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Indigenous Knowledge for Climate-Smart Agriculture

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Abstract: *Climate change significantly threatens rural livelihoods in Sub-Saharan Africa including other least developed countries. This is due to rural communities' susceptibility to the effect of climate change and variations in these regions. Climate change exposes Sub-Sahara Africa region through increased temperature, changes in rainfall patterns, and frequency of extreme weather events such as drought and floods. Changes in climate over generations have brought about alterations in most Sub-Sahara Africa rural communities engaged in agriculture production. Smallholder farmers in rural communities have been adjusting to these changes through their indigenous knowledge which has stood in existence from one generation to another, spread by word of mouth. The objective of this paper is to synthesize indigenous knowledge captured for climate-smart agriculture. Recent empirical studies on climate-smart agriculture have revealed that many agricultural technologies and practices positively contribute to climate change adaptation in the agriculture sphere. It has been more evident in rural agro-based communities and literature has also shown that indigenous people have been excellent in providing weather-smart information services. However, adoption of climate-smart agriculture technologies which incorporate indigenous knowledge is still low in developing countries. Thus, strengthening the role of indigenous knowledge in climate change has a likelihood of contributing to climate change adaptation in smallholder farming communities. Improved adaptation, capacity building and integrating indigenous knowledge with climate-smart agriculture practices might be crucial to enhancing effective community resilience to climate change.*

Keywords— Adoption, Africa, Communities, Contribution, Fallowing, Intercropping, Resilience

1. INTRODUCTION

In Africa the agriculture sector is a significant industry contributing to economic growth (Belachew et al., 2020; Collier and Dercon 2014), more importantly, the sector is praised as the primary driver of poverty reduction throughout Sub-Saharan Africa (SSA). Despite making a substantial contribution to livelihoods, the industry continues to experience difficulties due to poor financial support, soil nutrient depletion and climate change (Belachew et al., 2020; Kagoya et al., 2017). Rural households in SSA depend on agriculture for their wellbeing.

Sub-Saharan Africa's rural livelihoods are gravely threatened by climate change. This is due to the fact that rural communities in Africa, particularly in the SSA, are relative climate change victims compared to other regions (IPCC, 2014). The SSA region is subject to climate risk due to rising temperatures, shifting rainfall patterns, and changes in the frequency and intensity of extreme weather events including drought and floods (IPCC, 2014). Rural farmers have adapted to these changes over the course of their lives using their understanding of the local environment, even if changes have been occurring across generations (Mafongoya and Ajayi, 2017). The events' information is spread or shared by one generation to another. This information is affordable, easily accessible to farmers in rural areas, and a climate-smart tool for managing climate variability (Nchu et al., 2019). Environmental problems vary in both space and time, but rural farmers have accumulated vast local knowledge about nature in their locality through sustained interaction with it, experimenting, and learning from mistakes. This is fostered through promoting and, mobilizing local and indigenous peoples' distinctive knowledge and traditions in climate change adaptation. This knowledge and traditions are referred to as indigenous knowledge (IK). The same knowledge over the years has been broadened by technocrats and included into the Post-2015 Development Agenda (SDGs) (Boansi et al., 2017;Tume et al., 2019).

IK is the built-up, passed-down local knowledge that has been institutionalized, typically through word of mouth. IK is sometimes viewed as incidental in discussions of climate change adaptation (Nyong et al., 2007; Kronik et al., 2010;), despite the fact that it can serve as the foundation for

successful adaptation to the effects of climate change in smallholder farming communities. It is also referred as local environmental knowledge (LEK), traditional ecological knowledge (TEK), and indigenous traditional knowledge (ITK) (Odero, 2011). The terms are interchangeable and have comparable connotations when referring to indigenous people's local environmental or traditional knowledge due abilities that were established outside of the formal scientific community, ingrained in culture, and steeped in tradition through oral tradition (Mafongoya et al., 2017).

IK in modern age is referred to as sustainable agriculture leading to sustainable developing. Nonetheless, to meet the needs of the global population for food while preserving the environment, climate-smart agriculture (CSA) has been proposed (FAO, 2014). Following the 2009 Hague Conference on Agriculture, Food Security, and Climate Change, the food and agriculture organization first proposed the idea in 2010 (FAO, 2010; World Bank, 2010). The primary goal of CSA, according to FAO (2010), is to repackage agriculture in the context of a changing climate in order to ensure a "triple win," or adaptation, mitigation, and development. Due to its direct impact on farming, rainfall changes are the subject of most climate change studies, to the exclusion of other equally significant aspects that have an impact on livelihoods. It is obvious that in order to increase effective community resilience to climate change, scientific knowledge systems need to be supplemented with indigenous knowledge systems.

In SSA countries and other least developed countries agro-based communities' have an ability to adapt to climate change through improved agricultural techniques and technologies (FAO, 2018). Aforementioned countries especially the SSA region, adoption of proven climate-smart agricultural technologies is still low (Teklewold et al., 2013; FAO, 2018; Nkonya et al., 2018). Therefore, enhancing IK's involvement in managing climate change consequences is anticipated to increase smallholder farming communities in SSA's ability to adapt to the changing climate. Innovations in climate-smart agriculture are anticipated to gain greatly from increased adoption with a wide coverage. Not until farming communities adopt climate-smart agriculture will they realize benefits.

