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REVIEW ON CLIMATE CHANGES AND ITS IMPACTS ON LAND DEGRADATION

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ABSTRACT: *Changes in climate are recognized as one of the major factors responsible for land degradation affecting sustained development. To ensure sustained development, conjunctive efforts based on a sound understanding of the various factors that bestow to land degradation around the world are required. Hence, it is more significant to verbalize climate, an inherent driver of land degradation instead of addressing the consequences of land degradation. In order to accurately assess sustainable land management practices, the climate resources and the risk of climate-related or induced natural disasters in a region must be known. Land surface is an important part of the climate system and changes of vegetation type can modify the characteristics of the regional atmospheric circulation and the large scale external moisture-Fluxes. Following deforestation surface evapotranspiration and sensible heat flux are related to dynamic structure of the low level atmosphere and these change could influence the regional and potentially, Global Scale atmospheric circulation. Surface parameters such as soil moisture, Forest coverage, transpiration and surface roughness may affect the formation of connective clouds and rainfall through their effect on boundary- layer growth. Land use and land cover changes influence carbon fluxes and GHG emissions which directly alter atmospheric composition and radioactive forcing properties. Land degradation aggravates CO2-induced climate change through the release of CO2 from cleared and dead vegetation and through the reduction of the carbon sequestration potential of degraded land. The present review focuses impact of climate change on land degradation.*

KEYWORDS: climate change; land degradation; sustainable development; soil quality; soil erosion**;**

INTRODUCTION

Climate Change and Its Impact On land Degradation

Anthropogenic climate change is recognized as one of the major factors contributing to land, degradation. Land degradation means, reduction in the potential of the land to produce benefits, from a particular land use under a specified form of land management and is, considered to be one of the major problems of the world in recent times. Land degradation encompasses change in chemical, physical and biological property of the soil. Such a change in soil properties alter and reduce the soil ability to sustain a peculiar quality, and quantity of plant growth. Soils are also

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crucial to food security and change in climate has threatened the food security by affecting the soil property. Understandings of the effects are required to know how climate and soils interact and to understand changes in soil due to change in climate. At regional, ocean basin and continental scales, numerous long-term changes in climate have been noticed. These admit changes in ocean salinity, far-flung changes in precipitation amounts, changes in Arctic ice and temperatures, changes in wind patterns, change in the intensity of tropical cyclones and changes in heat waves and heavy precipitation. More acute and longer Carbon dioxide (CO_2) accelerated climate change and desertification stay inextricably associated because of feedbacks between precipitation and land degradation. Water resources are also inextricably associated with climate. Annual ordinary river runoff and water availability are projected to rise by 10-40 percent at high latitudes, in wet tropical areas, at mid-latitudes and in the dry tropics it decreases by 10-30 percent. The term land, as employed in land evaluation, land use planning, etc., has a wider meaning than just soil. It refers to all natural resources which contribute to agricultural production, including livestock production and forestry. Land thus covers climate and water resources, landform, soils and vegetation, including both grassland resources and forests. Land exhibited to degradation as a consequence of poor land management could become infertile as a result of climate change. Land degradation hazards included wind and water erosion, loss of soil carbon, nutrient decline mass movement, soil structure decline, acid sulfate soils and soil acidification. Hence the present review furnishes climate change and its impact on land degradation.

Objective

❖ To review Climate Change and its Impacts on Land Degradation.

Extent of Land Degradation

Global land degradation assessments still relies on outdated datasets, for instance soil data information (still FAO-UNESCO world soil map continues being the only data source available). Very complex process, challenging to assess it using unique indicators. Estimates that need field validation, its dynamic nature urges to monitor it, at least using proxy indicators. Reaching global agreement is a real challenge, yet process continues. FAO estimates according to LADA project, 43% of rangelands and 20% of croplands are degraded. This figures could further rise due to climate change. Global figures play a role on raising awareness and formulating global policies, but are very coarse for taking wise decisions at field level. Approximately 1.5 billion people, or a quarter of the world's population, depend directly on land that is being degraded. The question that arises, however, is how much of the land in the world is degraded and how much suitable for land rehabilitation treatment? The truth is that it is impossible to know. Produced during the late 1980s, GLASOD was the first systematic attempt to produce a global overview of soil and land degradation but since there is insufficient data for all but a tiny fraction of the earth's surface, much had to be based of guesswork and estimation. Nevertheless, GLASOD's "World Map of the Status of Human Induced *Land Degradation", the second edition of which was published by ISRIC and UNEP in* Wageningen in 1991 by Olde man and colleagues provides a benchmark. GLASOD suggests that the globally land degradation affects

