# CLIMATE SMART AGRICULTURE, FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

*GLOBAL ISSUES & LOCAL PERSPECTIVES* volume One

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# Preface

This book adopts an exegetical approach as well as a pedagogic model, making it attractive agriculture and environmental economics teachers, professional practitioners and scholars. It is eschews pedantry and lays bars the issues in such clarity that conduces to learning. The book elaborates on contemporaneous **Climate Smart Agriculture, Food Security and Sustainable Development** issues of global significance and at the same time, is mindful of local or national perspectives making it appealing both to international and national interests. The book explores the ways in which climate smart agriculture (CSA) food security, Sustainable Development issues are and should be presented to increase the public's stock of knowledge, increase awareness about burning issues and empower the scholars and public to engage in the participatory dialogue climate smart agriculture, food security, and sustainable development necessary in policy making process that will stimulate increase in food production and environmental sustainability.

**Climate Smart Agriculture, Food Security and Sustainable Development:** *Global Issues & Local Perspectives* is organized in three parts. Part One deals with The Concept of **Climate Smart Agriculture**, Part Two is concerned with The Concept of **Food Security And** and Part Three deals with the Concept of **Sustainable Development**

**Eteyen Nyong; October 2025**

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# Chapter Four
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## INTRODUCTION

The climate change phenomenon can easily be understood as a by-product of globalization. It is widely perceived as an amorphous and all-embracing concept, with increasing impacts on human activities with full forces that span across national boundaries. Climate change has had a profound effect on economic, socio, culture, political, technological and even biological nature of man and plants in the global village (Oladipo, 2009).

It is right to observe that many are still ignorant of climate change and the issues surrounding the phenomenon. The phenomenon is still largely understudied and therefore, understood, however, what is clear is that there are fears associated with it. Fear of natural catastrophe, of food insecurity and of technology change, as well as the human security and other socio-economic impacts that can lead to human annihilation. Perhaps, that is why the climate change and economic implication has become a major concern to global governance institutions, national government and civil society around the world (Agbu, 2009). At present human kinds dependence on carbon-based energy is causing global warming and climate change is accelerating more rapid and dangerous, than anticipated even predicated by scientists, The 2007 United Nations Report based on the work of (2000) scientist predicted that Africa and Sub-Saharan Africa which included Nigeria would suffer most from drought, agricultural change rising in sea level threatening coastal areas and the spread of tropical pests and diseases (UN Report 2007). Generally, the physical and scientific evidence that the Climate of the world are changing include global rise in sea levels, drought and increasing desertification drying up of water resources (Rivers and Lakes), as well as increase in ambient temperature and in changing climate.

## CONCEPT OF CLIMATE CHANGE AND GLOBAL WARMING

Climate change in a change in the earth's weather, including change in temperature, wind patterns and rainfall as a result of the increase in the temperature of the earth's atmosphere that is caused by the increase of GHGs especially carbon dioxide (Yusuf, 2015). In other words climate change is a long-term shift in the climate of a specific

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location, region or planet. The shift is measured by changes in features associated with average weather such as temperature, rainfall (amount and pattern) and show, wind pattern lasting for decades or longer (Yusuf, 2015). The concept of climate change has to be linked with green house effects (natural effect and accelerated effects). The natural effect is a blessing (Gambo, 2015) while the accelerated is what causes global warming. Climate change refers to general shift in climate including temperature, precipitation, winds and other factors. Whereas Global warming (as well as global cooling) refers specifically to any change in the global average surface temperature.

Climate change refers to a statistically defined change in the average and/or variability of the climate system; this includes the atmosphere, the water cycle, the land surface, ice and the living components of Earth. The definition does not usually require the causes of change to be attributed, for example to human activity, but there are exceptions. Climate change is impacting human lives and health in a variety of ways. It threatens the essential ingredients of good health – clean air, safe drinking water, nutritious food supply and safe shelter – and has the potential to undermine decades of progress in global health (Https://www.who.int)

Between 2030 and 2050, climate change is expected to cause approximately 250 000 additional deaths per year from malnutrition, malaria, diarrhoea and heat stress alone. The direct damage costs to health are estimated to be between US$ 2–4 billion per year by 2030. Areas with weak health infrastructure – mostly in developing countries – will be the least able to cope without assistance to prepare and respond (Https://www.who.int)

