The Use of Tillage Methods to Mitigate the Effects of Climate Change in Savanna Ecological Zone of Kwara State, Nigeria

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Abstract

Several indigenous local technologies in use have recorded huge successes especially among peasant farmers. These local technologies were handed down from one generation to the other and are still in vogue till today. Recently, evidences have shown that farmers are not eager to adopt or invest in management practices provided by agricultural extension workers which are known for their efficiency in combating land resource degradation issues and adaptation to climate vagaries but prefer to use the indigenous methods of combating weather fluctuations. The study aims at assessing the use of indigenous knowledge in application of tillage methods towards climate change mitigation and adaptation in the savanna ecological zone of Kwara State. Participatory Rural Appraisal (PRA) using focused group discussion was used to interview groups of farmers and key informant to assess the current perception of the farmers with respect to their choice of tillage and climate variation management at Bolorunduro and Jimba Oja farming settlements. The findings of the study reveals that several of the farmers make use of conservative/traditional tillage in the farming settlements and climatic variation have been controlled through the use of historic methods handed down from one generation to the other such as irrigation, land fallow system, avoidance, crop rotation among others. Based on the findings, the study recommended that intervention of government in providing promptly weather forecast for appropriate actions to be taken by farmers as well as improved or hybrid plant varieties that are resilient to climate change.

Keywords: Tillage Methods, Farmers, indigenous knowledge, climate change, Mitigation, Adaptation

Introduction

The average weather conditions prevalent from one season to another in the course of a year over a large area is known as climate. The average of these weather conditions is calculated from the data collected for several year (about 35 years) for a larger area as reported by American Meteorological Society (AMS) (2016). Climate change is unavoidable and associated weather extremes such as high temperature and heat waves, increased frequency of drought and high intensity rainfall causing floods. Circumstantial evidences almost confirm researcher's early predictions of a changing climate and a warming world (Lenka & Lenka, 2013). One of the prominent mitigation options is the management of agricultural land use as it occupies about 40–50% of the Earth's land surface. Agricultural systems contribute up to 20 % of this global warming (Yang et al, 2020). However, agriculture can reduce its own emissions while increasing carbon sequestration through use of recommended management practices, such as conservation tillage (CT) (Utomo, 2014).

Adoption of the best management practices (BMPs) contribute significantly to climate change mitigation through reduction in source and increase in sink of carbon. Of the global anthropogenic emissions, agriculture accounts for about 60% of Nitrogen Oxide (N2O) and 50% of Chlorocarbon (CH4) emission (medium agreement, medium evidence) (Smith et al., 2007). Among the various measures recommended as the BMPs, conservation tillage (CT), particularly, no-tillage (NT) has been much emphasized (Singh et al., 2014). Conservation tillage is defined as a tillage system in which at least 30% of crop residues are left in the field and is an important conservation practice to reduce soil erosion (Madejon *et al*., 2007). Tillage is considered to be the major mechanism by which soil is exposed to oxidation and thus loss of soil carbon. In fact, reduction in tillage intensity through no-tillage (NT) or reduced tillage (RT) practices have the potential to increase soil organic carbon (SOC) pool by capturing carbon inputs and decreasing carbon loss by tillage. Tillage strongly influences SOC distribution and storage by physically mixing soil and by distributing crop residues in the soil.

Agricultural sustainability is therefore needed as it increases the trend in per capita productivity to meet the present needs without jeopardizing the future potential. With continued population growth and increasing demand on water resources, conservation tillage will have an increasing role to play in farming during this millennium. The world population has been projected to be expected to be 8.5 and 9.0 billion by 2025 and 2050 respectively (Berry *et al.*, 2003).

Agricultural produce in Nigeria is mostly rainfed. Unpredictable rainfall variation makes it difficult for farmers to plan their operations (Anabaraonye et al., 2019 as cited in Haider, 2019). Higher temperatures, lower rainfall, droughts, and desertification reduces farmlands, lowers agricultural productivity and affects crop yields. Increased rainfall intensity in the coastal region, sea level rise, flooding and erosion of farmland will also lower agricultural production (Haider, 2019).

According to Ajibade and Eche (2019), agriculture places heavy burdens on the environment in the process of providing populations with food and fiber, while climate is the primary determinant of agricultural productivity. Indigenous communities have long been recognized as vulnerable to the impacts of climate change due to the close connections between their livelihoods, culture, spirituality, social systems and their environment. At the same time, however, this deep and long-established relationship with the natural environment affords many indigenous people with knowledge that they have long used to adapt to environmental change, and are now using to respond to the impacts of climate change. Local communities and farmers in Africa have developed intricate systems of gathering, predicting, interpreting and decision-making in relation to climate change problems.

