a major cause of bank destabilization and erosion.
- Brick making is also another main activity along the River Mbori, with disturbance/destabilization of banks and loss of vegetation.
- There are mining activities taking place for copper and gold which can result in the deepening of streams, lowering of the water table and in turn drying (desiccation) of the river;

In addition, the use of rivers and/or charco dams for stock watering and as a village supply has serious contamination issues, with the risk of epidemic diseases. This would become more critical with water scarcity during dry periods when close proximity is unavoidable. Poor agricultural practices and increased sediment loads from eroding landscapes and banks, also impact water quality and fitness as a supply source.

An important issue is the design of charco dams (example in Figure 72). Evaporation rates are high (approximately 2 m/annum) and seepage into the unconsolidated sandy soils also high. Consequently, the actual available storage for domestic supply and stock water is only a small proportion of the total. For a dam of say 2.5 m depth, this can be in the order of 25%.

Figure 72: Charco Dam, large and shallow, with livestock access

In addition to the effects of deforestation described above, and as indicated in the section above, there will be major impacts of climate change with:

- Changing rainfall patterns (fewer but more intense storm events), and with higher intensity exacerbating the existing flooding situation, until reforestation is undertaken
- Less reliable rain and a shorter rain season for agriculture. Already as shown in Table 35 above, there is a major difference between the inter-annual variability in total rainfall with, for example, the 1:5 dry receiving 240 mm (effective precipitation 163 mm) compared to the mean of 570 mm (effective precipitation 372 mm). In a 1:10 dry year there is only 149 mm (effective precipitation 101 mm). There is also an increased drought probability. This inter-annual variation will increase.
- The changing rainfall patterns and increased runoff rates will result in reduced aquifer recharge, and groundwater availability.
- With the longer and drier dry seasons, the inter-annual variability with years of below-average rainfall increasing in frequency, the shortage of water for many villages and stock will become even more critical.
- As temperatures increase the rate of evaporation increases from water surfaces in water storages, reducing the usable storage volume.
- As water becomes scarcer, without interventions, people will need to travel more to obtain water, taking a lot more time which could be better spent on other activities. In the longer dry and drier seasons, rivers and dug wells may dry out well before the next rain season.
- Potential to take part in other economic activities. Some buy water.

- Seasonal pattern interruption due to increased temperature and drought
- Failure of government projects and district initiatives due to water decline
- Drying of water resources (e.g. charco dams) and reduced aquifer recharge

7.4.5 Agriculture

Area suitable for crop production is 223,000 hectares. Only 142,277 ha are cultivated (63%). Main food crops grown are maize, millet, beans, paddy and sweet potatoes. Cash crops are groundnuts, onions, sesame and sunflowers. Extension services and use of modern farm implements are among the tools used to ensure an increase in productivity. Frequent droughts over the years have resulted in massive crop failure and livestock loss in this semi-arid area. District officers indicated that storms and floods are now major challenges facing the district every year during the rainy season. The recurring floods result in a significant loss of agricultural land.

With the changes that have already begun, with a trend towards shorter rain seasons, greater rainfall intensity, with cleared forests, runoff rates increase, resulting in greatly increased erosion potential. Gordon Eroded material from highlands during the storm events is carried downstream and deposited along watercourses, reducing hydrologic capacity, contributing to flooding and further bank erosion.

As pointed out in the Modelling report by Sanger (2019), for this project, the runoff is not directly proportional to the rainfall, so an increase of only 10% in extreme rainfall can, and almost certainly will, result in a much higher proportion of runoff, resulting in greatly enhanced quickflow (flash flooding). In addition, the erosive power of quickflow is approximately proportional to the fourth power of the runoff velocity, so a small increase in extreme rainfall will have a disproportionate impact upon hill-slope, soil and embankment erosion.

These scenarios are compounded by the effect of human activities (forest clearing, poor agriculture practices) upstream, on river banks and on the mountains.

The impact of climate change is less reliable rain and a shorter rain season for agriculture. Gordon's report for Mpwapwa shows a major difference between the inter-annual variability in total rainfall with, for example, the 1:5 dry receiving 240 mm (effective precipitation 163 mm) compared to the mean of 570 mm (effective precipitation 372 mm). In a 1:10 dry year, there is only 149 mm (effective precipitation 101 mm). There is also an increased drought probability. This inter-annual variation will increase. Communities confirmed cases of floods and landmass washed away.

As temperatures increase the rate of evaporation increases from water surfaces in water storages, reducing the usable storage volume.

7.5 Ongoing adaptation efforts

Forest

Afforestation and reforestation activities for commercial and conservation purposes are implemented on a very small scale. Likewise, beekeeping is promoted locally and has had a positive effect on the pollination of tree species that had come under pressure.

Rangelands

The district has put in place a program to establish pasture fields by providing individual pastoralists and landowners with appropriate seeds. However, further details on the contents and implementation of this program were not available.

In addition, the district has at least 1 extension officer available per ward, who undertake awareness-raising on rangeland conservation, support in enforcing by-laws to manage the resources, and support the Environmental Committee with capacity building tools.