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about 15% of the world's dry land surface and 22% of its agricultural land base and 70% of the world's dry land areas. Water erosion is the primary cause. The area where degradation is rated strong or extreme, where land rehabilitation is an issue, sums to around 3,050m.ha.Water erosion is the main reason on 73% of this land and wind erosion on 8.5%. Human induced chemical soil degradation, mainly due to salinization and pollution is thought to affect more than 12% of the total degraded land area and 15% of that requiring rehabilitation. Before GLASOD, earlier estimates suggested that, worldwide, perhaps 12 x 106 ha of degraded arable land is abandoned annually due to unsustainable farming practices. In 1984, Brown and Wolf wrote an influential pamphlet called "Soil Erosion the Quiet Crisis in the World Economy" for Washington's World Watch Institute. Here, they estimated that the world was losing around 28 bn. t. (25,400 million tons) of soil in excess of soil formation from its 1270 m. ha of cropland. Allowing each acre approximately 180 mm of topsoil, this suggested a decade loss rate of 7%, which if true would have eliminated half the world's productive topsoil before 2025. The mining away of the world's productive topsoil was called the "quiet crisis" because the changes involved may be imperceptibly tiny in the context of each annual agricultural cycle, but cumulatively Today, it has been suggested that, on the global scale, the loss of 75 bn. t. of topsoil to erosion each year represents a cost to each person on the planet the equivalent of $ 70 each year in lost production. Yield reduction in Africa due to past erosion is estimated as 8% overall. Many writers contest the link between erosion and yield reduction and soil loss, noting that biological productivity depends more on the quality of the soil that remains in the field than that lost in erosion. Nevertheless, the fact remains that the topsoil's, which are lost to erosion or damaged by physical or soil chemical degradation, rank with the most productive and the most critical to people that depend on them for their livelihoods. Topsoil damaging processes create the lands that demand rehabilitation treatment. For example in Central America, 75% of cropland is seriously degraded while in Africa, 20% of the total land area is at risk of undercover (Sida, 2007). In Ethiopia, land degradation has become a serious problem affecting all spheres of social, economic and political life of the population (Mesfin, 2010). It is one of the major challenges to agricultural development and food security of the country. Approximately 90% of the population lives in areas marked by land degradation and reduced agricultural productivity (Simon, 2012). The rate of the country's land degradation is very high.

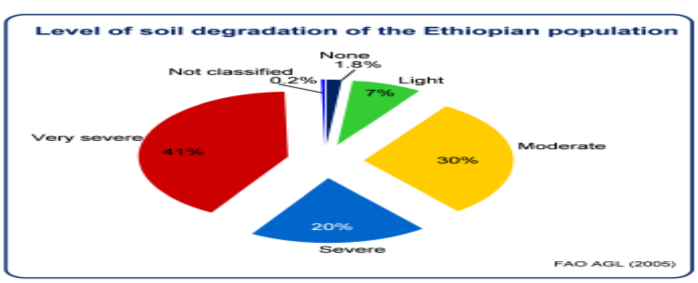

Figure 1: Level of soil degradation of Ethiopia

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Type of Land Degradation

Soil Erosion

Soil erosion is the movement and transport of soil by various agents—particularly water, wind, and mass movement—that leads to a loss of soil. Erosion has been recognized by many scientists and some governments as a major problem since the U.S. Dust Bowl of the 1930s (Jacks and Whyte, 1939); the causes and processes involved have been well-researched over the last 60 years, providing voluminous literature. The annual rates of new soil formation are crudely estimated to be between 2 and 11 t/ha (Wischmeier and Smith, 1978), although experimentally derived rates often are less than this (Lal, 1994a). Globally, rates of soil erosion can exceed these estimated values by 10- to 20-fold, thereby reducing productivity (Crosson and Stout, 1983; Sehgal and Abrol, 1994a, 1994b) and causing sediment and nutrient loading of rivers (Clark *et al.*, 1985).