Greenhouse gas emissions that result from the extraction and burning of fossil fuels are major contributors to both climate change and air pollution. Many policies and individual measures, such as transport, food and energy use choices, have the potential to reduce greenhouse gas emissions and produce major health co-benefits, particularly by abating air pollution. The phase out of polluting energy systems, for example, or the promotion of public transportation and active movement, could both lower carbon emissions and cut the burden of household and ambient air pollution, which cause 7 million premature deaths per year (Https://www.who.int)

## CLIMATE ADAPTATION

Adaption refers to adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects. It refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change. In simple terms, countries and communities need to develop adaption solutions and implement actions to respond to current and future climate change impacts.

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Adaption actions can take on many forms, depending on the unique context of a community, business, organisation, country or region. There is no 'one-size-fits-all' solution adaptation can range from building flood defences, setting up early warning systems for cyclones, switching to drought-resistance crops, to redesigning communication systems, business operations and government policies. However, greater action and ambition will be needed to cost-effectively manage the risk, both now and in the future (UNFCCC,2012).

Since the Industrial Revolution, human activities have released large amounts of carbon dioxide and other greenhouse gases into the atmosphere, which has changed the earth's climate. Natural processes, such as changes in the sun's energy and volcanic eruptions, also affect the earth's climate. However, they do not explain the warming that we have observed over the last century (National Academy of Sciences, 2020).

Climate adaptation is often interchangeable with climate mitigation – however, there is one key distinction between the two terms. Whereas climate mitigation sets measures to prevent climate change from happening, adaptation forms parameters for acclimating to shifting environmental conditions. Prioritisation of adaptation improves countries' chances of survival amid the most critical environmental problems. Some examples of adaptation strategies include constructing seawalls or increasing structural elevations to avoid sea level rise and floodin (UNFCCC, 2012)

## HUMAN VERSUS NATURAL CAUSES OF CLIMATE CHANGE

Climate change is one of the greatest global challenges of the 21st century whose threat is not only global but also multi-dimensional, invisible, unpredictable and transcends borders.

The IPCC Third Assessment Report (2007) noted that the Earth's average surface temperature increased from 0.6+ 0.2c in the 20th century. This trend is expected to persist with an increase of 1.4 to 5.0 centigrade by 2012. Even with the best mitigation efforts, some climate change cannot be avoided due to the inertia of the global climate system (IPCC Report, 2009). The causes of climate change can be broadly seen as natural and anthropogenic causes. It is unequivocal that human influence has warmed the atmosphere, ocean and land (Intergovernmental Panel on Climate Change IPCC, 2021). Scientists have pieced together a record of the earth's climate by analyzing a number of indirect measures of climate, such as ice cores, tree rings, glacier lengths, pollen remains, and ocean sediments, and by studying changes in the earth's orbit around the sun (Wuebbles, et al 2017). This record shows that the climate varies naturally over a wide range of time scales, but this variability does not explain the observed warming since the 1950s. Rather,

it is extremely likely (> 95%) that human activities have been the dominant cause of that warming (IPCC, 2013).

Concentrations of the key greenhouse gases have all increased since the Industrial Revolution due to human activities. Carbon dioxide, methane, and nitrous oxide concentrations are now more abundant in the earth's atmosphere than any time in the last 800,000 years (National Academy of Sciences, 2020). These greenhouse gas emissions have increased the greenhouse effect and caused the earth's surface temperature to rise. Burning fossil fuels changes the climate more than any other human activity.

Human-driven climate change is increasingly shaping the Earth's living environments. Rising temperatures, rapid shifts in rainfall and seasonality, and ocean acidification are presenting altered environments to many animal species (Sean, 2023). Animal nervous systems play a central role in both enabling and limiting how they respond to changing climates. Animals like mammals perceive temperature in part with special receptor proteins in their nervous systems that respond to heat and cold, discriminating between moderate and extreme temperatures. These receptor proteins help animals seek appropriate habitats and may play a critical role in how animals respond to changing temperatures (Sean, 2023).

WHAT ARE THESE GREEN HOUSE GASES AND WHAT ARE THEIR SOURCES?