Major gaps in this area include lack of land use plans, lack of resources for more widespread training and awareness, lack of budget for transportation of extension officers and lack of permanent water sources; all major factors in the low adaptive capacity of the district's rangelands. It was also reported at the stakeholder workshop that communities' level of knowledge on pasture cultivation and preservation as well as livestock carrying capacity is missing.

Biodiversity

The root cause of resources degradation in Mpwapwa (e.g. gullies) is human activities in the upland and accelerated by the effects of recurrent drought and floods due to climate variability. Key informants revealed that deforestation and forest degradation is highly influenced by governance challenges such as lack of political will at lower levels, including conflicting interests and motives of policy and decision-makers. Most of the activities implemented are scattered (not streamlined), and measures are neither systematically implemented nor comprehensively reviewed.

Adaptation measures so far missing on a significant scale in the district include:

- Conservation of water sources and catchment areas through tree planting and by-laws enforcement, awareness and education
- Proper enforcement of land use plans
- Sensitization and awareness on natural regeneration and coppicing

Water supply

At the present time, RUWSA are providing bores for seven villages, which did not have a water supply in the village. This leaves 39 without a supply, but which will be eventually provided a bore.

Climate change-related programmes and projects in the target region, relevant to EbARR

- National Livestock Research Institute Animal breeding and production (cattle, poultry, goats, sheep, pig)
- Livestock Training Institute Training of farmers, livestock keepers and extension officers
- Diocese of Central Tanganyika Farmers training Provision of inputs of soft loan
- District Prison Farmers training through Farmers Field Schools (FFS)
- INADES Promotion of farmers innovator services, local vegetable seed production, Training of farmers
- TVLA-Tanzania Veterinary Laboratory Agency Support farmers in poultry (chicken) keeping and vaccination programme
- ASA-Agriculture Seed Agency Support farmers in seed production and seed supply.
- TOSCI-Morogoro Certification of seeds
- TAHA (Tanzania Horticultural Association) Training Farmers on Horticultural crops

Most of these programs listed are long-term and many do not have end dates. Of these, TAHA and ASA are particularly suited to support the Ministry of Agriculture in achieving its CSA objectives. More information on the results of these initiatives are missing, as there is a lack of communication between various actors involved.

7.6 Interventions

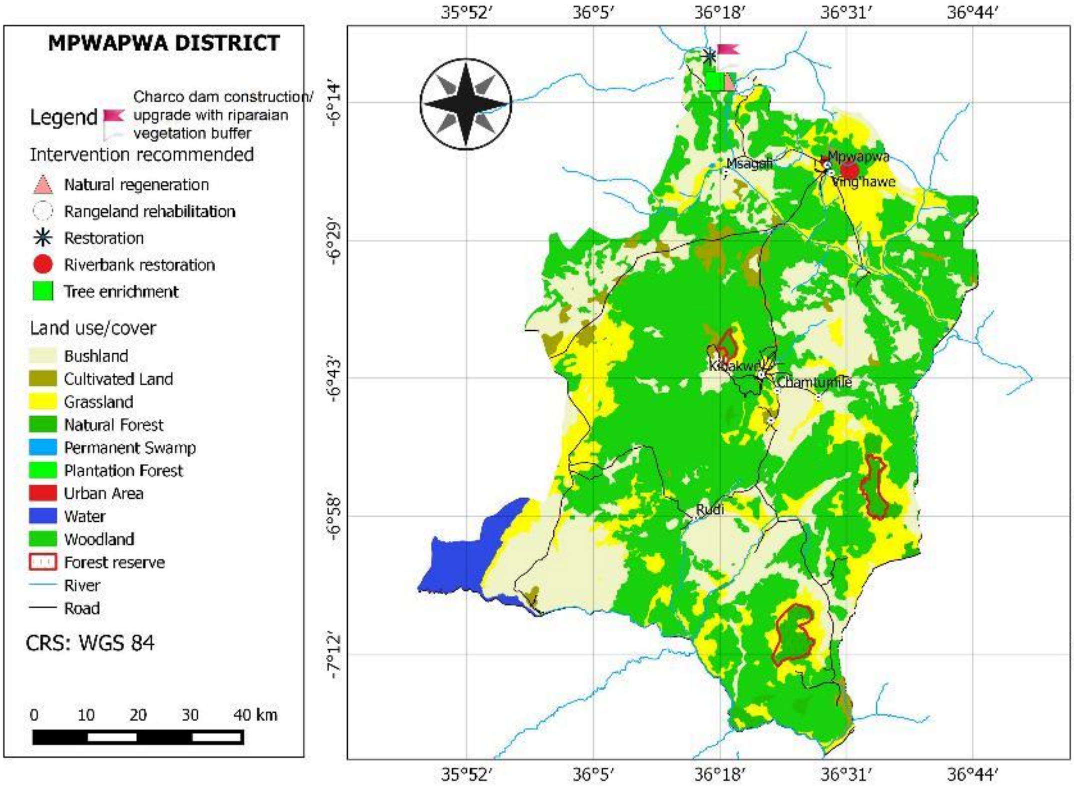
Table 36 summarizes the ecosystem level issues and impacts facing the community, as identified in the multi-stakeholder workshop held in November, as well as suggested or desired interventions. Although most issues are linked directly to climate change, some are only indirectly connected (e.g. exacerbated by climate change).