The adoption of existing and new technologies for adapting to climate change and variability is a high priority for many ecological regions in Nigeria. This includes crop diversification, the adoption of drought-tolerant and early maturing varieties of crops; and crop cover (Haider ,2019). Studies show that Nigerian farmers on their own and with the help of government and other intervention agencies are already adapting to climate change using these and other methods (Ifeanyi-obi & Nnadi, 2014).

Though there is a lot of information on tillage studies, the aspects that characterize the complexity of tillage systems and their environmental impact is yet to be fully researched. Also, estimates of the use of conservation tillage in Nigeria are quite low currently, projections indicate largely unexplored potential for conservation tillage in the country (Lal, 2001; Aina, 2011). Several indigenous local technologies have recorded huge successes especially among peasant farmers (Tekwa & Belel, 2008).

Traditional societies in many cases have built up knowledge over long periods about changes in the environment and have developed elaborated strategies to cope with these changes. However, traditional knowledge systems in mitigation and adaptation have for a long time been neglected in climate change policy formulation and implementation and have only recently been taken up into the climate change discourse. In spite of all these, recent evidences have shown that farmers are not eager to adopt or invest in soil management practices which are known for their efficiency in combating climate change, land resource degradation issues and improving soil productivity. This is due to particular challenges faced in its usage. Junge *et al* (2007) observed that some of the farming system practices aimed at tackling soil and water quality decline and degradation have wide spread acknowledgement with low usage. The study aims at assessing the use of indigenous knowledge in application of tillage methods towards climate change mitigation and adaptation in the Savanna ecological zone of Kwara State.

Conceptual Clarification

Tillage

Tillage is the agricultural preparation of the soil by mechanical, draught-animal or human-powered efforts. The activities usually involve ploughing, digging, overturning, shoveling, hoeing and raking (Aina, 2011). Moore (2020) defined tillage is a technique of manipulating the soil in preparation for crop production. The aim is to manage various characteristics of the soil, such as water retention, temperature, infiltration, and evapotranspiration.

as any physical loosening of the soil as carried out in a range of cultivation operations, either by hand or through mechanization. According to Verma et al (2023), tillage refers to both soil cultivation after planting and soil preparation for planting. By using tools, the soil is mechanically moved or manipulated into the desired state by tillage (such as pulverization, cutting, or movement).

According to Ohu (2011), the important effect of tillage on soil sustainability is through its impact on the environment through soil degradation, poor water quality, emission of greenhouse gases from soil-related processes among others. As a subsystem of a crop production, tillage can be used to achieve many agronomic objectives which will eventually lead to sustainability of the ecosystems. These include soil conditioning (modification of soil structure to favor agronomic processes such as soil seed contact, root proliferation, water infiltration, soil temperature control among others), weed/pest suppression (direct termination or disruption of weed/pest life cycles), residue management (movement, orientation or sizing of residues to minimize negative effects of crop yield/cover crop residues and promote beneficial effects), nutrient incorporation/mixing (placement or redistribution of substances such as fertilizers, manures, seeds, residues, sometimes from a less favorable location to a more favorable spatial distribution), segregation (consolidation of rocks, root crops, soil crumb sizes) and land forming (changing the shape of the soil surface such as ridging and roughening). Also, Lutz et al (2019) also reported that tillage affects a variety of biophysical processes that affect the environment, such as greenhouse gas emissions or soil carbon sequestration and can influence various forms of soil degradation (e.g. wind, water, and tillage erosion).

There are two main types of tillage systems: conventional tillage and conservation tillage. Conventional tillage is a tillage system using cultivation as the major means of seedbed preparation and weed control. It is defined as any tillage and planting system that leaves less than 15 percent residue cover after planting or less than 560 kilograms per hectare of small grain residue equivalent throughout the critical wind erosion period as proposed by Conservation Technology Information Center (CTIC ,2004). It includes systems such as mechanized and traditional tillage which involves the mechanical soil manipulation of an entire field, by ploughing followed by one or more harrowing.