Greenhouse gases are defined as gases which trap heat in the atmosphere and adversely affect climate change. Human activities as stated earlier are responsible for nearly all of the increases in greenhouse gases in the atmosphere in the past 150 years, greenhouse gases include the following. carbon dioxide (CO 2 ), methane (CH 4 ), nitrous oxide (N 2 O), hydro-fluorocarbons (HFCs), per-fluorocarbons (PFCs), sulphur hexafluoride (SF 6 ).

In 1987, the base year for many $CO_2$ reduction plans, 20.5 billion tons of carbon dioxide was pumped into the atmosphere. Thus; 80% of these gases were released by our world industries with united state having the highest industrial release (IEA, 2002). Power and other industrial sectors combined dominate current global $CO_2$ emissions, accounting for about 60% of total $CO_2$ emissions (IEA, 2002). Future projections indicate that the share of these sectoral emissions will decline to around 50% of global $CO_2$ emissions by

2050 (IEA, 2002). The $CO_2$ emissions in these sectors are generated by boilers and furnaces burning fossil fuels and are typically emitted from large exhaust stacks. These stacks can be described as large stationary sources, to distinguish them from mobile sources such as those in the transport sector and from smaller stationary sources such as small heating boilers used in the residential sector (IEA, 2002).

AN OVERVIEW OF CLIMATE CHANGE IMPACT IN AFRICA

Climate change impacts between 2000 - 2010 revealed an increase agricultural production in industrialized countries while developing countries recorded decrease in agricultural land, especially cereal production portending danger for food security in Africa and' particularly in West Africa which includes Nigeria (Eze 2010). Consequently, there is growing recognition that Nigeria may not be able to meet up with the millennium development goal target in the area of social economic development projects already put in pipeline.

According to IPCC Report (2007), the results of West Africa vulnerability analysis with climate change show that more than 280 million people are presently at risk and may be relocated due to climate variations and sea level changes. With the projected climate change the sea level use about 05m and the number of people that may be relocated assuming there would be increase may be about 27 million. In Nigeria, Ghana, Guinea and Cameroun, climate change has also caused flooding and wind erosion, thereby resulting to serious economic loss in terms of fishing and farming outputs (IPCC Report 2007). With the specific reference to the West Coast of Guinea, it is estimated that with an accelerated sea level rise (ASLR) of about 0.5 meters about 35% of the delta could be lost by the year 2015(IPCC Report 2007). According to the ECOWAS Conference Report (2007), this will impact the socio-economic livelihood of the people in that region. Global warming resulting in aridity has also compelled the pastoral farming in the Sahel Region of West Africa to move to other areas in search of pastures for their animals (ECOWAS Conference Report, 2007). With nearly 70% of the Sahel region population depending on agriculture and other socio-economic means for sustainable livelihoods, climate change impact becomes a serious concern for government, stakeholders and civil societies in West Africa (ECOWAS Conference Report, 2007).

In Nigeria, the climate change phenomenon can be seen in persistent drought in the North, desert encroachment, and water stress and scarcity, rising sea level and

inundation of coastal land by sea water in the south, whilst above average daily minimum and maximum temperature are common (Federal Ministry of Environment Report 2008).

As it highest number of population have their livelihood attached to agriculture, Nigeria which often not only speaks for itself, but also for Africa, climate change poses a specific challenge to its teaming population, about 140 million, most of whom depend on subsistent agriculture to survive. Quickly recognizing signs of global warming, designing appropriate policies and joining the global effort to address the issue are some of the immediate challenges facing Nigeria.

EFFECT OF CLIMATE CHANGE

1.Floods; Sea level rise is also racketing up the frequency and intensity of flooding on farms in coastal regions. These costly floods devastate crops and livestock, accelerate soil erosion, pollute water, and damage roads, bridges, schools, and other infrastructure. Heavy rainfalls can lead to more soil erosion, which is a major environmental threat to sustainable crop production (Gowda, P., et al. 2018).