Table 1: Estimates of current global rates of soil erosion and likely future trends.

	Soil Erosion by Water				Soil Erosion by Wind	
Region	Area[1] (10^6 ha)	Denudation Rate[2] (mm/yr)	Dissolved Load[3] (10^6 t/yr)	Future Trends	Area[1] (10^6 ha)	Future Trends
Africa	227	0.023	201	+	186	+
Asia	441	0.153	1592	+	222	+
South America	123	0.067	603	+	42	-
Central America	46	)	)	+	5	-
		0.055)	758)			
North America	60	)	)	+/-	35	-
Europe	114	0.032	425	+/-	42	+/-
Oceania	83	0.390	293	+	16	+
World	1094	0.079	3872	+	54.8	+

Notes: + = increased risks; - = decreased risks.
[1]Oldeman, 1991-92.
[2]Lal, 1994b.
[3]Walling, 1987.

All physical and economic evidence shows that loss of land resource productivity is an important problem in Ethiopia and that with continued population growth the problem is likely to be even more important in the future. There are several studies that deal with land degradation at the national level in Ethiopia. These include the Highlands Reclamation Study: Ethiopia (EHRS-FAO 1986); studies by the National Conservation Strategy Secretariat (Sutcliffe 1993), the Ethiopian Forestry Action Plan (1993), and Keyser and Sonneveld (2001); Effect of Soil Degradation on Agricultural Productivity in Ethiopia.

Conclusions from these studies vary in detail. The EHRS concluded that water erosion (sheet and rill) was the most important process and that in mid-1980's 27 million ha or almost 50% of the highland area was significantly eroded, 14 million ha seriously eroded and over 2 million ha beyond reclamation. Erosion rates were estimated at 130 tons/ha/yr for cropland and 35

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tons/ha/yr average for all land in the highlands, but even at the time these were regarded as high estimates. Sutcliffe produced new lower estimates for soil erosion, but emphasized the much greater importance of nutrient loss.

Map 1 illustrates the regional extent and intensity of soil degradation.

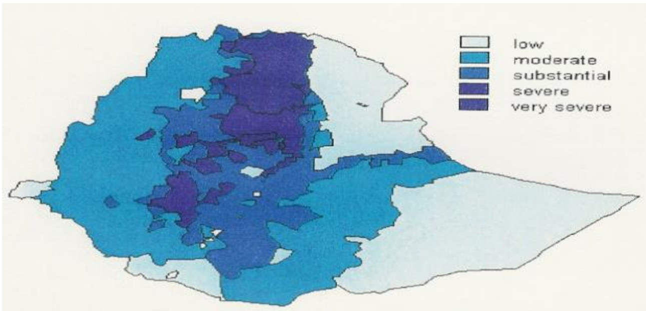

Figure 1. Soil degradation in Ethiopia (Source: Hakkeling, 1989).

Broad classification of soil erosion

Geological or natural or normal erosion: Erosion can occur naturally, transforming soil into sediment. This naturally occurring erosion devoid of man's influence is called geological or natural or normal erosion. Under this erosion type, the process of soil erosion is balanced by the process of soil formation, creating a state of equilibrium.

Accelerated erosion: When the process of soil erosion is influenced by human activities, it is accelerated. Such accelerated erosion is caused by removal of vegetation, and improper land use and management.

Soil erosion is a three phase process

1. **Detachment**
2. **Transportation**
3. **deposition**

The detachment of individual soil particles from the soil mass and their transport by erosive agents such as water and wind. When sufficient energy is no ranger available to transport the particles a third phase, deposition, occurs.

In real sense, when a soil mass which contains mixed grain sizes, the finer particles of that are hindered by the coarser particles to move ahead, as a result the finer particles are not removed until the velocity of flow is being sufficient to pick up the larger soil particles them from their places.

Type of movement of soil particles

Movement of particles in the runoff water occur as:-

1. suspension

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2. salutation
3. Surface creep

Suspension
Suspended sediments refer to the particles which remain in suspension in the flowing. Water for a considerable period of time with no contact with the stream bed. Soil particles may be brought in suspension in the moving stream in two ways:
(1) Due to the impact force of faving raindrops over the sheet of flowing water resulting in to splash and turbulence.
(2) The flow of water over the soil surface causes lifting of soil particles in the moving stream due to velocity gradients up wards from the surface.
Saltation
✓ The movement of sediment through particles skip or bounce along the stream bed.