Traditional tillage is practiced mostly by manual labour in the humid and sub-humid regions of West Africa, and in some parts of South America. It uses native tools which are generally few and simple, the most important are the cutlass and hoe which come in many designs depending on function. To facilitate seedbed preparation and planting, forest undergrowth or grass is cleared with a cutlass and trees while shrubs are left, but pruned. The cut biomass and residues are disposed of by burning *in situ*. This type of clearing is non-exhaustive, leaving both appreciable cover on the soil, and the root system which gives the topsoil structural stability for one or two years as observed by Aina *et al* (2011). Conservation tillage (CT) is defined as any tillage and planting system that covers 30 percent or more of the soil surface with crop residue after planting, to reduce soil erosion by water (CTIC,2004). According to Ohu (2011), conservation tillage includes no-tillage, ridge, strip tillage and mulch tillage. These have many variations covering a broad spectrum of farming methods primarily aimed at reducing soil disturbance, conserving and managing crop residue to reduce erosion

Climate Change

Climate change is one of the most extensively discussed topics in the late 20th and early 21st century on our planet. Climate change refers to significant, long term changes in the global climate due to an increase in the average atmospheric temperature. Increase in the average temperature of troposphere is called global warming. It occurred due to an increased amount of the heat striking the earth from the sun which is being trapped in the atmosphere and not radiated out into space. The earth's atmosphere acted as greenhouse which captures the sun's heat. Greenhouse gasses are responsible for global warming (Lahane & Jadhav,2020).

Climate change has emerged as one of the defining challenges confronting the world today. Its impacts, together with the measures required to address it (climate action) through mitigation and adaptation – have many implications for the economy and for society (Intergovernmental Panel on Climate Change (IPCC), 2018).

Climate remains the basic factor that determines agricultural production irrespective of crops and farmland. It is evidenced that climate change will have a strong impact on Nigeria- particularly in the areas of agriculture; land use, energy, biodiversity, health and water resources. Nigeria, like all the countries of Sub-Saharan Africa, is highly vulnerable to the impacts of climate change (IPCC, 2007).

The climate change indicators in Nigeria include increases in temperature, variable rainfall (decreasing rainfall amount in the continental interiors, increasing rainfall in the coastal areas), sea level rise, flooding and erosion, drought and increasing desertification, land degradation, extreme weather events (thunderstorms, lightning, landslides, floods, droughts, bush fires); and affected fresh water resources and loss of biodiversity (Elisha *et al*., 2017).

Participatory Rural Appraisal and Indigenous Knowledge

Participatory Rural Appraisal (PRA) is considered one of the popular and effective approaches to gather information in rural areas. This approach was developed in early 1990s with considerable shift in paradigm from top-down to bottom-up approach, and from blueprint to the learning process. In fact, it is a shift from extractive survey questionnaires to experience sharing by local people. PRA is based on village experiences where communities effectively manage their natural resources (Cavestro, 2003). Participatory Rural Appraisal (PRA) and Focus Group Discussion (FGD) are qualitative research techniques and important ways of understanding local perspectives (indigenous knowledge) on different issues. The techniques involved the communities in the process of identifying problems and in devising ways for minimizing or solving the identified constraints on development. The techniques facilitate the use of indigenous knowledge of the community by relying on norms, values and belief system of communities to select data and other information relevant in guiding development process (Lawal, 2017).

Indigenous knowledge (IK) is any understanding rooted in local culture. It includes all knowledge held more or less collectively by a population that informs interpretation of things. It varies between regions. People in different regions have unique cultural traditions and histories, which critically shape their views of their environments, livelihood choices, health and illness, social behavior and so on. Indigenous knowledge research seeks to incorporate these views more into development (Sillitoe, 2006). It is a development approach in which clients and stakeholders learn about and analyse local situations and decide together what to do and how to go about doing it to achieve the desired results (Olawepo, 2009).

