



NEW APPROACHES TO UPSCALE RESILIENCE AND ECOSYSTEM-BASED ADAPTATION PROJECT

ASSESSMENT OF IMPACTS OF CLIMATE CHANGE ON ECOSYSTEM IN SAME, SIMANJIRO, KITETO, CHEMBA AND MUFINDI DISTRICTS FOR POLICY ADVOCACY AND RESTORATION PLANS SUGGESTIONS



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1.0 Introduction

Climate change refers to long-term shifts in weather elements patterns. The weather elements include temperature, rainfall, relative humidity, solar radiation and wind. The shifts may be natural, but recently the human activities have been the main driver of climate change primarily through burning of fossil fuels and other activities which produce greenhouse gases such as carbon dioxide and methane.

Climate change is a global problem posing challenges to the survival of mankind and sustainable development. Impacts of climate change include floods, frequent and prolonged droughts, reduced water supply, decline in crop yields, increased vector-borne diseases, and rising sea level. These lead to displacement of people and disruption of both terrestrial and marine ecosystems as well as other important natural habitats. While climate change has global impacts, poor countries and communities are the most vulnerable because of their high dependence on natural resources that are directly impacted by climate change.

In Tanzania, the impacts of climate change are already evident and are manifested through changing patterns of rainfall, flood events, temperature and droughts. Tanzania's economic base is dependent on the climate sensitive natural resources, making the country highly vulnerable to the adverse impact of climate change. This calls for efforts in mitigation of and adaptation to climate change impacts to ecosystem to be spearheaded by both public and non-public sectors.

Ecosystems are dynamic communities of plants, animals, and microorganisms interacting with their physical environment as a functional unit. Effects of climate change reduces the ability of the ecosystem to offer the ecosystem services, thus affecting human beings and their well-beings as they depend entirely on the ecosystems. All human beings depend on the benefits that ecosystems provide. The benefits that people receive from ecosystems are referred to as "ecosystem services". Ecosystem services are essential for human beings, and they work in a complicated and interconnected way that they cannot be replaced by technology. Ecosystem services can be divided into four main categories: 1) provisioning services, which include food, fodder and building materials; 2) regulating services, which include water quality, storm protection, climate regulation, and hydrological regulation; 3) cultural services, which include recreational, tourism and religious values; and 4) supporting services, which include soil formation and habitat provision.

Adaptation to climate change is the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. It involves developing a set of initiatives and

measures aimed at reducing the vulnerability of socio-ecological systems to the potential impacts of climate change. Adaptation measures focus on short and long-term solutions, and consider socio-economic needs, ecosystem management components, disaster planning and management, among other aspects. Restorations are needed in order to reduce the effects of climate change.

Ecosystem restoration means assisting in the recovery of ecosystems that have been degraded or destroyed, as well as conserving the ecosystems that are still intact. Healthier ecosystems, with richer biodiversity, yield greater benefits such as more fertile soils, bigger yields of timber and fish, and larger stores of greenhouse gases. Restoration can happen in many ways – for example through actively planting or by removing pressures so that nature can recover on its own. Restoring ecosystems large and small protects and improves the livelihoods of people who depend on them. It also helps to regulate disease and reduce the risk of natural disasters. All kinds of ecosystems can be restored, including forests, farmlands, fisheries, managed plantations, and wetlands. Restoration initiatives can be carried out by almost anyone, from governments and development agencies to businesses, communities and individuals because the causes of degradation are many and varied, and can have an impact at different scales. However, enabling policy and regulatory environment is crucial for all players to participate in restoration initiatives. Direct contributions of the governments to efforts is also important.

2.0 Objective

The objective of this work was to assess the impacts of climate change on ecosystem in Same, Simanjiro, Kiteto, Chemba and Mufindi districts for policy advocacy and restoration plans suggestions. Specifically, the objectives were:

- i. To understand the status of climate change and its impact on ecosystems
- ii. To suggest restoration plans and areas where local (district) governments can make interventions

3.0 Methodology

This work employed use of survey questionnaire as a tool for extracting the information through key informant interviews (KII's) and focused group discussions (FGD's). The work was validated through validation workshops conducted in each district after preparation and presentation of the initial district reports.

3.1 Selectin of Key informants and focused group discussion participants

The key informants were selected based on their working position and expertise on an ecosystem which is affected by climate change. The key informants were experienced staff or heads of the following units in the district: livestock, crops, fishery, forestry/natural resource, water resource, and community development. Key informants were also drawn from local NGO/CBO's, agro processor, agro-input dealers and crop traders.

The focused group discussion participants' selection was done based on their social economic activities. Members were picked from experienced and longtime practicing livestock keepers, fishermen/fish traders, crop/livestock traders, members from women groups and local elders.

The gender balance was considered to have more women participants in both KII and FGD.

3.2 Interview process

The mode of interview for the key informants was one to one dialogue (Fig. 2). The interview was done making reference to guiding questions developed before the process (Appendix 1). The focused group discussion was done by the enumerator posing open questions for discussion and allowing members to discuss. Notes were taken through writing and audio recording.



Figure 1. Key informant interview in Kiteto district



Figure 2. Focused group discussion in Mufindi district

3.3. Validation Process

Validation was done in a one-day workshop organized for each of the five districts to present and discuss findings with district level participants. Participants of the workshops were invited from the District leaders and staff including District council representatives – among them the district Chairperson and vice chairperson, District Administrative Secretary (DAS), District Executive Director (DED), District heads of departments relevant to the study (Planning, Agriculture/Livestock, Community Development, Water, Fishery, Natural Resources), and some select ward and village executive officers. The workshops were meant for the districts authorities to comment and own the reports, and brainstorm on how they are addressing climate change impacts in planning and implementation at district level.



Figure 3. Validation workshop in Simanjiro district

4.0 Findings

The study revealed that climate change have been witnessed in all the project districts (Same, Simanjiro, Kiteto, Chemba and Mufindi) over the past 10 years. It was noted that the temperature has been increasing while the rainfall has been decreasing. It was further noted that despite the general change in trends of temperature and rainfall over the years, the changes are fluctuating within the years and over the years. Thus the climate has been unpredictable and unreliable over time. Causes contributing to climate change impacts in the districts were poor agronomic practices, encroachment and degradation of water catchment areas, charcoal burning, overgrazing, and bush/forest clearing for different purposes, among others. The sections below are presenting assessments of impacts of climate change on ecosystems for each of the five districts and suggest restoration plans and areas where districts can improve their planning to combat the impacts of climate change.

4.1. Impacts of climate change on ecosystem in Same districts and restoration plans suggestions

4.1.1 Impact of Climate change in agriculture

The results indicated that the agricultural sector in Same district has been severely impacted by climate change. The key informant interviews (KII's) participants mentioned the following as effects of climate change being witnessed in agriculture in Same district:

- insufficient soil moisture
- cropping shift,
- increased crop pests and diseases,
- declined soil fertility
- increased human diseases
- occurrence of invasive plant species
- increased soil erosion
- insufficient irrigation water

The same effects except soil erosion were mentioned by members in focused group discussion (FGDs). Furthermore, the members in focused group discussion mentioned unpredictable planting time as one of the effect of climate change. Other effects of climate change in agriculture that could be present but not mentioned by participants in both groups include loss of beneficial soil biodiversity and poor nutrient cycling.