Surface creep or bed load
✓ If is the movement of particles in almost continues contact with the stream bed The severity of erosion depends up on the quantity of material supplied by detachment and the capacity of the eroding agents (water, wind) to transport it. Where the agents have the capacity to transport more material that is supplied by detachment, the erosion is described as detachment limited where more material is supplied than can be transported, the erosion is transport limited.

Water Erosion
Soil erosion by water is the removal of soil particles by the action of water. Water erosion is the movement of soil by rain water running rapidly over the exposed land surface.
Type of water erosion:
- raindrop erosion
- shoot erosion
- rill erosion
- gully erosion
- Steam bank erosion.

Rain splash erosion/raindrop erosion
- Water erosion starts when raindrops strike bare soil and detach the soil particles, which are carried off with the following or, water.
- The strike (collision) of rain drops on bare soil and resulting splash is the major cause of soil erosion by water
- On level ground the soil particles move almost equally in all direction. On sloping land, more than half of the splashed particles move downhill.
- When the fine grains are detached by raindrop impact, they may be washed in to soil and pores. The surface seal or crust, which forms on drying, retards infiltration.

Sheet erosion

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- More or less uniform removal of soil in the form of a thin layer or in "sheet" form by the flowing water from a given width of slipping land.
- Sheet erosion is relatively slow moving and not capable of detaching much soil but it transports the soil that has been detached by raindrop splash.
- When rate of rain fall exceeds then excess water starts to collect over the land surface and tends to flow over the surface of sloping land.
- It is difficult to recognize /notice the sheet erosion at field but the occurrence of sheet erosion in a given field can be marked.
- Change of soil color
- Reduction in production
- Presence of coarse particles
- Expansion of depression size
- Engagement of tills.

-the most damaging soil erosion/ series production

Rill erosion

- ➢ Rill erosion is the removal of soil by runoff water with the formation of shallow channels that can be smoothed out completely by normal cultivation.
- ➢ Rills are usually small and can be easily removed by tillage.
- ➢ Rill erosion is much more easily noticed than sheet erosion.
- ➢ The detachment and transportation of soil particles are comparatively greater in rill erosion than the sheet erosion due to greater concentration of flow in rill which causes acceleration in the velocity of moving water.
- ➢ In rill erosion, detachment of soil particles mainly fakes place by the energy of flowing water, but in case of sheet by raindrop
- ➢ As the flow velocity increased, the detachability of soil also increased. **Eg**. As a velocity of running water increase, from 30cm/s to 60 cm/s, the soil detachability power is increased by four times.
- ➢ The capacity of moving water to transport the soil particles varies as the power fifth to its velocity (i.e v^5). -For example, an increase inflow velocity from 1 to 2 m/s, increase the transportation power of flowing water by 32 times
- ➢ The formation of tills is less pronounced on the upper part of the slope. Rill erosion usually begins to appear in the lower part of the slope. Because of velocity of surface runoff increased.

In unchecked, rills may extend in to the subsoil resulting in gully erosion.

Gully erosion

When rills advance, gullies are formed. These are erosion channels too large to be obliterated by ordinary tillage. In gullies, run off develops as powerful torrents with enhanced capability of erosion. Gullies have different shapes, depending on soil texture, and bedrock characteristics. They can be shallow troughs, V-shaped, U-shaped or complex in shape. A gully is active when

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its walls are free of vegetation and inactive when they are stabilized. Apart from shapes, gullies can also be classified according to depth:
Small gully < 1 m deep
Medium gully: 1-5 m deep
Large gully: > 5 m deep

Climatic consequences of land degradation
Land surface is an important part of the climate system. The interaction between land surface and the atmosphere involves multiple processes and feedbacks, all of which may vary simultaneously. It is frequently stressed that the changes of vegetation type can modify the characteristics of the regional atmospheric circulation and the large-scale external moisture fluxes. Changes in surface energy budgets resulting from land surface change can have a profound influence on the Earth's climate. Following deforestation, surface evapotranspiration and sensible heat flux are related to the dynamic structure of the low-level atmosphere. These changes in fluxes with in the atmospheric column could influence the regional, and potentially, global-scale atmospheric circulation.