2.Droughts; Too little water can be just as damaging as too much. Severe droughts have taken a heavy toll on crops, livestock, and farmers in many parts of the country, most notably California, the Great Plains, and the Midwest, over the past decade—and science tells us that rising temperatures will likely make such droughts even worse, depleting water supplies and, in some cases, spurring destructive wildfires. Since early 2020, the U.S. Southwest has been experiencing one of the most severe long-term droughts of the past 1,200 years. Multiple seasons of record low precipitation and near-record high temperatures were the main triggers of the drought (Mankin, et al. 2021). Some tribal communities are particularly vulnerable to wildfires due to their often-remote locations and lack of water caused by drought, lack of firefighting resources and staff (Gowda, P., et al. 2018). In addition, because wildfire smoke can travel long distances from the source fire, its effects can be far reaching, especially for people with certain medical conditions or who spend long periods of time outside.

3. Changes in crop and livestock viability; Rising temperatures and carbon dioxide concentrations may increase some crop yields, but the yields of major commodity crops (such as corn, rice, and oats) are expected to be lower than they would in a future without climate change (Gowda, P., et al. 2018). Climate change can affect crops, livestock, soil and water resources, rural communities, and agricultural workers. However, the agriculture sector also emits greenhouse gases into the atmosphere that contribute to

climate change. Dairy cows are especially sensitive to heat stress, which can affect their appetite and milk production. In 2010, heat stress lowered annual U.S. dairy production by an estimated $1.2 billion (Gowda, P., et al. 2018). Farmers choose crop varieties and animal breeds that are well suited to local conditions. As those conditions shift rapidly over the coming decades, many farmers will be forced to rethink some of their choices—which can mean making new capital investments, finding new markets, and learning new practices.

4. New Pests, Pathogens, And Weed Problems; Just as farmers will need to find new crops, livestock, and practices, they will have to cope with new threats. An insect or weed that couldn't thrive north of Texas in decades past may find Iowa a perfect fit going forward—and farmers will have to adapt. According to Sean (2023), Climate change is pushing more and more mosquitoes to take humans as their preferred hosts and it affects the chemical signals animals use to communicate with each other or harm competitors it can be especially complex because chemical compounds are highly sensitive to temperature.

5. Disruption of Habitat; Climate change disrupts the environmental cues animals rely on to solve problems like selecting a habitat, finding food and choosing mates. Some animals, such as mosquitoes that transmit parasites and pathogens, rely on temperature gradients to orient themselves to their environment. Temperature shifts are altering where and when mosquitoes search for hosts, leading to changes in disease transmission (Sean, 2023). Animals may respond to climate adversity by shifting locations, from changing the microhabitats they use to altering their geographic ranges. Activity can also shift to different periods of the day or to new seasons (Sean, 2023). These behavioral responses can have major implications for the environmental stimuli animals will be exposed to.

Agriculture is very sensitive to weather and climate, agriculture relies heavily on land, water, and other natural resources that climate affects (Gowda, P., et al. 2018). While climate changes (such as in temperature, precipitation, and frost timing) could lengthen the growing season or allow different crops to be grown in some regions, it will also make agricultural practices more difficult in others.

The effects of climate change on agriculture will depend on the rate and severity of the change, as well as the degree to which farmers and ranchers can adapt (Gowda, P., et al. 2018). There are over two million farms in the United States, and more than half the

nation's land is used for agricultural production. The number of farms has been slowly declining since the 1930s, though the average farm size has remained about the same since the early 1970s (USDA, ERS 2022). Agriculture also extends beyond farms; it includes industries such as food service and food manufacturing. United States agriculture already has many practices in place to adapt to a changing climate, including crop rotation and integrated pest management. A good deal of research is also under way to help prepare for a changing climate.

## ADAPTATION OF MANAGEMENT PRACTICES ON AGRICULTURAL (CROP AND ANIMAL PRODUCTION)

Climate change is a global environmental problem and whiles a developing continent like Africa has not contributed greatly to climate change; it is certainly among those areas first affected by the impacts of climate change (Pongo 2008 cited in Debray, 2015). As of 2009, kalemba in Debray (2015) says that "by the close of the century, more than 180 million people will suffer the consequences of climate change in sub-Saharan Africa. This is one reason why it is so important to attack Africa's environmental problems head on, both for present and future generations and for the whole world. It is evident from the IPCC 5$^{th}$ assessment report that "climate change will have widespread impacts on food security, water availability, livelihoods and human health in Africa". Vast proportions of African countries' populations rely on agricultural production (both crops and livestock) for livelihood and food security. Indeed, agriculture employs almost 70% of the population in most African countries and represents in average 21% of GDP in Africa, with a contribution ranging from 10 to 70% depending on the country (Boko et al., 2007). Yet it is often considered as the human activity that is the most dependent on climate (Sultan, 2008 in Debray., 2015).