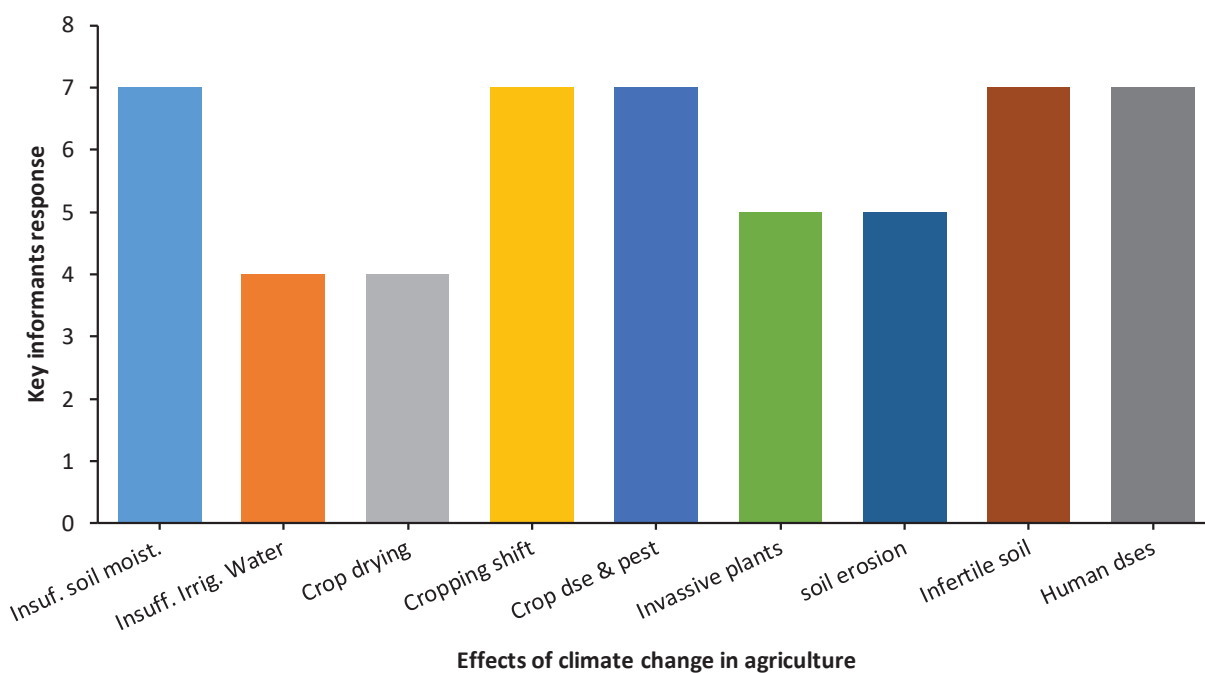


Figure 4: The effects of climate change in agriculture in Same District

The farmers coping strategies to climate impacts in agriculture

The coping strategies of farmers in adapting to the climate change impacts in agriculture in Same were mentioned as:

- use of improved crop cultivars
- use of synthetic fertilizers to increase productivity
- use of synthetic pesticides in controlling crop pest and diseases
- shifting cultivation to open new farms for the search of fertile lands
- cultivation of large farms to obtain the required amount of farm produce

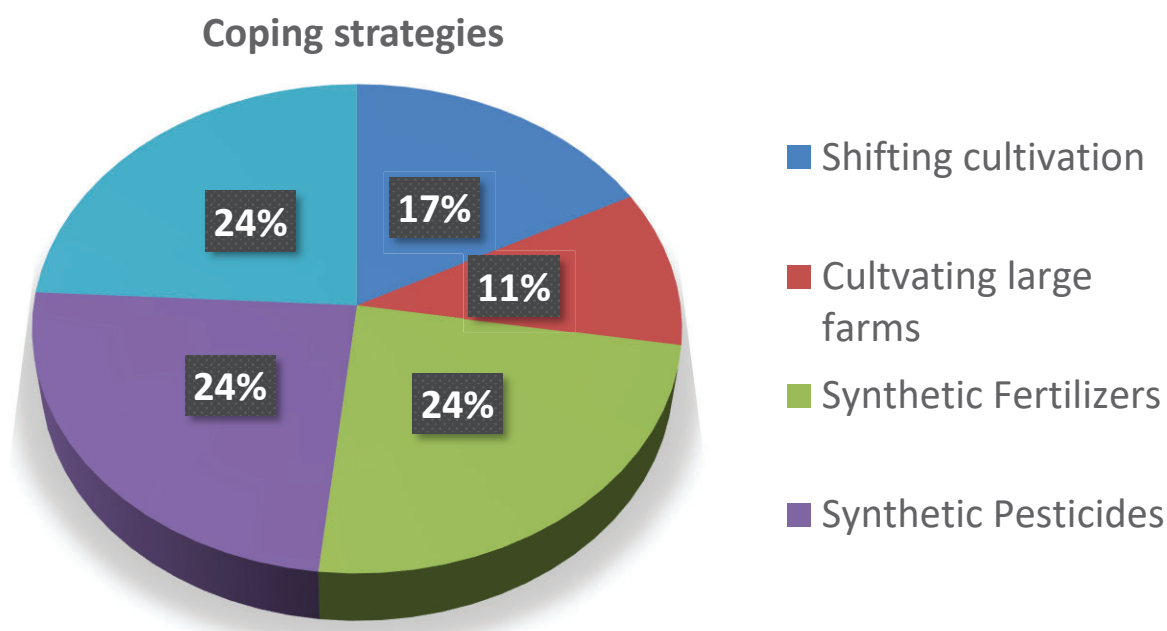


Figure 5. Coping strategies against climate change in agriculture in Same district

Restoration measures and suggested district interventions

There are existing efforts in Same district to restore the degraded land and maintain the agricultural ecosystems that have been affected by climate change. These are spearheaded by the district government and other partners including Same and Mwanga Environmental Conservation Advisory Organization (SMECAO) and Participatory, Ecological, Land Use Management (PELUM) NGO's. The NGO's operate in selected few villages including Mpirani in Maore ward, Vumari, Minyala and Kizungu in Vumari ward. The NGO's offer training in soil and water conservation practices in the selected villages. It was reported that the district sets aside a fixed percent (20%) of cash income collected from agriculture sources to go back and improve agriculture infrastructure. While this is highly commended, we suggest increase in percent and flexibility given the importance of climate change adaptation measures to improvement of agriculture and general livelihood of the people.

The restorations and interventions measures suggested are:

- Investing in water harvesting in the lower side of the district (Ruvu area) where River Pangani passes. It was reported that the river in many years floods during rainy season and when the Nyumba ya Mungu Dam excess water is discharged. The excess water is short lived and causes floods. If structures were present, the water could have been stored and be used in drier periods to support agricultural production. The Ruvu area is known for vegetable production within the Same district.
- Promoting and supporting maintenance, improvement and creation of soil conservations structures including contour bunds, fanya juu and fanya chini terraces are suggested to be established in the high altitude, high rainfall gently to steeply sloping areas of the district. We suggest renovation of the existing structures as well as enforcing them with trees and pasture. We also suggest designing and implementation of new structures in areas where they are not in place within the high altitude area of the district. The process will help to reduce soil erosion and encourage water infiltration thus maintaining soil fertility and soil moisture retention which are necessary for agricultural production.
- Supporting lining of 'ndiva' (small ponds used to store water for irrigation) is also suggested. During the validation workshop, it was realized that only a small percent of the 'ndivas' are lined, and thus they lose water fast through both evapotranspiration and deep percolation.
- Putting in place and monitor implementation of the development land use plans, especially in the mid and lower parts of the district where there are conflicts between agricultural and livestock keeping land users. This will facilitate sustainability of the soil and water conservation practices and structures.

Other strategies recommended include promotion of use of:

- organic manures mainly animal manure and compost
- cover crops
- deep tap rooted crops (eg pigeon pea) to open the compacted soils as well as reduce water runoff on soil surface.



Figure 6. Contour farming for soil and water conservation in sloping lands (*photo from internet*)

4.1.2. Impacts of Climate Change in Livestock Keeping

The effects of climate change in livestock in Same district were identified as:

- Insufficient water for livestock drinking
- Increased livestock pests and diseases
- Insufficient pastures
- Increased heat stress
- Reduced animal productivity
- Poor water quality due to decreased water level and dissolved materials in runoffs
- Conflict between pastoralists and crop producers.

Coping strategies

The major existing coping strategies mentioned by participants were:

- Shifting of livestock from one place to another in search of pasture and water
- Setting pastureland into fire before rains so that they get res pasture after it rains
- Feeding livestock into agricultural lands, even on crop despite resulting into conflicts and fines.

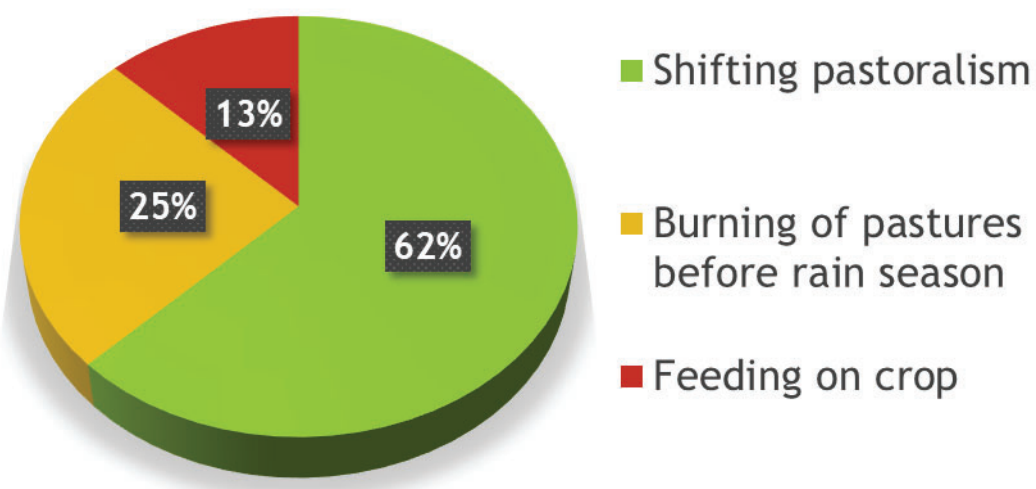


Figure 7. Coping strategies for climate change applied by livestock keepers in Same district