PRA is a methodology of learning rural life and their environment from the rural people. It requires researchers / field workers to act as facilitators to help local people conduct their own analysis, plan and take action accordingly. It is based on the principle that local people are creative and capable and can do their own investigations, analysis, and planning. The basic concept of PRA is to learn from rural people. Chambers (1994) has defined PRA as an approach and methods for learning about rural life and conditions from, with and by rural people. Chambers further stated that PRA extends into analysis, planning and action. PRA closely involve villagers and local officials in the process. Some of the useful PRA techniques for indigenous knowledge according to Olawepo (2009) and Cavestro (2003) includes:

a. Direct observation -- Observations are related to questions: What? When? Where? Who? Why? How?

b. Do it yourself -- Villagers are encouraged to teach the researcher how to do various activities. The researcher will learn how much skill and strength are required to do day to-day rural activities, gaining an insider's perspective on a situation. Roles are reversed: villagers are the "experts" and attitudes are challenged.

c. Group discussion - this is usually casual or organized brain storming workshop among the local people, they talk about their problems, environment and felt need objects and various solutions.

d. Participatory mapping and modeling -- Using local materials, villagers draw or model current or historical conditions. The researcher then interviews the villager by "interviewing the map." This technique can be used to show watersheds, forests, farms, home gardens, residential areas, soils, water sources, wealth rankings, household assets, land-use patterns, changes in farming practices, constraints, trends, health and welfare conditions, and the distribution of various resources.

e. Transect walks and guided field walks -- The researcher and key informants conduct a walking tour through areas of interest to observe, to listen, to identify different zones or conditions, and to ask questions to identify problems and possible solutions. With this method, the outsider can quickly learn about topography, soils, land use, forests, watersheds, and community assets.

f. Force Field Analysis - This is a technique, to visually identify and analyse forces affecting a problem situation character, simplicity, suitability for group work and applicability in planning for change makes it a potential tool with wide application in PRA.

g. Seasonal calendars -- Variables such as rainfall, labor, income, expenditures, debt, animal fodder or pests, and harvesting periods can be drawn (or created with stones, seeds, and sticks) to show month-to-month variations and seasonal constraints and to highlight opportunities for action. An 18-month calendar can better illustrate variations than a 12-month calendar.

h. Semi structured interviewing -- A semi structured interviewing and listening technique uses some predetermined questions and topics but allows new topics to be pursued as the interview develops. The interviews are informal and conversational but carefully controlled.

i. Local histories -- Local histories are similar to time lines but give a more detailed account of how things have changed or are changing. For example, histories can be developed for crops, population changes, community health trends and epidemics, education changes, road developments, and trees and forests.

Description of Study Area

The study was carried out at Bolorunduro and Jimba-Oja farming settlements which are located in Ilorin South and Ifelodun Local Government Area, Kwara State Bolorunduro is underlain mainly by the precambian to lower paleozoic crystalline basement of granitic and metamorphic rocks, mainly biotite gneiss with lensis and biotiteschots and pregmatite intrusions (Kassim, 2000). Jimba-Oja falls into undifferentiated basement complex comprising mixture of acid crystalline rock-gneisses schists (with biotite and mica) and quartizites. Basic amphibolites and olivine rich dykes are intruded within these formations while granites and granitic rocks occur. Apart from exposed iron pans in scattered areas, there are also localized outcrops of basement complex rocks. The percentage of the entire area occupied by the outcrop can be considered as localized impediments to mechanization. However, these outcrops can be effectively utilized in conservation planning as erosion barrier (Agaja et al., 2022).

Bolorunduro is located close to the University of Ilorin Teaching and Research Farm and is drained mainly by Oyun River which takes her source cross-sect from Ita-Oregun in Osun State and flow through Otan-Aiyegbaju (also in Osun State) to Offa and finally to Ilorin where it is dammed at the University of Ilorin main campus. Jimba- Oja is located close to National Center for Agricultural Mechanization (NCAM), Idofian and it forms parts of the lower catchment area of River Oyun that bounds it to the West. The catchment of Oyun River is located between latitudes $9^{0}50'$ and $8^{0}24'$ North and Longitudes $4^{0}38'$ and $4^{0}03'$ East. Its total area is 800.0 km2 with a length of 71.4 km and it lies within Kwara State.

The climate falls within the tropical hinterland climatic zone. It is tropical and seasonal having a dry season occurring between November to April while the rainy season between May and October. Occasionally, there could be early beginning of the rainy and the dry season may be extended (Mustapha, 2008). The dry season is characterized by absence of rainfall, high temperature and mean monthly rainfall total of about 360mm and the annual rainfall is close to 1040mm (Mustapha, 2008). The mean annual evaporation is in the range of 1000-1200mm (Figure 2.5). The humidity ranges between 30-80%. Relative humidity is high during the rainy season and low in dry season. The temperature ranges from 20^{0}C-30^{0}C (Adelana & Olasehinde, 2004). The type of rainfall experienced is convectional storms, sometimes very windy. The heaviest rainfall is often recorded between June and early August. There is a short spell of drought between August and early September (Olaniran, 1983; Oyegun, 1983). The annual rainfall ranges between 1000mm and 1500mm (Figure 1). Relative humidity in the wet season is between 75 and 80% while in the dry season it is about 65% (Tinuoye, 1990). The daytime is always sunny with the sun brightly shinning for about 6.5 - 7.7 hours daily from November to May (Olaniran, 1983).