In Sub Saharan Africa 97% of total crop land is rainfed and many African countries lacks efficient irrigation systems (Boko et al., 2007).The livestock sector is also very important in Africa, with a concentration in sub arid and sub humid zones, because of susceptibility to diseases and low digestibility of grasses in tropical environments (Boko et al., 2007). African smallholder farmer's rainfed farming systems are particularly dependent to precipitation variability and therefore critically vulnerable to climate evolutions. Besides the challenges of climate change, African farmers have to cope with constraints such as poor soil fertility, pests, crop and animal diseases and restricted access to inputs and improved seeds (Boko et al., 2007). There is a growing recognition that more can and should be done to address the causes and impacts of recurrent effect of climate change. However, the adaptive strategies were employed to cope with the challenges of climate change and land degradation which includes; small scale irrigation, use of

drought tolerant crop varieties, improve tree management, conservation agricultural practices and livelihood diversification among others (Swift, J.1998).

i. Small Scale Irrigation: This strategy reduces farmers' dependence on rain-fed agriculture and increase overall household food security and income. Dependence on rain-fed agriculture often leads to varied yields, crop failures and the risks of food insecurity as a result the variability in rainfall, while studies have shown that rain-fed agriculture combined with conservation agriculture techniques can increase crop yields by storing water in the soil more effectively. A range of irrigation technologies and methods have been adopted in African drylands, including water abstraction with gravity or mobile pumping schemes, canal or pipe conveyance systems, and furrow irrigation, depending on the biophysical, geographic, topographic and socio-economic conditions on the ground (Tafesse, M. (2003).

ii. Use of Drought Tolerant Crop Varieties: Some drought-resistant, fast-growing crops such as sorghum and chickpeas are used by the smallholder farmers because they can thrive and yield relatively well even with high water scarcity within the shortened length of the growing seasons, as they mature before the depletion of soil moisture, thereby reducing the threat from dry spells (Dar, 2009).

iii. Improve Tree Management: tree planting and management or afforestation technique is an adaptive strategy use by the smallholder farmers in the African Dryland to reverse desertification processes, and soil erosion, as it helps in holding the soil together, increase land cover, as well as trapping soil moisture (Swift, J.1998).

iv. Conservation Agricultural Practices: These are agronomic practices which are the important agricultural practices that contribute to the conservation and productivity of cultivated lands also referred to as conservation farming's or advanced agronomical methods.

They include:

a. Contour farming,

b. Tillage and keeping the land fallow,

c. Crop rotation, sowing of leguminous crops and mixed cropping,

d. Mulching and

e. Strip cropping, and mixed farming.

a. Contour farming: It is practiced in the hilly regions or on the slopes. In such areas the rain water is absorbed in very little amount because of its quick downward movement on the slopes. If these sloppy areas are ploughed up and down the slope, the heavy rainfall may cause gully development. Taking into consideration this defect, the sloppy areas are ploughed and seeded against the slope, i.e., in circular furrows around the slopes. This process is termed as contour farming (Van den Ban, A.W. 1998). The contours (circular or peripheral furrows) catch the downwardly moving water until it is absorbed in the soil. The ridges reduce the flow of water. The circular rows of plants across the slopes check the soil erosion. Thus, contour farming reduces run off, saves more water for crops, reduces soil erosion and increases the yield of crops hence increasing the soil productivity. The figure below is a representation of contour farming.