Restoration measures and suggested district interventions

The suggested restoration measures which we propose district authorities to implement and promote include:

- Reducing number of livestock to carrying capacity of the grazing lands
- Keeping improved livestock breeds
- Grow improved pasture

- Reseeding the degraded pasturelands
- Weeding of rangelands – removing thickets and invasive species
- Apply soil and water conservation practices e.g. water harvesting, half moon structures
- Rotational grazing to allow regeneration of pasture
- Improve mixed stocking to take advantage of mixed pasture types



Figure 8. The half-moon structures which can be used in grazing lands of Same district
(Photo from internet)

4.1.3. Impacts of Climate Change on Biodiversity

In Same district, the impacts of climate change on biodiversity were identified to be caused by higher temperature, decrease in rainfall, flood incidences as well as drought. The major climate change impacts on diversity identified were:

- Loss in natural vegetation which are trees, grasses and bush where by trees and bush were observed to be more affected.
- Increased invasive plant species which are causing damages in suppressing natural vegetation mainly grasses.
- Decrease in biodiversity and population of beneficial soil inhabitants due to high temperature and floods but increase in pathogens being favoured by the change.
- Wild life shifts for the search of suitable habitats and food, resulting to human – wildlife conflicts, where wildlife, especially elephants move from their areas and go to human habitat (farms) in search for water and food
- Preference on keeping types of livestock and crops that are resilient to the change, thus changing the composition of the reared animals and crops

Restoration measures and suggested district interventions

Suggested restoration measures include:

- Application of soil and water conservation measures to keep soil nutrient status and moisture level at the optimum level for the existing biodiversity
- Reduce overgrazing pressure to retain and maintain vulnerable species
- Promote agro-ecology based farming with justified use of fertilizers, herbicides and pesticides
- Discourage opening up of new lands for agriculture and livestock keeping
- Train and avail modern honey bee keeping and bee honey harvesting to avoid forest fires
- Introducing and enforcing by-laws that protect the environment at local (village/ward) level.

4.1.4. Impacts of Climate Change on water

The major impacts of climate change which were highlighted by key informants but also noted in focused group discussion were:

- Reduced water level in water sources through drying
- Reduced water level of water bodies due to sedimentation
- Flash floods.
- Death of aquatic organisms including fish due to higher oxygen demand, change in temperature and change in pH.

Restoration measures and suggested district interventions

Suggested restoration measures to reduce the impact of climate change include

- Organizing reforestation campaigns around catchment areas, by planting water conserving trees
- Enforcing by-laws which protect the catchment areas against human activities that affect water flows and quality such as:
 - grazing
 - vegetation clearing
 - burning
 - agriculture
 - settlement
 - lumbering
- Promote improvement and maintenance of soil cover
- Promote agricultural and livestock activities that would improve water infiltration and discourage runoff and soil erosion



Figure 9. Maintaining soil cover and restricted human activities will reduce impact of climate change in water sources (Photo from internet).

4.1.5. Impacts of Climate Change on Forestry

The drivers of climate impacts on forests in Same district were mentioned as forest fires, honey harvesting, charcoal burning, lumbering, grazing, and expansion of farms. The impacts of climate change in Forest ecosystem were mentioned as:

- Reduced forest size
- Change in growth patterns and canopy cover
- Reduced organic matter deposits in forest soils
- Reduced forests biodiversity

Restoration measures and suggested district interventions

The proposed restoration measures include:

- Promotion and implementation of annual reforestation campaigns, with emphasis on taking care and protection of the young planted trees
- Provision of education on importance of keeping forests safe for human life especially through primary and secondary schools students, who may transfer the knowledge and enthusiasm to the parents, also apply when they up.
- Creation of by-laws and enforcement of by-laws that protect the forests
- Promote participatory approaches to forest management, so that the locals feel the ownership of the forests present in the local areas
- Promoting planting of trees which give immediate benefits to the people around eg fruit and fodder trees
- Promoting growing of woodlots and practicing agroforestry to provide fuel at farm scale
- Provide incentives to encourage use of alternative sources of cooking and heating energies such as use gas and electricity instead of firewood and charcoal
- Promote manufacture and use of energy saving charcoal cooking stoves

4.2. Impacts of climate change on ecosystem in Simanjiro district and restoration actions suggestions

4.2.1. Impacts of Climate Change on Agriculture

Impacts of climate change on agriculture in Simanjiro district were identified by both KII's and FGD as:

- soil erosion and soil fertility degradation
- loss of crops
- loss of agricultural lands
- insufficient and unsafe irrigation water
- increased crop pests and diseases
- increased invasive plant species dominance
- cropping shift from traditional to adaptive crops