Impact by Wind and Water Erosion
Wind and water erosion are the most widespread form of degradation. In the arid and semi-arid areas risk of wind erosion is serious. It happens whenever soil is left bare of vegetation as a result of cultivation and overgrazing following overstocking. Wind leads to the removal and deposition of soil particles from the top soil surface by its action. Apart from this, it can ensue extra damage by burying buildings, machinery and land with undesirable soil.

Water erosion admits various processes such as splash erosion, rill and gully erosion and sheet erosion. Splash erosion normally starts water erosion and takes place as raindrops fall onto the bare soil surface and break up the surface soil aggregates and splashes particles into the air. Soil particles falling into the abandons between the surface aggregates reduce the amount of rainwater and can pass through into the soil and increasing runoff. Water running above the soil surface has the ability to pick up some of the soil particles released by splash erosion and besides, it also detach particles from the soil surface. This consequence may lead to removal of soil particles from the soil surface reasonably on consistent basis and is known as sheet erosion. Rill and gully erosion occurs when runoff gets concentrated into channels. Rills are small streamlets or head cuts of a size that can be checked by tilling. Gullies erode away large amounts of soil with a huge amount of rain. Gullies are similar as rills but basically larger in size. Normal tilling doesn’t easily cease gullies.

Impact of Climate Change on Organic Matter Levels
Organic matter is one of the significant constituent of soils. It frame soil structure and stability, water and oxygen holding capacity and nutrient storage, hence it furnishes a home ground for numerous soil micro flora and fauna. Organic matter is sensitive to changes in the climate and their decomposition rate increases with increased temperature. Expanding of agriculture and its

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intensification has decreased the levels of soil organic matter. Majority of this organic matter had been lost as carbon dioxide in the atmosphere and this proves that some intensively cropped land release a substantial amount of greenhouse gases. Increase in plant growth due to increased atmospheric CO2 concentrations demonstrates the high use of organic matter from the soils. Hence with the climatic change organic-matter content of the soil highly affected.

Acidification

Acidification is a natural process that usually occurs as a consequence of nitrate leaching in high-rainfall areas. Most countries contain large areas of acidified soils and have become a primary problem for agricultural soils, where land management practices modify and aggravate the process. Increase in extent of acidification depends on both temperature and rainfall, i.e. regulated by climate. Substantial increase in rainfall increases leaching and cause acidification, whereas decline in rainfall reduce intensity and extent of acidification. Sub humid and arid geographical zone soils are influenced by seasonal changes i.e. from leaching conditions to evaporative conditions. Acid sulfate soils are the examples of acidification as they suffer from extreme acidity as a result of the oxidation of pyrite when pyrite-rich parent materials are drained

Impact on Nutrient Levels

Nutrients are another important constituents of soil and concentration of soil nutrients varies from one geographical region to another. Soil nutrient quantity is often affected by climatic factor. Change in temperature and precipitation could affect soil nutrient levels in numerous manners. Increasing temperatures could act to assert nutrients within the soil because of raised evaporative forces and abbreviate leaching. Downward movement of water in soil leads to loss of soil nutrient; hence movement of water to a great extent affects the soil nutrient level. Moreover, decrease in rainfall may cause upward movements of nutrients and thus leads to Stalinization. In tropical and subtropical countries, loss of soil nutrient is an increasing problem.

Acid Sulfate Soils

Acid sulfate soils are natural soils that contain iron sulphides generally in the form of iron pyrite. Two different forms of acid sulphide soils occur in nature. One, in which pyrite remains in reducing environment and another in which pyrite has been oxidized by exposure to air leading to the geological formation of sulphuric acid. Oxidation of metal sulfides to sulfuric acid and liberation of significant quantities of metals in environment is responsible for a major environmental menace in coastal lowlands and mined areas where sulfides are present. The climate change has severe impacts on acid sulfate soils and severity has reached to extreme by increase in the frequency and of weather events such as heavy rains and droughts. With climate change, the blushing of acid sulfate materials from soil containing acid sulfate and mine wastes will cause greater increases in concentrations that will be an ever increasing threat to aquatic life.