The Jimba-Oja soil is classified as Topic Haplustalf of Eruwa, and Odo-owa series. The parent material consists of Micaceousschists and genesis of basement complex origin which are rich in ferro-magnesian minerals (Ahaneku, 1990). The soil of Bolorunduro is ferruginous tropical soil. The vegetation of Ifelodun L.G.A is Guinea savannah grassland which is intercepted by few fringes that is in Oro-Ago and Ilere districts of the Local Government while the vegetation of the Ilorin South L.G.A is derived savannah. Majority of the people in Ifelodun and Ilorin South Local Government Area practice subsistence farming and petty trading to earn their living. According to Ahmed (2009), the food crops produced abundantly include: Yam, Cassava, Maize, Rice, Soya beans, Locust-beans and Groundnut. Generally, the people are very hospitable, peace-loving, accommodating and famous for their high level of self-help development efforts. The popular local industries in the area include: Garri processing industries Shea butter processing industries, trading, commerce, administration etc.

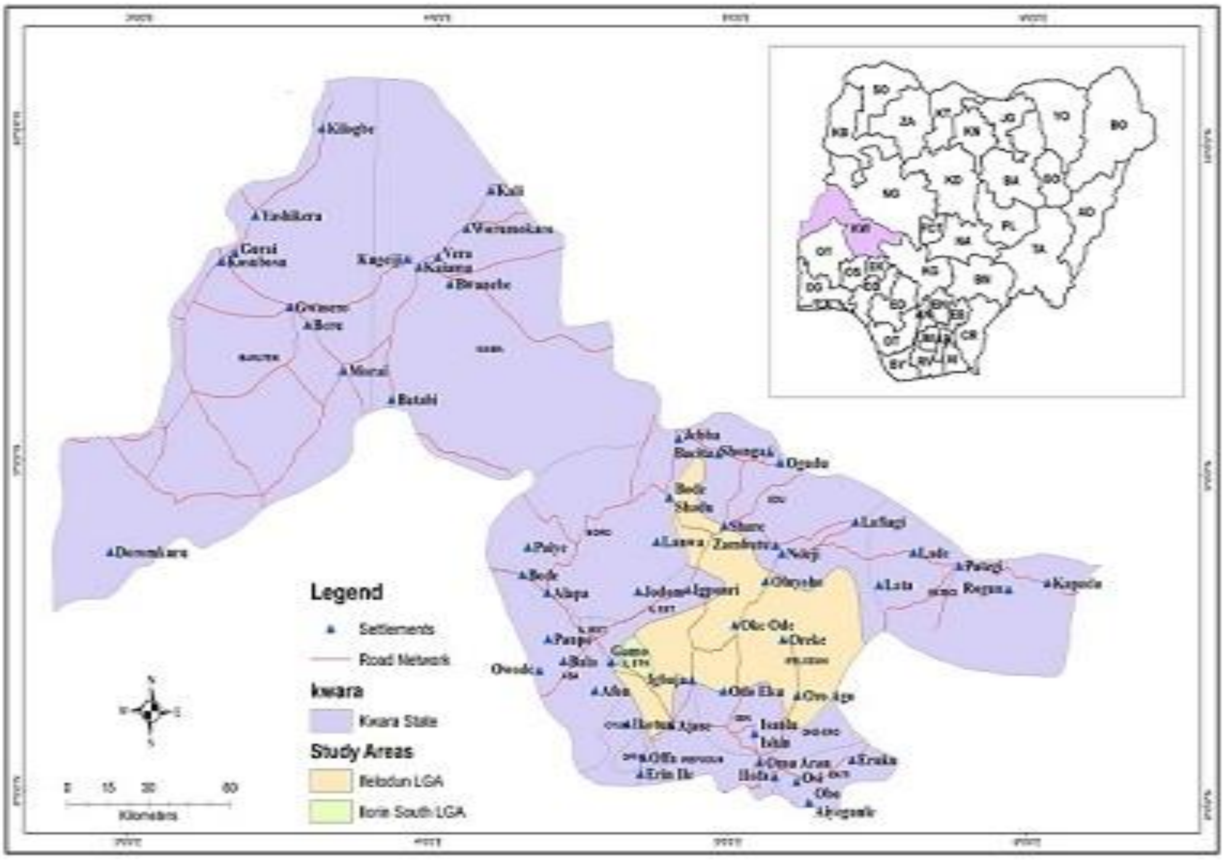

Figure 1: Map of Kwara State Showing the Study Area with inset Map of Nigeria

Sources: Adapted from Kwara State Bureau of Lands and Survey (2002)