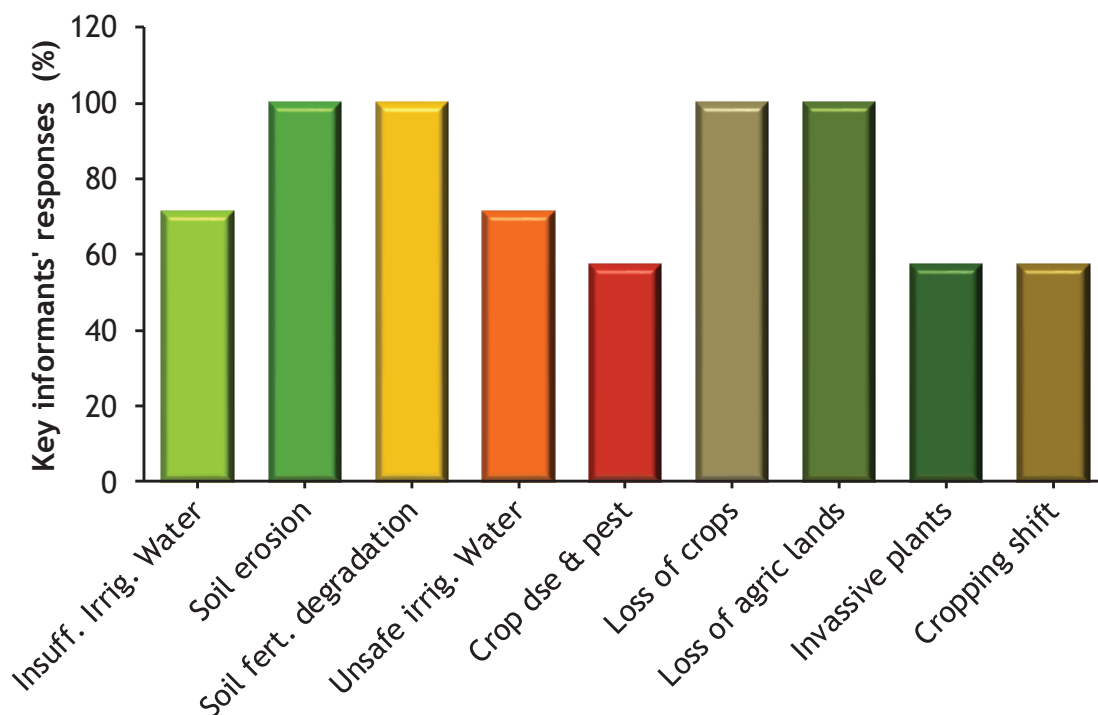


Figure 10. The effects of climate change in agriculture for Simanjiro districts

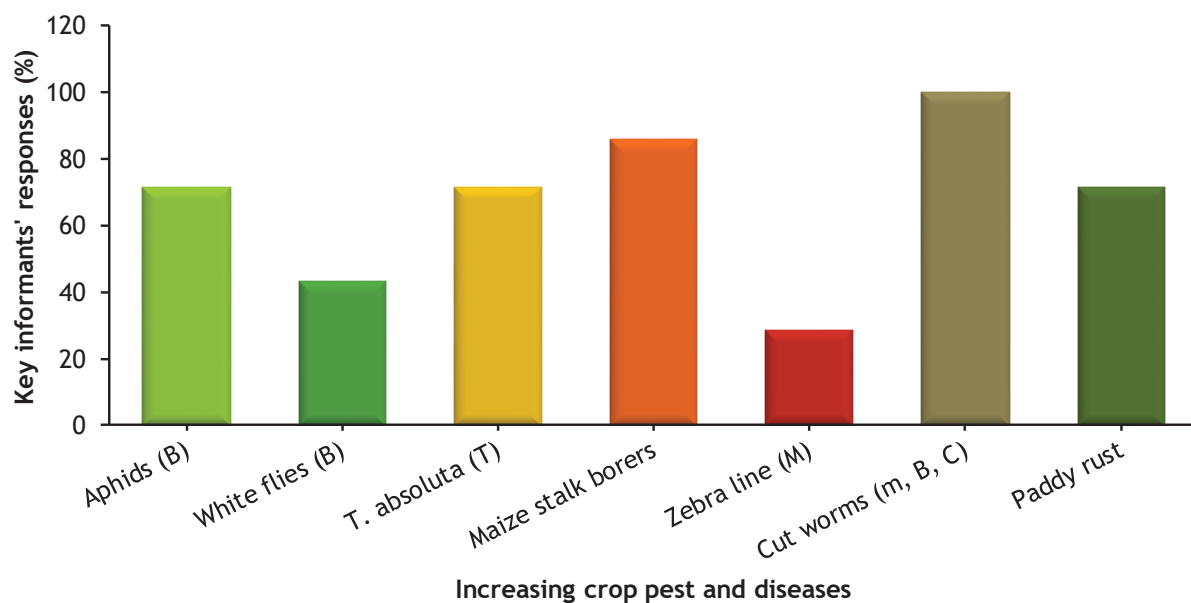


Figure 11. The major crop pest and diseases in Simanjiro

The major local coping strategies for impact of change in agriculture in Simanjiro

The major coping strategies in climate change effects in agriculture include:

- Use of pesticides to control pests and diseases
- Shifting cultivation in search of fertile soil
- Cropping shift to improved short maturity cultivars
- Increasing farm sizes to obtain more yield
- Use of synthetic fertilizers to increase crop productivity.

Climate change coping strategies

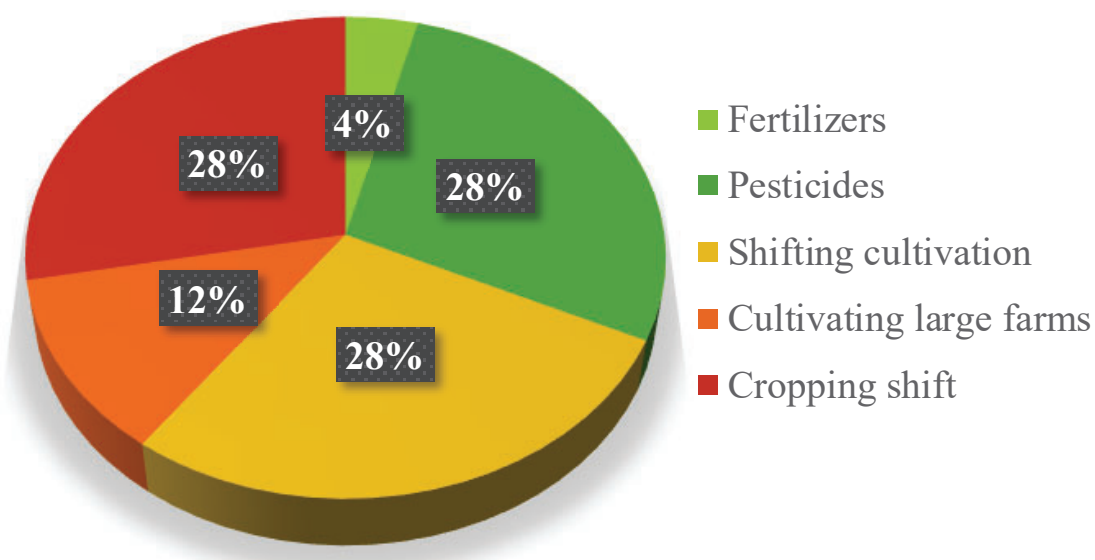


Figure 12. The major local coping strategies to climate change effects in agriculture

Restoration measures and suggested district interventions

The proposed restoration plans which we suggest the Simanjiro district council to address include:

- Promoting use of improved crop cultivars
- Promoting agro ecological farming focusing on soil and water conservation farming through contour farming to control runoffs and encourage water infiltration
- Promoting use of cover crops (cowpeas, common beans and Lablab), also intercropping and mulching using crop residues
- Promoting making use of animal manure (Since there is a lot of livestock in the district)
- Developing and implementing land use plans to avoid compaction and pulverization of soils by livestock which leads to poor soil water holding capacity and increased soil erosion due to increased surface runoff.

4.2.2. Impacts of Climate Change on livestock

The major effects of climate change in livestock keeping in Simanjiro district included:

- Decreased livestock productivity
- Increased livestock diseases
- Insufficient pastures
- Water shortage, especially during the dry season.
- Occurrence of invasive plant species including carrot weed, endipilikwa/ortipilikwa (name in Maasai), *Ipomea* sp and *Olorrohirohi*. The invasive species colonize grazing lands by outcompeting the pastures. Most of them are not eaten as pasture and some are poisonous to the livestock.



Parthenium hysterophorus



Ipomea sp

Figure 13. Some invasive plant species in grazing lands of Simanjiro district

Coping strategies

The interviewed participants mentioned different coping strategies to climate change effects on livestock for Simanjiro district.

- Shifting pastoralism in search of pastures and water during the dry season
- Burning of pastures before rain season
- Rotational grazing in communal land.
- Feeding livestock on crops, which leads to conflict between farmers and pastoralist.

Restoration measures and suggested district interventions

The suggested restoration measures include:

- Encouraging keeping number of livestock in line with carrying capacity of the land
- Introducing and promoting improved livestock breeds
- Support starting and promote pasture growing enterprises
- Support and supervise reseeding of pasture in areas of reduced abundance
- Introduce and supervise weeding of the rangelands
- Train on and advocate application of soil and water conservation practices e.g. water harvesting, constructions of half - moon structures
- Devise and supervise rotational grazing by putting demarcations and orders
- Advocate mixed stocking to take advantage of mixed pasture types

4.2.3. Impacts of Climate Change on biodiversity

Effects of climate change on biodiversity in Simanjiro district included

- Loss in natural vegetation such as trees, bush/shrubs and grasses
- Increase in plant invasive species which are causing damages in suppressing natural vegetation
- Change in plant life cycles through development of growing adaptation features such as early maturity
- Increase in pathogens in favour of the change
- Wild life migrations for the search of suitable habitats
- Decrease in population and biodiversity of beneficial soil inhabitants

Restoration measures and suggested district interventions

The suggested restoration measures on impacts of climate change in biodiversity include:

- Promotion of soil and water conservation practices which will maintain soil fertility and moisture status favourable for natural biodiversity
- Enforce measures that will control overgrazing which would otherwise lead to total removal of vulnerable plant species
- Promote judicious use of pesticides, herbicides and fertilizers in agriculture and livestock keeping to prevent toxifying the environment
- Introducing and re-enforcing bylaws that protect the environment.

4.2.4. Impacts of Climate Change on water

The major impacts of climate change on water in Simanjiro district which were identified by both the key informants and focused group discussion were:

- Reduced water level in water sources through drying
- Reduced water level of water bodies due to sedimentation
- Water pollution and contamination leading to water borne diseases.
- Death of aquatic organisms including fish due to increased temperatures and change in pH

Restoration measures and suggested district interventions

Suggested restoration measures to reduce the impact of climate change include

- Organizing reforestation campaigns around catchment areas, by planting water conserving trees
- Enforcing by-laws which protect the catchment areas against human activities that affect water flows and quality such as:
 - grazing
 - vegetation clearing
 - burning
 - agriculture
 - settlement
 - lumbering
- Promote improvement and maintenance of soil cover
- Promote agricultural and livestock activities that would improve water infiltration and discourage runoff and soil erosion

4.2.5. Impacts of Climate Change on Forestry

The impacts of climate change in forestry were identified as:

- Decreased size of land covered by forests
- Change in types of forest vegetation (biodiversity)
- Increased natural and human induced forest fires
- Reduced organic matter in forest soils

Restoration measures and suggested district interventions

The following are the suggested restoration measures and district interventions:

- Organizing annual reforestation campaigns
- Creation of by-laws and enforcements to protect the forests
- Adopt participatory approaches to forest management where citizens get tangible benefits from forests thus, see the importance of improving and maintaining the forests
- Promote growing of fruit trees and fodder trees around farms and homesteads to reduce encroachment of forests for firewood and grazing lands



Figure 14. Training and reforestation campaigns in schools (*Photo from internet*)

4.3 Impacts of climate change on ecosystem in Kiteto district and restoration plans suggestions

4.3.1. Impacts of Climate Change on Agriculture

The following were revealed as impacts of climate change on agriculture in Kiteto district:

- Reduced soil moisture to support crop growth
- Soil fertility degradation
- Insufficient irrigation water
- Increased crop pest and diseases
- Increased soil erosion
- Crop failures due to drought
- Loss of agricultural land
- Increased completion from Invasive plant species

Major local coping strategies to climate change impacts in agriculture

The major coping strategies in climate change effects in Kiteto revealed by the study were:

- Use of synthetic fertilizers to improve productivity
- Use of synthetic pesticides to protect crops from pests
- Increasing farms sizes to increase volume of crop production

Restoration measures and suggested district interventions

The running restoration measures in the district include the provision of education on different sustainable agriculture techniques to some of the farmers in selected villages. This is done through the collaboration of the Kiteto district council and Kinnapa Development Programme (KDP).