Table 36: Issues and interventions identified in multi-stakeholder workshop in Mpwapwa

Issue		Intervention
Major issues identified	**Impacts to community**	
▪ Increased incidence of drought ▪ Proliferation of pest, weed and disease (Kidua, army worms) ▪ More intense floods and soil erosion ▪ Reduced water quality (saline) and access, particularly in dry season, decreased aquifer recharge ▪ Disappearance of water sources (e.g. *sungura*, *mgae* and *mtema changele)* ▪ Desertification and overall environmental degradation ▪ Disappearance of biodiversity (*misani, misani, miheme, mitembwe, mikakatika,* dik-dik, tortoise and various micro-organisms*)*	▪ Decreased crop productivity ▪ Farmer pastoralist conflicts (both in Nghambi and Kazania villages) ▪ Agriculture moving into mountain areas (in search of fertile soils and water), causing further land degradation ▪ Livestock productivity declining (emerging pest and disease e.g. trypanomiasis-Ndigana Kali and decreased pasture area, water) ▪ Lost opportunities for income (esp. women) due to lack of water nearby ▪ Migration of communities into cities/other areas ▪ Failure of various government and donor funded development projects due to lack of water and capacity development	▪ Developing land use plans ▪ Tree planting and afforestation to reduce erosion and effects of drought ▪ Plant drought resistant crops such as millet, cassava and sunflower ▪ Rainwater harvesting ▪ Farming field school ▪ Crop rotation ▪ Agroforestry (cashew nut) ▪ Cultivation of pasture and fodder ▪ Charco dam construction (strategically placed) ▪ Building cattle dips ▪ Improved animal husbandry (also beekeeping, chicken, goat rearing, dairy production etc.) ▪ Alternative energy sources ▪ Awareness raising on land use planning and management

Based on expert observations and inputs of workshop attendants, the study recommends four EbA interventions around Mpwapwa district. In Nghambi ward, there is urgent need for strategically placed charco dams with buffer vegetation, tree enrichment and natural regeneration, as well as rangeland rehabilitation in the degraded patches around the ward. Around Mpwapwa ward, it is recommended to undertake highland riverbank rehabilitation for stabilization (see Figure 73).

Figure 73: EbA interventions recommended in Mpwapwa



8 IMPLEMENTATION OF INTERVENTIONS

This chapter provides a so-called process or guideline that can be used by EbARR to plan and implement the four major categories of EbA interventions proposed. Please note that this is a general guidance, which must be elaborated and updated for each project district, based on locally-specific conditions and capacities, and in collaboration with LGAs working on the ground. Particularly all interventions relating to riverbank restoration will require close cooperation with the Basin Authority and local research institutes to perform more in-depth studies on river and water dynamics. All forestry related interventions should be finalized with support from the forest department and NGOs active in each area (listed in the district profiles above), as many activities are already being undertaken and can be scaled-up quite easily. Rangeland rehabilitation interventions should be undertaken simultaneously with – or following – the development of village land use and rangeland management plans.

8.1 Riverbank restoration

Issue

It is normal for rivers to erode to some degree and for rivers to meander across flood plains. A most important **ecosystem service** is the regulation of flows by vegetation cover, particularly natural vegetation, including forests, woodland and grassland/shrubland. The forests and woodlands on the ranges where watercourses have steeper grades and high erosion potential are particularly important. Changes to hydrological patterns have occurred though catchment wide land-use changes, which result in the loss of this vegetation, resulting in increased velocities, erosion, downstream sedimentation and increased flooding. The clearance or loss of protective riparian vegetation on river banks leads to loss of habitat, further erosion and sedimentation.

Process

Ideally, river works should planned on a whole of catchment basis, and consider the whole length of the river system, as work done along one stretch may affect downstream stretches. A master plan would be prepared as part of an overall Integrated Catchment Water Management Plan (or Catchment Water Resources Plan). This would provide important hydrological information on velocities, frequency of various size flow events etc. River works would be integrated with broader land-use/erosion control strategies, such as reforestation. It may also involve the use of flood control structures, or measures to increase groundwater recharge.

In the absence of an over-arching plan, successful works can be undertaken. Site specific assessments of rehabilitation work requirements should be undertaken in the first instance by an experienced civil engineer. **Ultimately works should aim to establish a stable and self-maintaining cover of vegetation on the banks and a riverine corridor on both sides.**

It is important to appreciate that it is normal for rivers to erode to some degree and for rivers to meander across the floodplain. Consequently the complete control of these processes is not possible. These processes naturally usually occur over a very long time frame and have shaped the landscape, with our valleys and plains. It is the accelerated rate of change due to human activities which is problem.