Methods

The Participatory Rural Appraisal (PRA) using focused group discussion was used to interview farmers and key informant to assess the current perception of the farmers in respect of their choice of tillage at Bolorunduro and Jimba Oja farming settlements. Adopting the use of "community traits" from Olawepo (2015), analysis of these challenges, solution to overcoming them as well as adaptation and mitigation measures that can help to conserve the land resources amidst climate change were suggested by both the participants and the researcher. Olawepo (2015) defined community traits as any legend or landmark or peculiar feature commonly known by the residents. It could be a river, common tree or shrub, mountain or specified game or trend of event. The participants were led to draw a "problem tree" using the Locust Bean Tree which is common in this environment.

Focus groups were chosen at this stage because they are a useful way to examine grower beliefs, indigenous knowledge and perceptions, and to understand the decisions made on operations. Focus groups are an effective method for interacting with stakeholders and engaging them to learn more broadly about their concerns, knowledge, experiences, and barriers to implementation of the different tillage methods (Krueger & Casey, 2000).

The Focus Group Discussion was conducted with groups of farmers (10-15 participants) in each location. This allowed for a thorough dialogue between the farmers and also allowed for full participation and expression of individuals present. Farmers with at least 30 years' experience were selected so as to harness their wealth of experience over three decades. According to Krueger (2002), a focus group discussion should not be less than six and more than fifteen participants so as to allow full contribution from all participants. This enabled an assessment of the current perception of the farmers to their choice of tillage methods and how they have adapted over time to climatic variations.

Some of the questions that made up the check list includes:

a. what was their understanding of tillage, tillage methods used and why?
b. what were their experiences in the usage of each tillage methods in terms of cost of labour, runoff, removal of topsoil or erosion, crop yield among others?
c. is there any historical perspective to the adoption of these methods in terms of seasonality, climate change, and experience over a 30year period among others?
d. have they tried alternative tillage methods during climate variations and what was the outcome?
e. is there awareness of the various conservative tillage methods that can be adopted to mitigate against climate change and as it being practiced?
f. what was the outcome of applications of these conservative tillage methods?

The study conducted focus group discussions with farmers in the Savanna zone, utilizing semi-structured interview guides to capture their experiences, perceptions, and strategies regarding tillage methods and climate change adaptation. Narrative analysis was applied to understand and analysize the data.

Result of the Findings

Climate Change Mitigations and Adaptation Strategies

The findings of the study revealed that the farmers are faced with several challenges adapting to the climate change of the region and are also aware that the right tillage application can be used to adjust and adapt to the climatic fluctuation in the study area. Using the community-trait tree, farmers were able to group the methods of adaptation and challenges faced into root, trunk and fruits as shown in Figure 2. The farmers revealed that some of the climate change impact include increases in temperature; decreasing rainfall amount, flooding and erosion; drought, land degradation; extreme weather events (thunderstorms, lightning, bush fires), pest and disease invasion, fresh water resources affected and loss of biodiversity.

The farmers also reported that the application of some conservative tillage (traditional heap tillage and no-tillage) include allowing crop residues to act as an insulator and reducing soil temperature fluctuation, building up soil organic matter, and conserving soil moisture. They reported that conservation agriculture changes soil attributes compared to conventional tillage such as bulk density, water holding capacity, pore size distribution, and aggregation. This submission is not farfetched from Lenka *et al* (2013) reporting that conservation agriculture changes soil properties and soil processes compared to conventional agriculture. These changes can in turn, affect the delivery of ecosystem services, including climate regulation through carbon sequestration and greenhouse gas emissions, and regulation and provision of water through modification in soil physical, chemical and biological properties. Also, Simpson (2017) reported that climate change modifies the interactions between plants and their pests in space and over time.