On the other hand, the suggested restoration plans include

- Promotion of the use of improved crop cultivars which have been selected for their adaptation to the climate change
- Promote agro ecological farming focusing on soil and water conservation techniques including mulching and use of cover crops especially cowpeas, common beans and lablab
- Promote education and application of water conserving agronomic practices such as use of contour farming and restriction of surface runoff to avoid soil erosion and water loss
- Promote use of animal manure and compost to help address soil fertility and soil water management challenges

4.3.2. Impacts of Climate Change on Livestock Keeping

The impacts on livestock keeping in Kiteto district were:

- Reduced livestock productivity
- Insufficient pastures due to limiting growth conditions
- Water scarcity for livestock drinking
- Increased competition to pasture from Invasive plants species
- Increased livestock pest and diseases
- Heat stress
- Conflicts between pastoralist and farmers

Major local coping strategies

The major local coping strategies which are used by pastoralist in Kiteto are:

- Shifting pastoralism for the search of pastures and water
- Burning of pastures before the rain season
- Establishment of temporary settlements in the bush (ronjo) saving as bases during dry seasons for grazing livestock keeping.
- Cutting down the number of livestock by selling when the situation is worse

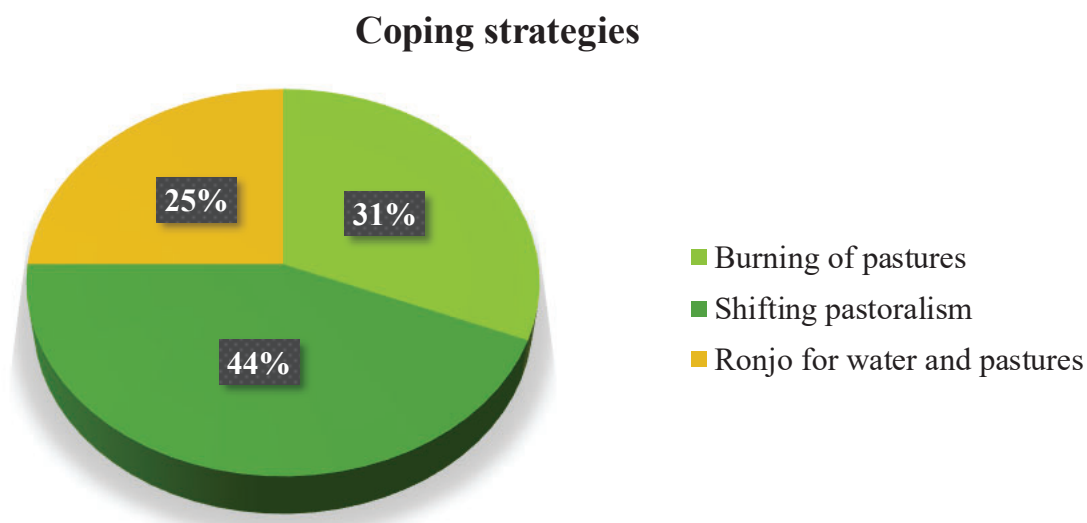


Figure 15. The local coping strategies for climate change effects in Kiteto

Restoration measures and suggested district interventions

The suggested measures include:

- Putting in place sustainable land use plans for specific use e.g. agriculture, livestock; and monitoring and enforce the implementation of the plans
- Promote programs to reduce livestock numbers to fit the carrying capacity of the land
- Introduce and promote zero grazing

- Promote keeping improved livestock breeds
- Support and promote feed storage for dry season
- Facilitate reseeding programs in the rangelands
- Promote and support pasture growing and selling enterprises
- Promote and supervise rotational grazing

4.3.3. Impacts of Climate Change on Biodiversity

The following were the impacts of climate change on biodiversity in Kiteto district:

- Loss in natural vegetation where trees and bush were observed to be more affected
- Increase in plant invasive species which are causing damages in suppressing natural vegetation mainly grasses
- Change in plant life cycles through development of growing adaptation features such as early maturity
- Decrease in biodiversity and population of beneficial soil inhabitants due to high temperature and floods
- Increase in pathogens in favour of the climate change conditions
- Wild life migrations for the search of suitable habitats

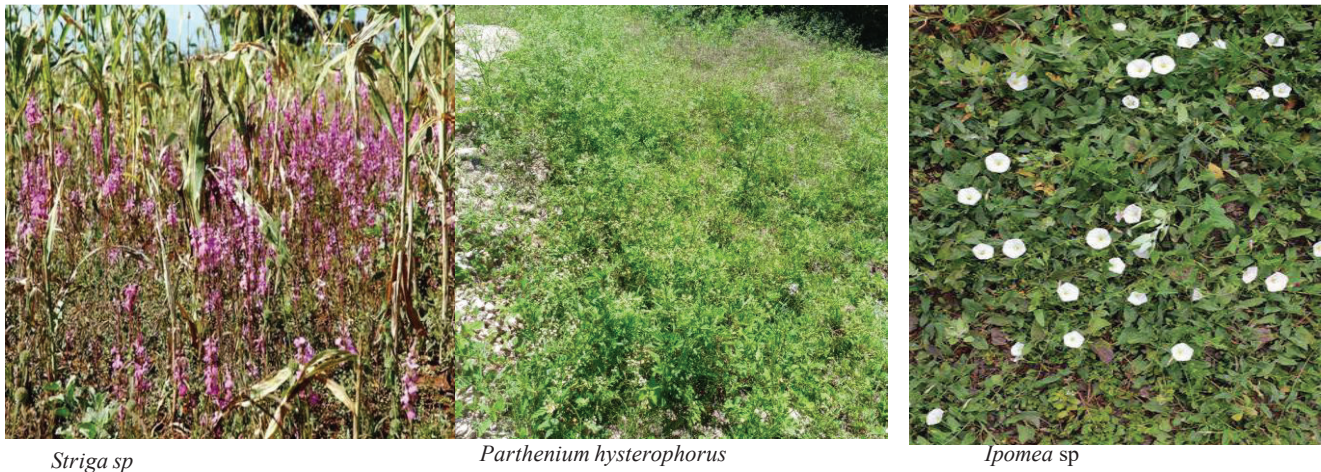


Figure 16. Invasive plant species in Kiteto

Restoration measures and suggested district interventions

The suggested restoration measures on impacts of climate change in biodiversity include:

- Promotion of soil and water conservation practices which will maintain soil fertility and moisture status favourable for natural biodiversity
- Enforce measures that will control overgrazing which would otherwise lead to total removal of vulnerable plant species
- Promote judicious use of pesticides, herbicides and fertilizers in agriculture and livestock keeping to prevent toxifying the environment
- Introducing and enforcing by-laws that protect the environment.