Types of works include:

River alignment

- Use of mesh fencing or brush fencing (when material available) to train a river to desired alignment, along with vegetation establishment
- Construction of rock groynes to deflect current and/or deposit sediment in embayments.

Bank protection and rehabilitation

- Use of rock wall to protect urban areas, infrastructure

Figure 74: Example of engineering works around Mpwapwa

Protective works

- Use of logs secured to bank.
- Rockfill, either on its angle of repose or gabions placed on a prepared bed.
- Removal of lopping of undermined trees which are in danger of falling to prevent loss of bank material and also prevent the fallen tree being an obstruction, causing scour, deflecting flows onto banks with increased erosion and also reducing the hydraulic capacity of the channel.

Figure 75: Lack of vegetation around water bodies observed across all project regions

High rates of sedimentation, trees being undermined, eroding banks with minimal protective vegetation needing stabilization

- Re-establishment of protective vegetative cover to as great a width as practical, with trees, shrubs and grasses/groundcovers, which also requires:
  - Protection of areas being rehabilitated from stock access.
  - Providing nominated stock watering points.

Preventing bed erosion

- Use of concrete drops or rock shuts, as grade reducing structures, which would need to be consistent with waterway area requirements.

On a larger scale:

- Works could involve desilting to maintain channel capacity and the use of levee banks to reduce the extent of inundation (flooding) during large events.
- Controlling erosion rom road runoff, which causes gullying and the deposition of silt loads into watercourses. Road runoff management also provides an additional opportunity for water harvesting.

8.2 Watershed rehabilitation

Issue

To address the varying forest-related issues identified in this report, the study recommends three sub-categories for watershed level rehabilitation:

- Tree enrichment: using native or non-native species (depending on the very specific site conditions) to increase the density desired species on secondary forests that currently contain few commercial species.

- Natural regeneration: in this case there is no plantation of new seedlings or trees, but the focus is on forest protection from human or natural disasters such as soil degradation, deforestation, diseases and pests infection. In one instance, coppicing is also recommended.
- Reforestation: in cases where forest areas are already installed, the natural or intentional restocking of existing, depleted forests and woodlands is recommended. Reforestation can be used to improve various ecosystem services and supplement incomes as well.

Process

1. Decision on level or scope of intervention, in tandem with VLUP development
   First, it is necessary to develop aims (in tandem with local land use plans and ongoing village/ or district activities), and plan and source the materials and human resources needed. At this stage, a further assessment of the strengths and weaknesses of LGAs and communities help in producing a realistic plan, including the views and expectations of all stakeholders.
   An analysis of the number of beneficiaries, the demand for wood fuel and other forest products, the plantation area, the priority target group, the size of the nursery (in case it is needed), water resources available etc. should be conducted by district technicians.
2. Identification of suitable sites
   The choice of the site strongly depends on the local soil, water, social/policy conditions. During this phase, a technical/land use analysis is crucial to understand the soil properties, the water dynamics and resource availabilities (logistics). The involvement of local leaders and government is essential. Using the risk, land use and intervention maps in this report, LGAs can locate areas, as well as manage and monitor plantations, rehabilitation and protection sites taking in account environmental conditions, site extent, distance from beneficiaries, land use authorization, and current land use or land cover.
   The most important steps after are:
   - Produce land use and management plans with a calculation of the area to be covered (if management plans exist already, update them with this new information)
   - Estimate the work load
   - Start with the most suitable sites to increase the chance of success
   - Gather experience and share lessons learned or resources with existing projects/NGOs
3. Tenure and access rights
   The plan should include when and how the forest products will be harvested and who owns the right to harvest., taking into account existing regulations and laws, the ownership of the plantations and intervention areas, the land, the trees and others assets. These rules and rights should be discussed between the different partners through community leaders using for example posters, meetings and other communication products.
4. Plantation establishment
   - Stakeholder involvement: starting at the earlier planting phase, particularly involving women and ensuring the management plans take into account their capacities, responsibilities and schedules
   - Selection of species: bare land should be reforested with pioneer species because they are adapted to open conditions, whereas secondary species would not perform

as well on such sites because they are unable to take advantage of direct sunlight in the way pioneer species do. The selection ultimately should be done by district technicians, who are most aware of local conditions, availability and feasibility of success. Based on consultations and literature, ficus, mahogany cedar, silky oak, African tulip tree, apple tree, peach, avocado, pear tree, plum tree, moringa, cashew and macadamia in are well advisable. Albizia Shimperiana and Croton Megalacapus, fast-growing species, which will provide communities with a sustainably managed wood resource to avoid cutting within existing forests. Most of these species may already be under consideration in concurrent EbARR project budget lines, as part of agroforestry and alternative income generation efforts.

- Timing: Managers should establish yearly and monthly schedules to ensure successful plantation. Being aware of the time needed for each operation (planning, seedling, production, site preparation and out-planting) will ensure proper scheduling.