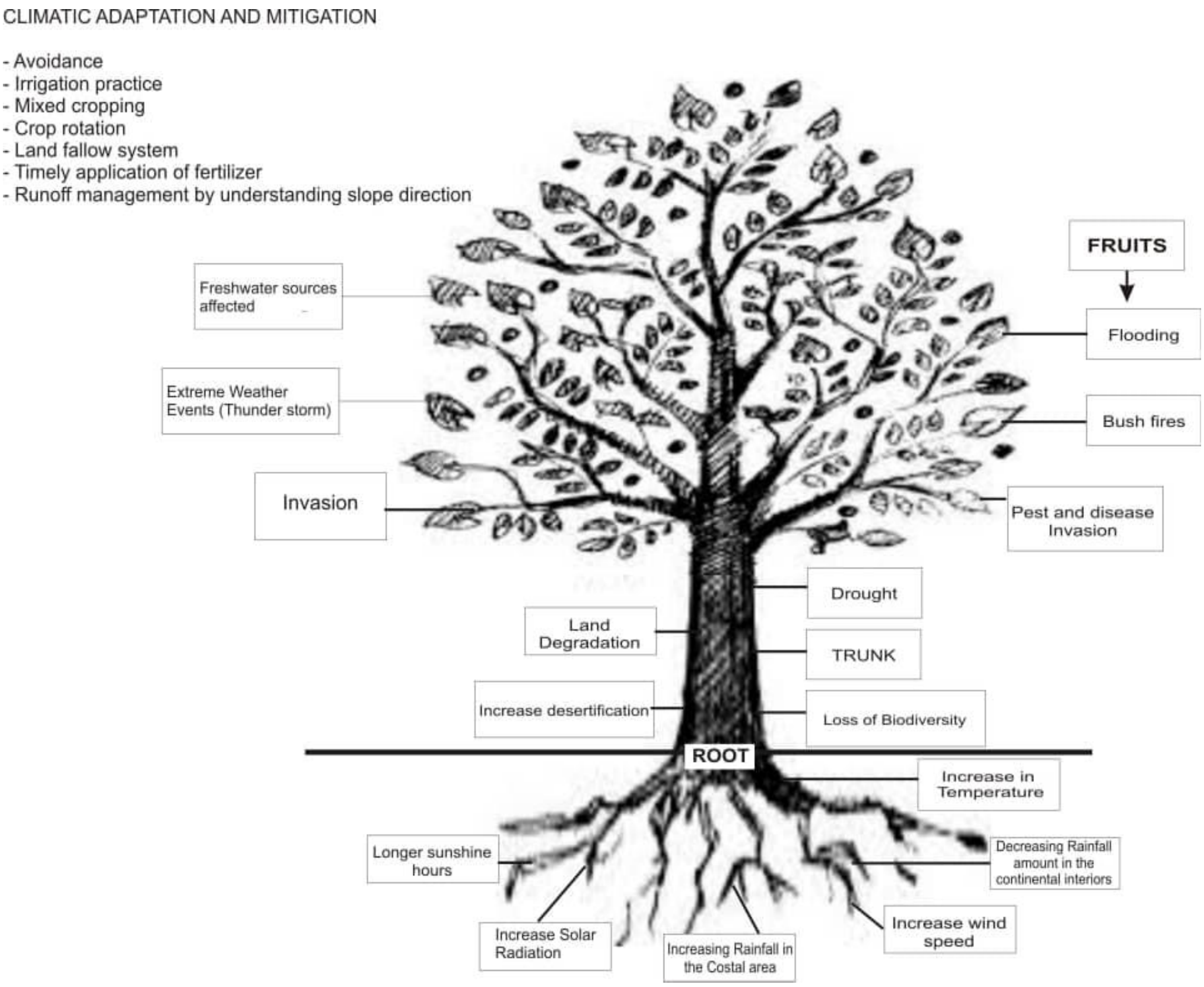

Figure 2: Community-Trait Tree used to assess challenges faced by farmers in the use of tillage methods

Source: Authors Fieldwork (2023)

Some of the ways the farmers in the study area have adapted to climate change through the application of agricultural practices are:

i. Use of improved crop varieties: An indispensable input for climate-smart crop production is quality seeds and planting materials of well-adapted varieties. It is impossible to harvest good crops with bad seeds (FAO, 2011). Crop production is highly sensitive to climate. It is affected by long-term trends in average rainfall and temperature, interannual climate variability, shocks during specific phenological stages, and extreme weather events (IPCC, 2012). Some crops are more tolerant than others to certain types of stresses, and at each phenological stage, different types of stresses affect each crop species in different ways (Simpson, 2017).