4.3.4. Impacts of Climate Change on Water

The impacts of climate change on water in Kiteto district were identified to be:

- Reduced water level in water sources through drying
- Reduced water level of water bodies due to sedimentation
- Flash floods to lower lands
- Deaths of aquatic organisms including fish due to low oxygen supply, change in temperature and change in pH

Restoration measures and suggested district interventions

Suggested restoration measures to reduce the impact of climate change include

- Organizing reforestation campaigns around catchment areas, by planting water conserving trees
- Enforcing by-laws which protect the catchment areas against human activities that affect water flows and quality such as:
 - grazing
 - vegetation clearing
 - burning
 - agriculture
 - settlement
 - lumbering
- Promote improvement and maintenance of soil cover
- Promote agricultural and livestock activities that would improve water infiltration and discourage runoff and soil erosion

4.3.5. Impacts of Climate Change on Forestry

The impacts of climate change in forests of Kiteto district revealed during the study are:

- Decreasing size of land under forests
- Reduced biodiversity in the forests
- Degradation of soils under the forests
- Increased incidences of bush/wild fires

Restoration measures and suggested district interventions

The following are the suggested restoration measures and district interventions:

- Organizing annual reforestation campaigns
- Creation of by-laws and enforcements to protect the forests
- Adopt participatory approaches to forest management where citizens get tangible benefits from forests thus, see the importance of improving and maintaining the forests
- Promote growing of fruit trees and fodder trees around farms and homesteads to reduce encroachment of forests for firewood and grazing lands

4.4 Impacts of climate change on ecosystem in Chemba district and restoration plans suggestions

4.4.1. Impacts of Climate Change on Agriculture

Chemba is among the districts affected by climate change. The impacts of climate change in agriculture in Chemba district include:

- Decline in soil moisture to support annual and perennial crops
- Degradation of important soil properties such as soil fertility leading to low soil productivity
- Increased incidences of crop pests and diseases
- Conversion of agricultural lands to badlands, thus loss of agricultural land
- Unpredictable onsets and outlets of crop growing seasons due to unpredictable rainfall amount and distribution

Major local coping strategies to climate change effects on agriculture in Chemba district

The major coping strategies in climate change effects in Chemba are:

- Increasing farms size by bush clearing to increase amount of crop produced
- Use of synthetic pesticides to protect crops from pests
- Use of synthetic fertilizers to supplement nutrients for crops.

Local coping strategies

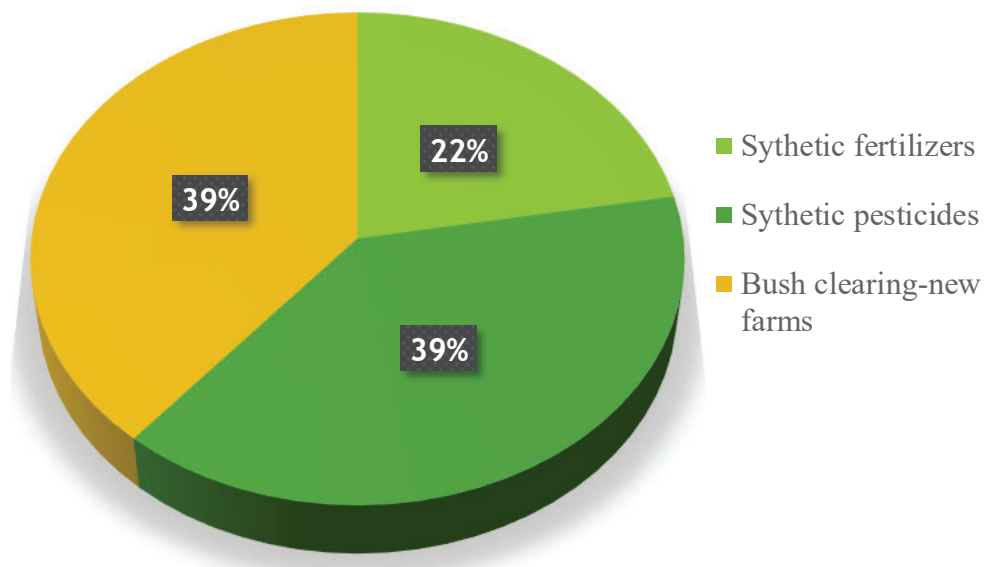


Figure 17. The local coping strategies to climate change effects in agriculture

Restoration measures and suggested district interventions

There are existing restoration efforts in the district through collaboration with INADES project. The project is implementing different climate resilient interventions in different villages within the district focusing on agriculture. The interventions include awareness creation on climate change impacts in the district, provision of education on agro ecological farming including agroforestry, seed selection for next crops and use of cover crops and soil fertility enhancing crops such as lablab.

It is suggested that the efforts of INADES be complemented by allocation of district based budget to support restoration processes and training. It is further recommended that the activities be expanded to other areas of the district apart from the selected project areas of the NGO.

Despite efforts of stakeholders in training, it was reported in the validation workshop that the performance is not as good as in other districts. It was thus proposed to organize a trip where farmers and leaders from Chemba would go and learn in other districts, preferably Babati.

4.4.2. Impacts of Climate Change on Livestock Keeping

Impacts of climate change in livestock keeping in Chemba district are:

- Reduced animal productivity
- Insufficient water
- Increased livestock pest and diseases
- Increased occurrence of Invasive plants species
- Decreased amount and diversity of pastures
- Increased heat stress
- Conflict between pastoralist and farmers

Major local coping strategies for climate change effects on livestock in Chemba district

The major local coping strategies which are used by pastoralist in Chemba are:

- Shifting pastoralism where by livestock keepers move from one place to another in search of good pastures
- Keepers with few number of livestock buy crop residues from the farmers and graze in the farms
- Burning of the pastures before the rain season to allow regeneration of new pasture.
- Burning of the pastures before the rain season to kill some parasites including tsetse flies and ticks

Restoration measures and suggested district interventions

The suggested restoration measures include:

- Putting in place and monitor the implementation of sustainable land use plans for specific use, for instance agriculture, livestock, forest reserves and others.
- Encourage harvesting excess livestock through selling and invest in other climate resilient business
- Promote zero grazing

- Promote keeping of improved livestock breeds
- Promote feed storage and put in place the feed storage facilities for dry season.
- Support and create awareness on pasture reseeding in grazing lands
- Introduce and promote growing of improved pastures
- Facilitate and enforce use rotational grazing with water infrastructures
- Implement and promote application of soil and water conservation practices suitable for grazing lands such as water harvesting, half-moon structures
- Promote mixed stocking to take advantage of mixed pasture
- Educate on importance of weeding to get rid of un-useful plants and invasive plants

4.4.3. Impacts of Climate Change on Biodiversity

There are several effects of climate change in biodiversity in Chemba district including:

- Loss in natural vegetation such as trees, shrubs and grasses
- Increase in plant invasive species which are causing damages in suppressing natural vegetation
- Change in plant life cycles through development of growing adaptation features such as early maturity. Increase in pathogens in favour of the change
- Increase in wild life migrations for the search of suitable habitats.
- Decrease in the population and diversity of beneficial soil inhabitants which are important in soil health maintenance

Restoration measures and suggested district interventions

The suggested restoration measures include:

- Promoting soil and water conservation practices to create and maintain soil and environment suitable for the existing and improved biodiversity
- Controlling overgrazing to protect palatable plant species from being overgrazed which endangers their existence.
- Introducing and enforcing by-laws that protect the environment
- Promote judicious application of pesticides, herbicides and fertilizers, not to damage the environment and ecosystem
- Promote and supervise physical/mechanical, agronomical, and chemical eradications of invasive plant species before they dominate the land



Striga sp



Parthenium hysterophorus



Ipomea sp

Figure 18. Some invasive plant species in Chemba

4.4.4. Impacts of Climate Change on water

The major effect of climate change on water in Chemba district are:

- Reduced water level in water sources through drying
- Reduced water level of water bodies due to sedimentation
- Flash floods
- Change in aquatic life biodiversity due to increased temperature, pollution and change in water pH

Restoration measures and suggested district interventions

Suggested restoration measures to reduce the impact of climate change on water include

- Organizing reforestation campaigns around catchment areas, by planting water conserving trees
- Enforcing by-laws which protect the catchment areas against human activities that affect water flows and quality such as:
 - grazing
 - vegetation clearing
 - burning
 - agriculture
 - settlement
 - lumbering
- Promote improvement and maintenance of soil cover
- Promote agricultural and livestock activities that would improve water infiltration and discourage runoff and soil erosion

4.4.5. Impacts of Climate Change on Forestry

The impacts of climate change in forests of Chemba district revealed during the study are:

- Decreasing size of land under forests
- Reduced biodiversity in the forests
- Degradation of soils under the forests
- Increased incidences of bush/wild fires

Restoration measures and suggested district interventions

The following are the suggested restoration measures and district interventions:

- Support and improve work being done by INADES to provide education on starting and managing tree nurseries eg grafting and budding technologies for early maturing fruit trees
- Organizing annual reforestation campaigns
- Creation of by-laws and enforcements to protect the forests
- Promote use of alternative sources of cooking and heating energy to reduce use firewood and charcoal
- Adopt participatory approaches to forest management where citizens get tangible benefits from forests thus, see the importance of improving and maintaining the forests
- Promote growing of fruit trees and fodder trees around farms and homesteads to reduce encroachment of forests for firewood and grazing lands

4.5 Impacts of climate change on ecosystem in Mufindi district and restoration plans suggestions

4.5.1. Impacts of Climate Change on Agriculture

The study revealed the following impacts of climate change on agriculture in Mufindi district:

- Reduced soil moisture to support crops, especially in the dry zone of the district
- Increased crop pest and diseases
- Reduced amount of water used for irrigation
- Changed and unpredictable crop growing seasons (unpredictable onset of rain seasons and uncertainty on seasonal rainfall distribution)