In case of availability of nurseries:

- Choose the right species with advise with LGAs
- Find suitable source for seeds or cuttings for the selected species, procure
- Determine whether the plantation will be established by direct sowing or by planting seedlings.
- Consider the use of grafting for the propagation of fruit trees in the nursery, with the aim of reducing the time before first fruiting.
- Know how to grow the species in nurseries (if seedlings are required), including seed pretreatment and seedling hardening.
- Indicate tree arrangements (e.g. rows or groups).
- Calculate the number of seedlings or seeds required and divide this by a nursery mortality coefficient to determine the number to be grown in nurseries (if seedlings are to be planted)
- Determine the work required to prepare the site and to outplant and tend the seedlings.
- Determine the need for protection (e.g. with fencing) and the period over which the plantation should be guarded.
- Specify the harvesting techniques to be used and the work involved.
- Specify the type of pits to be dug and the harvesting techniques to be used.
- Calculate the theoretical harvesting age or diameter and indicate the sustainable harvesting level and rotation length.
- Determine whether watering will be required, and if so, ensure water supply.
- Is fodder harvest possible? If so, indicate the beneficiaries and the allowable harvest.
- For planting inside camps, seedlings can be distributed directly to the community. This will also ensure community buy-in.

A note on coral rag restoration

Coral rag forests are scrub forests, which are intermediate in structure (i.e. between forest and bushland and thicket), usually 10 - 15 m high. Trees (woody plants with well-defined and upright boles) are usually present but do not form a closed canopy. Smaller woody plants (principally bushes and shrubs) contribute at least as much as the trees to the appearance of this vegetation type. The vegetation comprises of evergreen thickets that are the climax vegetation types on shallow, easily desiccated soils that lie over coral limestone.

Coral rag restoration is already underway on a small scale in Zanzibar, and EbARR may support LGAs with their existing interventions to scale up the effects.

A note on coppicing in Mpwapwa

Coppicing is a traditional method of woodland management which exploits the capacity of many species of trees to put out new shoots from their stump or roots if cut down. In a coppiced wood, which is called a copse, young tree stems are repeatedly cut down to near ground level, resulting in a stool.

Coppicing, as part of natural regeneration, is the woodland management technique of repeatedly felling trees at the base (or stool), and allowing them to regrow, in order to provide a sustainable supply of timber. This practice has a number of benefits over replanting, as the felled trees already have developed root systems, making regrowth quicker and less susceptible to browsing and shading. These days the demand for coppice timber is lower, but it remains a popular conservation practice for the benefits it offers to wildlife and to the trees themselves. It is therefore recommended for Mpwapwa. Trees naturally retrench (shedding their branches to extend their lifespan) and coppicing can be an excellent way of simulating this to increase the life of the tree. It also increases woodland biodiversity, as greater amounts of light can reach the ground, allowing other species to grow there.

Coppice or (KISIKI programme) is implemented in Mpwapwa by LEAD foundation. The program targets at least 180,000 households, which is half of the total number of households of Dodoma Region to have restored 180,000 hectares with at least 14,000,000 trees raised through FMNR by 2021 (40 trees in a 2-acre farmland and 40 trees on a half-acre woodland per household). The program also targets at least 2 hectares of communal land per community to be conserved though FMNR and rain water harvesting techniques through community management making a total of 600 hectares communal land conserved in 300 communities. It is proposed that the EbARR project support the KISIKI program with future and ongoing coppicing activities.

8.3 Charco dam construction/upgrade

Issue

Water supplies harvested in small dams, which include charco dams, hillside and Valley dams are essential for human use, stoke water and irrigation supplies. This water is required for the dry season, however, in many instances these are drying up well before the onset of the next wet season, particularly during periodic dry years of below average rainfall. The charco dams observed during the EbARR Missions appeared not to be well designed, in that they were too shallow. This would not allow the water resource to be efficiently used, because of the scale of evaporation and seepage losses. In addition, the use of dams for stock watering and as a village supply has serious contamination issues, with the risk of epidemic diseases. This would become more critical with water scarcity during dry periods when close proximity is unavoidable. Poor upstream agricultural practices and increased sediment loads from eroding landscapes and banks, also impact water quality and fitness as a supply source.

Process

Information should be available to assist in the design, construction and maintenance of dams, for the efficient use of harvested water. For this purpose the following handbook, prepared for use in East Africa, is recommended as a guide:

Water from Small Dams: A handbook for technicians, farmers and others on site investigations, designs, cost estimates, construction and maintenance of small earth dams. Erik Nissen-Petersen, for Danish International Development Assistance (Danida) 2006.

This handbook provides information on site investigations, design, cost estimates, legal issues and construction and maintenance. The handbook, while available to all, could be a district level resource, used by district technicians in the initial planning and design of dams.