Impact on Soil Structure

Soil structure is unique property of the soil that have a fundamental effect on the behavior of soils, such as, water holding capacity, nutrient transformations and movement, nutrient leaching,

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and drainage. Climate change deteriorates the soil structure. Changes to soil structure are hard to quantify because of the influence of land use and management, hence further research is this area is required for better understanding of the effect of climate change on soil structure. Soils containing high clay contents incline to shrink when they are in dry condition, but they swell as they went up once again. This leads to formation of large fissures and cracks. Dry climatic conditions increase the size and frequency of crack formation in soils, particularly in temperate regions. Increase in crack with increase in quantity of metals, such as aluminum, iron, manganese, heavy metals is observed in case of acid soils when they are subjected to climatic change.

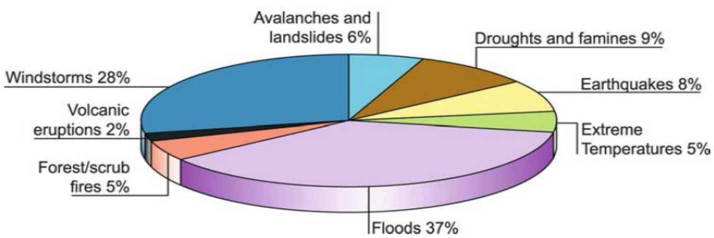

Figure 2. Global distribution of natural disasters

Carbon sequestration to mitigate climate change and combat land degradation

The soil organic carbon (SOC) pool to 1-m depth ranges from 30 tons ha-1 in the arid climates to 800 tons ha-1 in organic soils in cold regions (Lal 2007). Conversion of depletion is exacerbated when the output of carbon (C) exceeds the input and when soil degradation is severe. Depletion is exacerbated when the output of carbon (C) exceeds the input and when soil degradation is severe. Carbon sequestration implies transferring atmospheric CO2 into long-lived pools and storing it securely so it is not immediately reemitted. Thus, soil C sequestration means increasing SOC and soil inorganic carbon stocks through judicious land use and recommended management practices. Some of these practices include mulch farming, conservation tillage, agroforestry and diverse cropping systems, cover crops and integrated nutrient management, including the use of manure, compost, bio solids, improved grazing, and forest management.

RESULTS AND DISCUSSION

These climatic stresses include high soil temperature, seasonal excess water, short duration low temperatures, seasonal moisture stress and extended moisture stress, and affect 18.5 million km2 of the land in Africa. This study clearly exemplifies the importance of the need to give more careful consideration to climatic factors in land degradation. According to the database of the Belgian Centre for Research on the Epidemiology of Disasters (CRED), weather, climate and water-related hazards that occurred between1993-2002 were responsible for 63 per cent of the US$ 654 billion damage caused by all natural disasters. These natural hazards are therefore the

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most frequent and extensively observed ones and they all have a major impact on land degradation.

CONCLUSIONS

There is over whelming evidence which points the consequences of climate change in land degradation. Understanding of the consequence and their effects are urgently required to know how climate and soils interact and to understand changes in soil due to change in climate. Further, contribution of research in this field is needed to developed ability to cope and adapt to climate change, ability to assess how and where weather and climate patterns are likely to change and the ability to predict the continuous fluctuations in risk and vulnerability. Many research studies concluded that climate change is increasing and will increase in future. In response to these harsh conditions both pastoralist and farming communities were used indigenous climate change adaption strategies. Indigenous adaption strategies were contributed a lot for communities with providing solution/remedy for the changing environment in their working environment. These indigenous adaption strategies were essential for understanding either local or worldwide impacts of climate change on socioeconomic, political and environmental development/ wellbeing of the people. Pastoralists are aware of climate variability including decreasing trends of rainfall in amount and distribution. It is important for stakeholders to recognize the role of local and indigenous knowledge. Management of mobility and resources has long been guided by traditional institutions, and therefore these institutions have been a vital part of pastoralists' adaptive strategy, helping pastoralists take advantage of opportunities and cope with the consequences of climate variation. Therefore, building the capacity of this local institution is crucial in implementation of adaptation strategies and measures. Farmers are adapting climate change through different indigenous adaption strategies. Yet, some of the coping strategies are become less effective and cannot be scaled up easily to other areas.

To adapt and limit the negative effect of climate change in the region, efforts should base on clear understanding of local context, practices and knowledge. Finally, it is vital to integrate local knowledge and scientific approaches should have a potential to develop and look an alternative adaptation strategies.

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