Fig.1 Contour Farming

b. Tillage operation and keeping the land fallow: There are several diverse opinions as to whether deep ploughing gives good result or shallow ploughing. A number of researches support the view that in dry areas, shallow ploughing gives comparatively good crop yields Shallow ploughing removes the weeds and enables the soil to absorb water. Deep ploughing leads to soil erosion but in the areas where rainfall is sufficiently high, deep ploughing (up to 15-30 cm deep) is effective in removing weeds and increasing crops yields (Alvarez and Steinbach 2009). If the land is left uncultivated and sheep, goats and other cattle are allowed to graze and sit over it for some time, the soil becomes fertile. Though this practice is useful yet it is not possible in the countries like India where exists severe problem of cereals because of thick human population (Fernandez et al. 2010).

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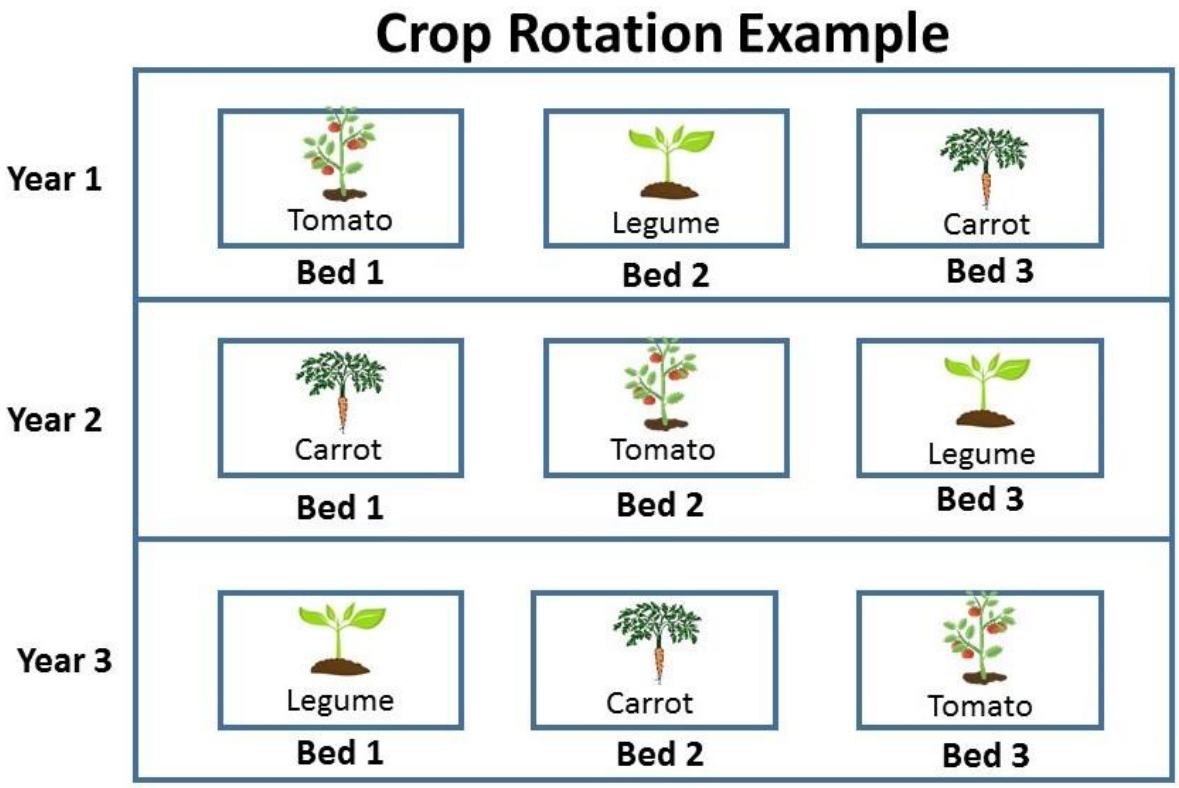
c. Crop rotation, sowing of legumes and mixed cropping: When the same crops grown in the field every year, the soil becomes depleted in certain minerals. The soil loses its fertility even after the use of fertilizers and ultimately erosion sets in. Rotation of crops is an important method for checking erosion and maintaining soil productivity. After 2 years crop should be changed in the fields. A good rotation should include a cultivated row crop, densely plane small grasses and a spreading legume or a legume and grass mixture. Selection of crops for rotation should be made taking into consideration the climate, economic condition, soil types, soil texture, slopes, nature of erosion, etc. Deep-rooted crops should be rotated by shallow-rooted crops. Deep-rooted crops absorb nutrients from the deeper strata of the soil Thus; the minerals on the top soil remain stored for future use by shallow-rooted plants. When the deep rooted crops decay they add humus in the soil which is future storehouse of plant nutrients (Alvarez and Steinbach 2009). Mixed cropping is another important method for increasing productivity of the soil. In this practice, one main crop and one or two subsidiary crops are grown together on the same land, as for example, growing of maize along with beans. This practice checks the soil erosion and avoids the risk of crop failure. If one crop fails due to diseases or any other factor, the others remain ensured (Knowler, D. et al. 1998). The figure below explain the technique in crop rotation.