Key design points addressed include:

- Size of dam

Evaporation rates are high (approximately 2 m/annum) and seepage into the unconsolidated sandy soils also high, and the handbook assumes 1m/annum as indicative. Consequently, the actual available storage for domestic supply and stock water is only a small proportion of the total. For a dam of say 2.5 m depth, this can be in the order of 25%. The volume of water required for human use, stock and irrigation to last the dry season should be estimated and the dam designed to provide this volume, allowing for losses. Dams should be at least 4.5 m in depth. Methods to compact soils by rolling logs are suggested to reduce seepage loss.

- Capturing seepage

Downstream of the dam, wells can be used to harvest the seepage losses from the dam through its base. This may provide water of better quality for human use as it will have been filtered.

- Separating stock

Methods for the separation of stock are outlined, including piping water below the dam to a stock watering point.

- Sediment basins

The design issue of sedimentation is addressed, with upstream sedimentation basins.

Note: A fish, Tilapia Nilotica, that feeds on mosquito larvae, can be raised in borrow pits to reduce the risk of malaria. Mudfish, which can survive even when small dams dry up, can also be raised to increase food supply and cash income.

8.4 Rangeland rehabilitation

Rangeland rehabilitation is entirely dependent on the formulation and enforcement of land use management plans. Three subcategories of this intervention are proposed:

- Demarcation of exclosure zones, watering points etc.
- Pasture establishment
- Pests and weeds control

Demarcation and pasture establishment

It is recommended that EbARR upscale *Ngitili* practices wherever possible. In this approach, areas are demarcated and remain closed to livestock during the wet season and are then opened for grazing at the peak of the dry season. *Ngitili* areas are traditionally established on degraded land and around homesteads. They vary in size from 0.2 to 20ha for private ones to 50ha for communal *ngitili*. The boundaries are usually not rigidly marked, and physical barriers are not established, but ownership rights are well respected. The *ngitili* are protected via by-laws enforced by the traditional local guards (*sungusungu*), and offenders must pay penalties (hence the need to write these into VLUPs). The site selection for *ngitili* establishment is influenced by land availability, proximity to homesteads and ease of protection. Initial siting of the area is the responsibility of the household head. In the case of private or communal *ngitili*, a group of elders becomes responsible (Kilahama, 1994a). The potential sites are demarcated at the beginning of the wet season. Once the *ngitili* are demarcated and closed for protection, very little or no management is required during the rainy season. Grazing starts in July or August, at the peak of the dry season, after the crop residues and fallow vegetation have been depleted. The most common system involves temporary demarcation of paddocks for specific periods. Upon the completion of fodder on a particular paddock, animals are moved to a fresh paddock. The demarcation of paddocks and the movement of animals between them is controlled by experienced elders, who make management decisions on the basis of specific indicators such as the utilization level and the availability of fodder. Management should be aimed at optimizing fodder and thatch grass production and growth of other vegetation species, hence improving biodiversity. Large trees which would possibly deter grass growth are deliberately removed, while fodder trees are protected.

Guidelines and plans to produce these participatory management documents are already in place. The participatory LUP (Land Use Plan) guidelines of 2011 (revised version) detail six main steps to follow when developing VLUPs (Village Land Use Management Plan), as follows:

1. Preparations at district level (including NGOs/CSOs and all district level technicians)
2. Participatory rural appraisal (with full consultation and participation of communities, or at least community heads, with specific inclusion of women and minorities)
3. Mapping existing village land uses
4. Participatory village land use planning (PVLUP) including rangeland resources mapping
5. Implementation of village land administration: enhancement of tenure security
6. Village land use management implemented

Demarcation must occur through participatory land use management plans (both at the village and rangeland level), which is a highly time and resource intensive exercise (to be covered through an alternative EbARR project budget line). Communities, with support from district technicians and the project, should identify the most degraded as well as convenient locations to demarcate and sustainable manage, keeping in mind access to water sources, livestock routes and local conditions. In Simanjiro and Kishapu, pasture rotation practices are already in place and must be scaled up to include more pastoralists and villages. In specifically marked points, where pasture has degraded beyond use, it is recommended that DTs and communities establish new pasture. While pasture seeds and extension support is already offered to some extent from the government and certain NGOs, EbARR can contribute to the scaling-up of these efforts through provision of seeds, establishment of water sources, rangeland management capacity building and general extension support. Appropriate species should be chosen based on local experience.

Weed and pest control

Controlling undesirable plants on rangeland is also an important part of an overall range management program. Undesirable plants use space, moisture, and nutrients that could be put to better use producing forage for grazing animals. Poisonous plants are an additional threat to animal health and productivity. Methods often used in range management are chemical, roto-beating, plowing, disking, railing, chaining, burning, reseeding, and changes in grazing schedules. There is however a local preference and interest in biological management options. Under this category, suggestions include foreign exploration and introduction of exotic insects, notes, and plant pathogens as biocontrol agents; augmentation of native biocontrol agents, especially plant pathogens; grazing systems; and positive and aversion conditioning for various classes of livestock to use against troublesome weeds or brush or to avoid palatable poisonous weeds. The aim of bio-control is to improve ecological systems by using biotic agents to restore target plant species to lesser competitive intensities or even to negate their effects so that they do not cause damage to livestock. The usual results of biocontrol are improved agricultural production, improved ecosystem functions and status in terms of species richness and diversity of plant and animal communities, and improved protection of rare species. The project must make an in-depth and balanced evaluation of risks, benefits, and the potential for success, in close cooperation with district technicians who are already looking into these techniques and applying them on a small-scale (Quimby 1991).