Major local coping strategies to climate change effects on agriculture in Mufindi district

To cope with effects of climate change in agriculture, farmers in Mufindi district do the following:

- Use pesticides excessively to control pest and diseases
- Use synthetic fertilizers to supplement nutrient for crop requirement
- Open new farms to increase volume of crop produce
- Use ripening chemicals eg ethylene to fasten maturity of vegetables

Coping strategies

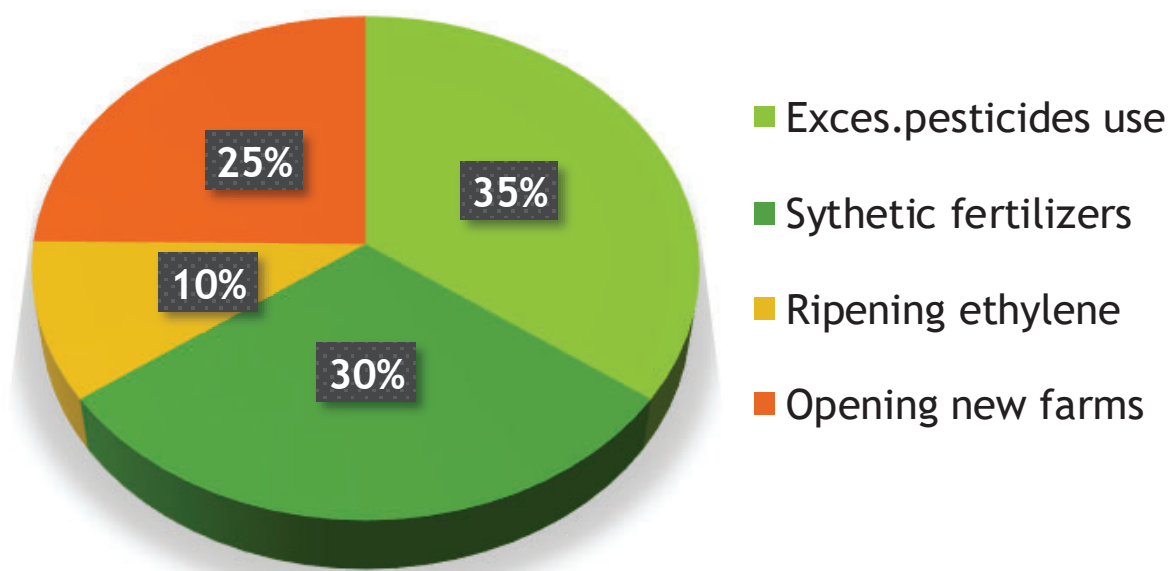


Figure 19. Local coping strategies to climate change effects in agriculture

Restoration measures and suggested district interventions

There are existing restoration efforts in the district. Through Rural Development Organization (RDO) several farmers organized in groups have been trained on different sustainable agricultural techniques including organic farming, livestock keeping for manures, contour farming based and permaculture which comprise avocado farming, fish farming and bee keeping.

It is suggested that these efforts be strengthened and get more involvement of the district staff for uptake and sustainability

Other recommendations to the district are to:

- Organize training sessions on proper use of pesticides
- Promote use of tested and approved biopesticides in management of crop pest and diseases
- Support soil testing exercise to get recommendations on fertilizer types and amounts to apply
- Promote incorporation of crop residues into soil instead of burning them
- Facilitate installations of more effective irrigation systems which would use lower amount of water

4.5.2. Impacts of Climate Change on Livestock Keeping

Livestock is being kept in low lands of the district. The effects of climate change to the livestock keeping identified are:

- Presence of invasive plants species in the grazing lands
- Insufficient water during the dry season
- Insufficient pastures during the dry season,
- Increased livestock pest and diseases,
- Poor water quality due to pollution.
- Conflict between livestock keepers and farmers due to interaction of activities between two groups especially in the dry season.

Major local coping strategies for climate change effects in livestock keeping

The major local coping strategies used are:

- Shifting livestock to wetter areas during dry season
- Feeding the livestock on crop residues.

Restoration measures and suggested district interventions

Proposed actions for restoration are:

- Promote zero grazing system of livestock keeping
- Introduce and promote keeping of improved livestock breeds
- Promote feeds harvesting and storage to be used in dry season.
- Facilitate education on reseedling of pastures
- Promote growing of improved pastures
- Install water drinking points infrastructure to facilitate rotational grazing.
- Promote applications of soil and water conservation practices such as water constructions of half-moon structures
- Promote improvement of mixed stocking to take advantage of mixed pasture types
- Start campaigns on weeding of pastures to remove weeds and invasive plant species

4.5.3. Impacts of Climate Change on Biodiversity

There are several effects of climate change in biodiversity in Mufindi district including:

- Loss in natural vegetation such as trees, shrubs and grasses
- Increase in plant invasive species which are causing damages in suppressing natural vegetation
- Change in plant life cycles through development of growing adaptation features such as early maturity. Increase in pathogens in favour of the change
- Increase in wild life migrations for the search of suitable habitats.
- Decrease in the population and diversity of beneficial soil inhabitants which are important in soil health maintenance

Restoration measures and suggested district interventions

The suggested restoration measures include:

- Promoting soil and water conservation practices to create and maintain soil and environment suitable for the existing and improved biodiversity
- Controlling overgrazing to protect palatable plant species from being overgrazed which endangers their existence.
- Introducing and enforcing by-laws that protect the environment
- Promote judicious application of pesticides, herbicides and fertilizers, not to damage the environment and ecosystem
- Promote and supervise physical/mechanical, agronomical, and chemical eradication of invasive plant species before they dominate the land

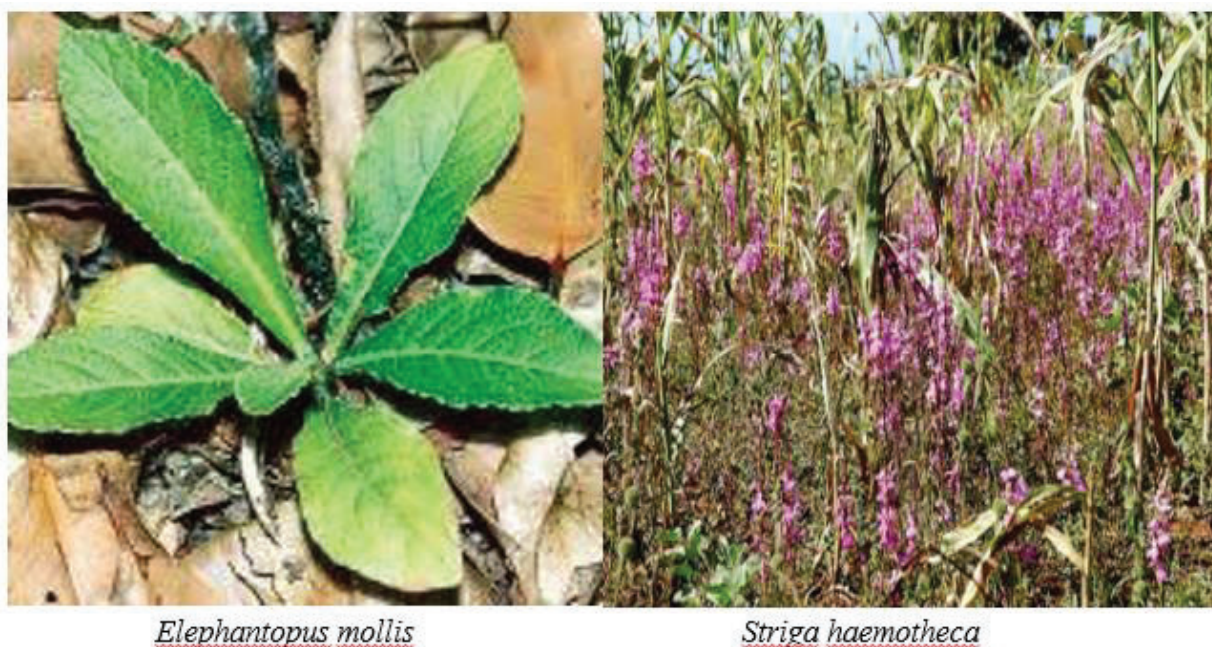


Figure 20. Some invasive plant species in Mufindi

4.5.4. Impacts of Climate Change on Water

The impacts of climate change on water in Mufindi district were identified to be:

- Reduced water level in water sources through drying
- Reduced water level of water bodies due to sedimentation
- Flash floods to lower lands
- Deaths of aquatic organisms including fish due to low oxygen supply, change in temperature and change in pH