d. Mulching: It means covering the soil surface by straw, leaves or grasses. Mulches of different kinds check soil erosion, increase soil fertility and also minimize moisture evaporation from the top soils. Various types of surface tillers and crop residues are helpful in obstructing the movement of soil particles (Knowler, D. et al. 1998).

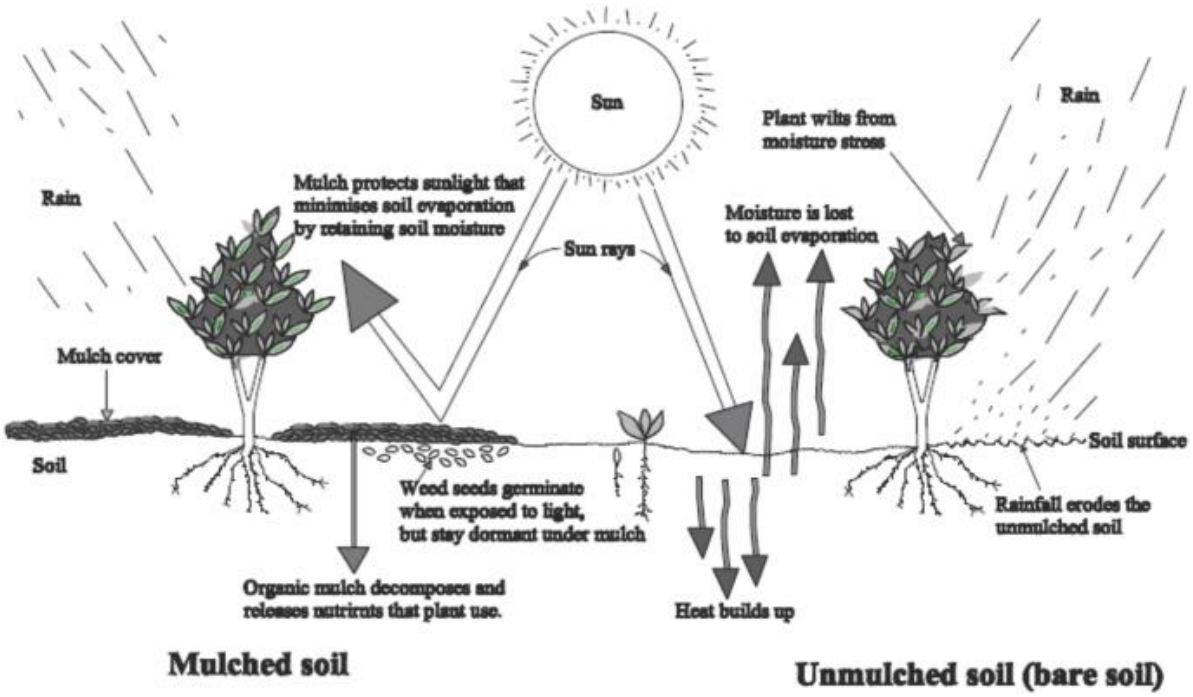



Fig 3; Mulching and how it works

e. Strip cropping: It is an important method which employs all the advanced cultivation practices such as contour farming, proper tillage, crop rotation, mulching, cover cropping, etc. Strip cropping is very effective and practical means for controlling soil erosion which in turn will reduce loss of nutrients from the soil and making it more productive (Knowler, D. et al. 1998).