9 BEYOND THE VIA

Climate change is increasingly a fundamentally social problem, highlighting the need for prompt and informed actions to address it. The evidenced climate related effects to ecosystem's services and livelihood providing sectors (agriculture, livestock, fisheries and coastal ecosystems, wildlife, forestry and water) in many places in the country has enormous impacts leading to declining incomes, threats to livelihoods and the overall impacts to the country's Gross Domestic Product (GDP). Moreover, the unprecedented effects of climate change have affected ecosystems and people differently; with women, children and marginalized being grossly affected. It should be underscored here that, women are often responsible for gathering and producing food, collecting water and sourcing fuel for heating and cooking. With climate change, these tasks are becoming more difficult. Ultimately, these impacts call for deliberate and concerted efforts in addressing in the country across levels and scale. With the adoption of the landscape/ Catchment approach, The EbARR project posits/ suggests to be one of such intervention to address the situation.

As described in various chapters and sections of this report, the Vulnerability Impact Assessment (VIA) was well informed by a vigorous, systematic and a step-wise climate modelling and projection for the past, current and the future situation. Risk maps covering probability of erosion, floods, drought to occur as well as Land Use/ Land Cover changes were also developed to inform the VIA study. Through gender-inclusion, informed stakeholders' consultations in the project sites and at the national levels were held and quite substantial information were gathered to inform the study.

Figure 76: Discussions organized to ensure balanced representation of women and minorities

Both EbA approaches and conventional interventions/ approaches were suggested and developed for each project site. Since the VIA study focused more on EbA approaches, one comprehensive approach/ intervention titled reforestation and restoration of coral-raged forest was suggested and adopted for Kaskazini A district while three EbA interventions were suggested and adopted for each of the four districts in the Tanzania mainland. Furthermore, to complement all these EbA approaches a set of conventional approaches, which creates/ serves as an enabling environment are also suggested in the report. A team of Consultants for the VIA study notes the usefulness of deploying the two approaches concurrently for meaningful results and enhanced rural communities' resiliency in the country. Furthermore, it is the expectation of the VIA consulting team that, if multi-sectoral and multi-stakeholders' engagement is done in the implementation of the proposed project activities, then these interventions will realize the expected outcomes for the good of the communities and the country at large.

Despite this thorough study on Vulnerability Impact Assessment, the suggested Ecosystem based Adaptation interventions for Rural Resiliency in Tanzania and its recommendations, more is yet to be studied if meaningful interventions are to be realized in the country. It is however, important to note that, in all the project sites, which the VIA team in conjunction with other project implementers visited during stakeholder's consultations and engagement, an issue of water for domestic and livestock use came out very strongly. Unfortunately, the current harsh climatic state as well as the massive environmental degradation evident in the project sites indicates that demand for water will heighten as time mounts. As such, the VIA team calls for deliberate effort to undertake several studies for the good of communities' livelihoods. The studies may include but not limited to:

- A study on the potential of underground water in the project sites so that deep water wells are established/ drilled. If the geomorphology of different places is studied and understood, strategic water points and sources will be mapped and water will be made available for the good of the communities and the country as a whole.
- A study on the potential and possibilities of undertaking massive rainwater harvesting projects for use during drought seasons. As it stands currently, no serious and huge projects that serves that purpose despite heavy rains during rainy season; leading to losses and wastage of water to the oceans/ soil seepage/ percolation unprofitably.
- A study on geomorphology and soil characterization so that among things, the EbARR project/ Stakeholder can understand what species are needed and suggest other landscape approach interventions that can be deployed for the good of the sites and communities' livelihoods. This can also include various ecosystem services provided in the certain contextual environments.
- A study for documentation of various similar studies and climate change related interventions in the project areas so that synergies can be established for complementarity.