ii. Avoidance: Water logged areas are totally avoided for planting. Overtime, farmers have been able to understand the direction of the slope which determines the flow of runoff which is used to guide the direction of planting. This will help prevent erosion and top soil removal enabling a suitable condition for crop yield.

iii. Irrigation practices: To curtail the influence of erratic rainfall pattern and amounts the farmers practices irrigation which is used to meet the water requirement of their crops.

iv. Infrastructure: the necessary infrastructure that will enable the farmers easily adapt to climate change are increasingly important as rain fed agriculture becomes more unreliable. Facilities such as good road for distribution of agricultural input to the rural farmers, maintenance of adequate spaces to allow for easy infiltration of surface runoffs during rainfall through proper urban (Federal Ministry of Environment, 2014; Haider, 2019)

v. Mixed cropping: Farmers practice mixed cropping which increases the fertility of the soil especially in locations where the soil is degraded due to overuse.

vi. Crop rotation: This is the practice where the farmers plant a different crop at different seasons to resuscitate the soil particularly by interchanging the crops with leguminous and cover crop to improve the soil fertility.

vii. Land fallow: The ancient practice of leaving the land so that the land can regain it fertility is still practiced by the farmers in these settlements**.**

viii. Application of fertilizer: The farmers have the understanding of the right timing and occasion to applying fertilizer to crops. For instance, fertilizer is not applied to a land that is already fertile due to agricultural practices such as mixed cropping or land fallow.

ix. Runoff management. The farmers are able to manage runoff through their understanding of the type of slope, direction of surface/overland flow in the area and by constructing ridges across the slope. Also, the type of tillage applied to such a slope can be used to retain water in such a land for plant use. This has helped to reduce top soil removal for improved crop yield and also help in soil carbon sequestration thereby increasing terrestrial storage of carbon.

The farmers in the study area combined different climate change mitigation and adaptation strategies so as to have a productive agricultural season year in year out. This above listed strategies are in line with Oluwole *et al* (2016) reporting that the most highly used climate change adaptation strategies by farmers include; cultivation of improved varieties, altering of planting date, fertilizer application and mixed cropping and the associated constraints were; capital unavailability, irregular extension services, inadequate production inputs and poor access to information on climate change.

Farmers in the study area are showing more enthusiasm in the adoption of best management practices and this is in line with the American Society of Agronomy (2019) which reported that farmers are showing more and more interest in adapting conservation practices on their operations. However, adopting a new tillage system can be intimidating due to many real and perceived concerns. This is because farmers with better access to information of the changing climate through extension services also have a greater likelihood of adopting adaptation measures (Haider, 2019). However, the reverse is the case in the study area. There is need for the recognition of agricultural extension services and this must be matched with corresponding capacity for extension professionals to provid for the needs of the farmers in the area (Dimelu *et al,* 2014).

The respondent identified zero tillage (ZT) as the most environmentally friendly among various tillage techniques in climate change mitigation and adaptation. Conservation tillage, which includes ZT and minimum tillage, has the potential to break the surface compact zone in soil with minimal disturbance, leading to an improved soil environment and better crop yields while minimizing environmental impact (Busari et al., 2015). Ifeanyi-Obi and Nnadi (2014) revealed that farmers, with support from the government and other intervention agencies, are already adapting to climate change, particularly in the South-South zone. The respondents recommended adaptation measures such as improving farm inputs and shifting towards more disease-resistant crop varieties.

Conclusion

The study concluded that tillage practices play on critical role of in enhancing agricultural resilience to climate change. Zero tillage (ZT) and minimum tillage methods emerged as particularly effective, promoting soil health and productivity while minimizing environmental impact.

Recommendations

The study recommends the promotion and widespread adoption of Conservation Tillage practices, including zero tillage (ZT) and minimum tillage, to improve soil health, retain soil moisture, and enhance crop yields while minimizing environmental impacts. Expansion of Irrigation Infrastructure and accessibility to improved crop varieties is crucial for climate-smart crop production, enabling farmers to better withstand climate variability and extreme weather events. Lastly, provision of financial support and improve access to credit for farmers to invest in climate adaptation measures and purchase necessary inputs enable farmers to implement effective adaptation strategies and improve their livelihoods.

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