v. Diversification of Livestock Animals and Crops ;An adaptation such as the modification of production and management systems involves diversification of livestock animals and crops, integration of livestock systems with forestry and crop production, and changing the timing and locations of farm operations (IFAD, 2010). Diversification of livestock and crop varieties can increase drought and heat wave tolerance, and may increase livestock production when animals are exposed to temperature and precipitation stresses. In addition, this diversity of crops and livestock animals is effective in fighting against climate change-related diseases and pest outbreaks (IFAD, 2010, Kurukulasuriya and Rosenthal, 2003). Agroforestry as a land management approach can help maintain the balance between agricultural production,

environmental protection and carbon sequestration to offset emissions from the sector. Agroforestry may increase productivity and improve quality of air, soil, and water, biodiversity, pests and diseases, and improves nutrient cycling (Jose, 2009, Smith et al., 2012).Changes in mixed crop-livestock systems are an adaptation measure that could improve food security.

vi. Improved Animal Nutrition and Breeding; Changes to animal diets can reduce greenhouse gas emissions and increase animal productivity, but they can also risk harming animal welfare. However, bolstering nutrition by supplementing poor diets or using improved forages can both reduce greenhouse gas emissions and improve welfare at the same time. In regions of the world with a seasonally dry tropical climate, such as Africa, the low nutritional value of most animal feeds during the dry season is a major constraint on animal productivity (Tothill, 1985). In developing countries, ruminant animals are often fed on low quality grasses and crop residues (stover). Inadequate nutrition is a key factor limiting fertility (Hristov, et al 2013).). A large potential to mitigate emissions exists in these low-yield systems. For example, modeling of small ruminant production in West Africa suggests that improvements in forage digestibility, along with other animal health and husbandry measures, can potentially reduce emissions by 27% to 41% of baseline emissions, amounting to 7.7 to 12 million tons of $CO_2$-eq (Geiber, 2013) . Given that feed production accounts for about 47% of livestock emissions, it is a key target for mitigation. However, there are a number of welfare concerns with some of the current proposals to reduce emissions using feed alterations (Gerber, 2013). Direct reduction of GHG emission through breeding using selection and identification of animals that are high or low GHG emitters (knowing the different diets and different systems conditions) is a valid mitigation strategy. Many factors influence ruminal $CH_4$ emissions, including food intake and composition and alteration in ruminal microflora.

vii. Biodiversity Conservation: New science findings by Schmitz (2023) reveals that restoring species will help limit global warming, Solving the climate crisis and biodiversity crisis are not separate issues. Animals remove billions of tons of carbon dioxide each year, protecting wildlife across the world could significantly enhance natural carbon capture and storage by supercharging ecosystem carbon sinks, The study, published in *Nature Climate Change* and co-authored by 15 scientists from eight countries, examined nine wildlife species — marine fish, whales, sharks, grey wolves, wildebeest, sea otters, musk oxen, African forest elephants, and American bison. The data shows that protecting or restoring their populations could collectively facilitate the additional capture of 6.41 billion tons of carbon dioxide annually. This is 95% of the amount needed every year to meet the Paris Agreement target of removing enough carbon from the atmosphere to keep global warming below the 1.5-degree Celsius threshold (Schmitz, 2023);.

Animals play a critical role controlling the carbon cycle in terrestrial, freshwater and marine ecosystems through a wide range of processes including foraging, nutrient

deposition, disturbance, organic carbon deposition, and seed dispersal, Schmitz's research has shown. The dynamics of carbon uptake and storage fundamentally changes with the presence or absence of animals. To ignore animals leads to missed opportunities to enhance the scope, spatial extent, and range of ecosystems that can be enlisted to help hold climate warming to within 1.5 degrees Celsius. Endangering animal populations to the point where they become extinct could flip the ecosystems they inhabit from carbon sinks to carbon sources (Schmitz, 2023). According to Schmitz (2023), Wildlife species throughout their interaction with the environment, are the missing link between biodiversity and climate, this interaction means rewilding (the act of restoring a natural area to its former wild state) can be among the best nature-based climate solutions available to humankind.

## CONCLUSION

This chapter explores the far-reaching consequences on our planets ecosystems, societies and on economies. The chapter also underscores the urgent need for adaptive strategies to mitigate the adverse effect on agriculture (crop and animal production). The chapter also explores the cascading effects on biodiversity emphasizing the interconnectedness of species and ecosystem.

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