Restoration measures and suggested district interventions

Suggested restoration measures to reduce the impact of climate change include

- Organizing reforestation campaigns around catchment areas, by planting water conserving trees
- Enforcing by-laws which protect the catchment areas against human activities that affect water flows and quality such as:
 - grazing
 - vegetation clearing
 - burning

- agriculture
 - settlement
 - lumbering
- Promote improvement and maintenance of soil cover
- Promote agricultural and livestock activities that would improve water infiltration and discourage runoff and soil erosion

4.5.5. Impacts of Climate Change on Forestry

The impacts of climate change in forests of Mufindi district revealed during the study are:

- Decreasing size of land under forests
- Reduced biodiversity in the forests
- Degradation of soils under the forests
- Increased incidences of bush/wild fires

Restoration measures and suggested district interventions

The following are the suggested restoration measures and district interventions:

- Organizing annual reforestation campaigns
- Creation of by-laws and enforcements to protect the forests
- Adopt participatory approaches to forest management where citizens get tangible benefits from forests thus, see the importance of improving and maintaining the forests
- Promote growing of fruit trees and fodder trees around farms and homesteads to reduce encroachment of forests for firewood and grazing lands

5.0 Discussions

5.1. Impacts of Climate Change on Agriculture

Climate change is associated with decrease in rainfall thus affecting soil moisture as well as recharge capacity of irrigation water sources. Due to prolonged dry season and less soil cover of soil, the farm lands remains bare for long time and hence erosion of soil by wind and water when the rain comes. Soil erosion in turn removes the top soil which harbours nutrients, leading to soil fertility degradation. Different studies (Chaudhry & Sidhu, 2022; Duchenne-Moutien & Neetoo, 2021; Hussain et al., 2020) have demonstrated that, climate change is associated with different effects in agriculture productivity. The loss of beneficial soil biodiversity and poor nutrient cycling is linked to drought which causes decrease in decomposers and metabolizers of different compounds in the soil resulting to less transformation of nutrients and food insecurity issues occurs due to crop productivity failure (Bibi & Rahman, 2023).

The occurrence of crop diseases and pest as well as human diseases in the favour of climate change have been highlighted in the previous studies (Bibi & Rahman, 2023; Duchenne-Moutien & Neetoo, 2021). Climate change influence the occurrence of various diseases as it influences the ecological aspects including disease causing pathogens and parasites. The increasing cases of malaria in Same during the hot season may be attributed to the influence of high temperature which influence the hatching of mosquito eggs in water after the end of rain season (Babaie et al., 2018). The cases of skin burns may be due to increasing UV radiation in hot seasons (Fathy & Rosenbach, 2020) while headache is linked to body dehydration due to high temperature despite being the indicator of many physiological changes in the body (Tzadok et al., 2015).

The occurring fluctuations in climate, rainfall due to continuous rise of greenhouse gases (GHG) such as carbon dioxide and high temperature in prolonged dry seasons, have led to an increase in the frequency of extreme events that cause flooding and drought disasters which poses serious threat to crops productivity (Chaudhry & Sidhu, 2022; Duchenne-Moutien & Neetoo, 2021; Hussain et al., 2020). The variation in temperature and rainfall has direct effects on the growth and maturity time of crops, due to which the crops are adversely subjected to various biotic and abiotic stresses (Chaudhry & Sidhu, 2022). In addition, abiotic stress of climate such as drought, high temperature less rainfall and expanded range of biotic including in pests and pathogens that could lead to an increased frequency and severity of plant diseases results global crop productivity loss of up to 30–50% (Bibi & Rahman, 2023).

Cultivation of improved crop cultivars is believed and have been used as one of the coping strategies to climate change impacts in agriculture. This is due to their enhanced resistance to adverse environmental conditions, with the intention of maintaining or increasing crop yields under stress conditions (Kopeć, 2024). However, farmers involved in the study complained on the failure of available cultivars especially maize, to withstand drought when the rainfall end before crop maturity. Moreover, the cultivars are observed to be susceptible to pest and diseases as compared to local varieties/lines. The susceptibility results in the excessive use of pesticides which may health implications to the consumers and harm beneficial organisms in crop production system.

In order to increase production volumes, farmers have been expanding lands under agriculture or shift to newly opened lands. This results to further degradation as the left land will not recover on time given the existing unfavourable conditions (Nath et al., 2022).

The restoration measures revolve around regenerative agriculture and mainly in practices of soil and water conservation (Kopeć, 2024). Use of chemical solutions offer effective but not sustainable solutions. Thus use of agro-ecological solutions is recommended. The techniques may focus on agro ecological farming which includes conservation farming techniques by including Lablab dolichos which is highly tolerant to drought to ensure soil cover for long time. The use of microbial biostimulants (Kaushal et al., 2023) such as plant growth promoting (PGP) functions is important for success and sustainability of suggested techniques. The microorganisms can offer PGP functions such as nitrogen fixation (rhizobacteria/rhizobia), nutrients solubilization under problematic soils such as those which are acidic, saline or alkaline. Other PGP functions include suppression of disease causing pathogens through production of different phytohormones, imparting stress tolerance to plants and hence improve crop quality and productivity.

5.2 Impacts of Climate Change on Livestock Keeping

Livestock keeping depends very much on availability of pasture and water. Different plants including grasses and forages have optimum range of temperature and moisture for regeneration as well as survival. Above the optimum temperature and below the optimum moistures the pastures fail to regenerate. Higher temperature and less moisture in soil as well as reduced water level or drying water sources poses direct impact on the growth of pastures through drying or unavailable drinking water resulting drying of pastures as well as death of animals (Godde et al., 2021). Furthermore, increased temperature results to reduced animal growth, production

and welfare resulting from reduced feed intake, and direct physiological and metabolic effects (Gauly, 2020).

Shifting pastoralism is mainly associated with lack of pastures, therefore, pastoralists move from one place to another in search of pastures. The technique has been among the frequently applied coping strategy by the most of the pastoralist communities. However, the system results to different impacts including soil erosion and loss of natural vegetation but also due to increasing drought and enclosed land for different uses, the system is not sustainable (Unks et al., 2023). Pastoralist have the tendency of burning pastures to allow the regeneration of new pasture grasses or forages as well as killing pests, however, the process poses effect to other ecosystem biodiversity. Apart from shifting pastoralism, there are cases of feeding livestock on crops which results to conflict between farmers and pastoralist.

Climate change is also associate with increased livestock diseases incidences through favoring the pathogen causing diseases or parasites. Most of the diseases are fovoured by climate change based on the seasons. For instance, changes in precipitation and humidity positively affect the reproduction and spread of vector-borne pests such as, flies and ticks including lumpy skin disease (LSD) which are mentioned by the participants in this study. Other diseases which are associated with climate change include bacterial and parasite such as worms (Ali et al., 2020).

5.3. Impacts of climate change on Biodiversity

It is difficult to analyses the loss of biodiversity exclusively due to climate change as other human induced environmental changes such as habitat loss and degradation, overexploitation of bioresources and introduction of alien species also interact with climate change and affect biodiversity and ecosystems. In recent decades there has been a massive loss of biodiversity leading to initiation of the sixth mass extinction crisis due to human-induced environmental changes. For the case of forest and the associated biodiversity, increase in temperature enhances the drying of organic matter thus increasing the risks of wildfires. Wildfires also release large amounts of carbon dioxide, carbon monoxide, and fine particulate matter into the atmosphere causing air pollution and consequent health problems. When temperature increase beyond optimum range in aquatic environment, the growth and reproduction of fish decreases and when the pH changes for instance becoming acidic, the results is death of aquatic organisms (Shivanna, 2022).

6.0 Conclusion and Recommendation

From the results, it is evident that, climate change impacts in the study districts are mainly contributed by increasing human activities. The major human activities which causes climate change includes bush clearing and burning for new farms which involves cutting of larger trees and burning for charcoal. Based on the activities it is clear that, there is huge decrease in plant biodiversity and population, which is a threat to future generation if the actions will not be seriously taken to serve the situation. Generally, there is high pressure in exhaustion of natural resources which needs creation of awareness through different approaches including through seminars, workshops and practical by involving the community.

It is recommended that district authorities take the leading role in restoration practices. It has been noted in this study that the restoration practices are left to be done by donor funded projects under non governmental organizations and community based organization. We recommend that the restoration strategies suggested specifically for each district and ecosystem area has to be spearheaded by the district authorities while inviting other stakeholders to take part.

The restoration measures revolve around regenerative agriculture and mainly in practices of soil and water conservation. Use of chemical solutions offer effective but not sustainable solutions. Thus use of agro-ecological solutions is recommended.

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