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11 ANNEX

VIA second mission schedule

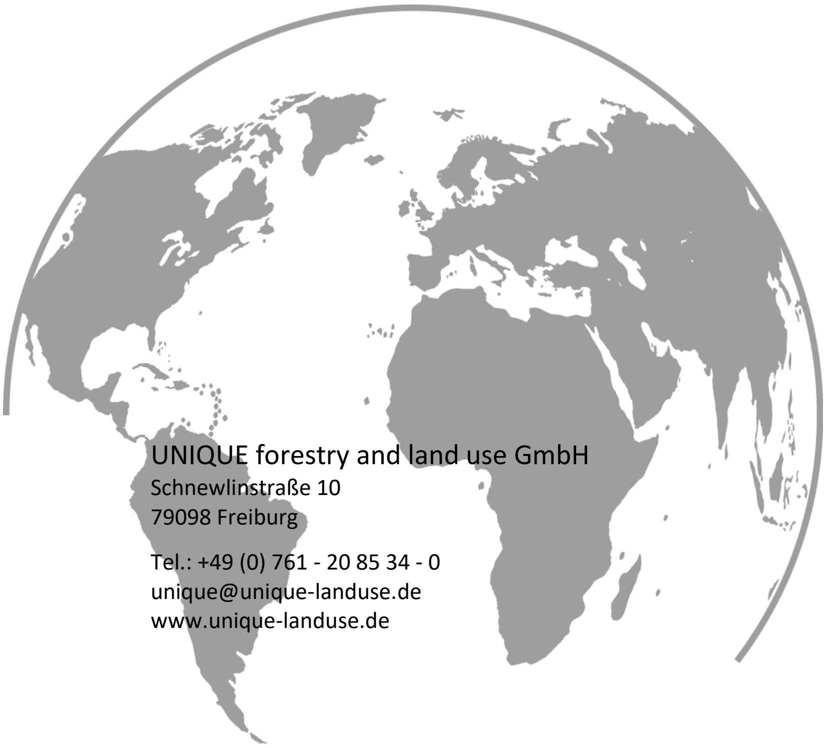
Date	Place	Notes	
10.11.2019 Sunday	Dar es Salaam	Morning	Internal team meeting; finalizing presentations for workshops
		Evening	Travel to Zanzibar
11.11.2019 Monday	Zanzibar	-	Field visits – Kaskazini A
12.11.2019 Tuesday	Zanzibar	Morning	Stakeholder workshop (Kaskazini-A)
		Evening	Travel to Morogoro
13.11.2019 Wednesday	Dar/Morogoro	-	Field visits - Mvomero
	Morogoro		
14.11.2019 Thursday	Morogoro	Morning	Stakeholder workshop (Mvomero)
		Afternoon	Meetings with district authorities
15.11.2019 Friday	Travel Day	-	Consultant team splits into two – one team travels to Kishapu; one team to Simanjiro
16.11.2019 Saturday	Report writing/ buffer day	-	Report writing, data analysis
17.11.2019 Sunday	Team 1: Shinyanga Team 2: Manyara	-	Field visits - Kishapu/Simanjiro
18.11.2019 Monday	Team 1: Shinyanga Team 2: Manyara	Morning	Stakeholder workshop (Kishapu/ Simanjiro)
		Afternoon	Field Visits, stakeholder meetings/report writing
19.11.2019 Tuesday	Travel to Dodoma	Travel Day	Team 1: travel from Shinyanga Team 2: travel from Manyara
20.11.2019 Wednesday	Dodoma	Morning	Meet the Director of Environment Field visits - Mpwapwa
21.11.2019 Thursday	Dodoma	Morning	Stakeholder workshop (Mpwapwa)
	Dodoma	Afternoon	Individual meetings with stakeholders as necessary - Mpwapwa
22.11.2019 Friday	Dodoma	Morning	Wrap up meeting with VPO
	Dar es Salaam	Evening	Return to Freiburg/Adelaide

Workshop agenda

S/N	Agenda point	Time/duration
1.	Introduction to the project	09:15 – 09:30 (15 minutes)
2.	Climate projections	9:30 – 10:05 (35 minutes)
3.	Climate change impacts across target sectors	10:05 – 10:20 (15 minutes)
Break - 10:20 to 10:40 (20 minutes)		
4.	Group work (a) Identification of sectoral impacts (b) Selection of ecosystem service indicators (c) Risk mapping	10:40 – 11:55 (1 hour 15 minutes)
5.	EbA Interventions	11:55 – 12:35 (40 minutes)
6.	Wrap up and way forward	12:35 – 13:00 (25 minutes)

Guiding questions for stakeholder consultations during VIA

1. What is the community's understanding of weather/ climate and climate change in the District, ward and Village?
2. What has been the rainfall and temperature pattern in the District and wards since 1970 to date?
3. What changes are seen and associated impacts of climate change on livelihood sectors notably:-
   - Agriculture?
   - Livestock (Rangelands)?
   - Water?
   - Forestry? and,
   - Ecosystems?
4. What other/ additional stressors/ drivers on livelihood sources/ sectors in the District and their particular areas (Wards and villages?)
5. What have been the sources of energy for daily use in the Districts and their wards/ villages?
6. What development programmes/ projects are implemented in Districts, wards and villages in particular?
7. How have the communities been adapting to the associated impacts of changing weather or climate and other stressors/ drivers on their livelihoods sectors? (What are the coping/ adaptation Strategies?)
8. How are women integrated in the development and implementation of programmes and projects as part of strategies to enhance resiliency in their areas?
9. Any other issues that are important to contribute to VIA report?



UNIQUE forestry and land use GmbH
Schnewlinstraße 10
79098 Freiburg

Tel.: +49 (0) 761 - 20 85 34 - 0
unique@unique-landuse.de
www.unique-landuse.de