2. THE ADVANCMENT OF INDIGENOUS KNOWLEKDGE IN THE ARENA OF GLOBAL CLIMATE CHANGE

Global climate change was identified in the 1980s as one of humanity's most daunting challenges (UNFCCC, 1992; Maslin, 2014). This recognition led to the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988, and the United Nations Conferenceon Environment and Development in 1992 (Earth Summit, Rio de Janeiro, Brazil) that established the United Nations Framework on global climate change. The debate on climate change has largely concentratedon particular areas of the planet – low-lying tropical islands and coastlines, high- altitude zones, tropical forests and the polar regions (Orlove *et al*., 2014, IPCC, 2014). It so happens that most of these areas, except ice - covered Antarctica is home to indigenous people. Despite the world's growing interest in indigenous people and their homelands as harbingers of the impacts of global climate change, much work needs to be done to understand their concerns and appreciate their knowledge.

2.1 Characteristics of Indigenous Knowledge

The idea that IK is derived through experience gathered over time and is tailored to local community cultures and their surroundings is supported by all definitions of IK. Additionally, traditional knowledge is passed down verbally from generation to generation and is frequently held in common ownership. Indigenous knowledge frequently takes the comprises of tales, adages, folklore, cultural norms, rituals, and beliefs as well as local laws, dialects, and agricultural practices (Convention on Biological Diversity, 2001). Indigenous knowledge is crucial when rural households are making decisions about daily activities.

2.2 Role of Indigenous Knowledge in Climate-Smart Agriculture Adoption and Scaling Up

According to empirical studies, indigenous people are excellent at delivering weather-smart information services for agriculture (Mafongoya and Ajayi, 2017). For instance, native Americans have been documented using tree phenology, animal behaviour, astronomy, and moon movements, to name a few, to anticipate weather *(i.e*., the start of rainy season) (Kalanda-Joshua et al., 2011; Roudier et al., 2014; Mafongoya et al., 2017).

Previous studies have proved that rural communities in SSA's poorest regions have benefited from using IK in the past to survive adverse environmental conditions (Van Veldhuizen et al., 1997; Hart and Mouton, 2005). The domestication of crops and cattle, preservation of agro-biodiversity resources, the development of animal traction, and the crossing of plant and animal species are all considered to have been made possible by IK historically (Mettrick, 1993). This suggests that IK may be essential for implementing climate-smart agriculture in smallholder farming farmlands. To increase the adoption of CSA innovations, policymakers and other stakeholders must recognize that rural communities have already been coping with climate change in a variety of creative ways. External interventions can only be effective if they build on what rural farmers have already done to adapt to the changing environment (Chavula, 2021). For ages, traditional farmers have created a variety of agricultural systems that are regionally appropriate and have been managed using indigenous techniques that are frequently successful in guaranteeing sustainability and food security (Altieri, 2004).

3. MAJOR INDIGENOUS PRACTICES FOR CLIMATE-SMART AGRICULTURE

Indigenous people are good weather and climate observers, and can adapt to changes through a variety of

adaptive measures. Terracing system, mulching, intercropping, ridge and contour ploughing practice, crop rotation, mixed farming, agroforestry, improved grazing, fallowing, weather forecasting, and water diversion ditch are a few of the practical techniques that are included in CSA that are important in building climate resilience in smallholder farming communities.

Crop Rotation and Intercropping

Crop rotation and intercropping are cultural practices or systems with less mechanical tillage based on mulch cover and organic tillage; different methods of controlling pests and weeds must be devised. Practicing crop rotation and intercropping has many advantages, which include reduced risk of pest and weed infestations; better distribution of water andnutrients through the soil profile; nutrients and water of diverse strata of the soil profile by roots of many different plant species (Chavula, 2022), resulting in greater use of the available nutrients and water. Increased nitrogen fixation through certain plant-soil biota; improved balance of nitrogen, phosphorus and potassium (N-P-K) from both organic and mineral sources and increased formation of organic matter.

Crop rotation, improves nutrient management, can minimize nitrogen fertilizer use by up to 100 kg per hectare annually, significantly lowering associated greenhouse gas (GHG) emissions (nitrous oxide has a global warming potential 310 times larger than CO2), as well as lowering production costs. Reduced usage of synthetic fertilizer also results in lower manufacturing and transportation-related greenhouse gas emissions (PANW, 2012).

Fallowing

Fallowing has been defined as a farming practice wherein no crop is grown and all plant growth is controlled by cultivation or chemicals during a season when a crop might normally be grown (Haas *et al*., 1974; Paustian et al., 2019). The main goal of fallow land is to stabilize crop production by forgoing crop production in one season in the hope that crop production will improve at least somewhat the following season (Greb et al., 1974; Karlen et al., 1994; Rathee et al., 2018; Kukal et al., 2018).).

Weather Forecasting

Indigenous people rely on sky indicators, plant cues, or the behaviour of both wild and domesticated animals (Rasp et al., 2020). Forecasts might be short-term, which refers to the current day, the days to come, or seasonal variations, or long-term, which corresponds to the months in which rainfall is anticipated (with or without rain, storms, or notes corresponding to several days of rain) (Fente et al., 2018).

Mixed Farming

When crop production and animal husbandry are integrated, this is referred to as mixed farming (Ahmad et al., 2019). For example, the practice of raising cattle, cash crops, food crops, and feed crops on the same piece farmland. Livestock enterprises work in conjunction with crop production to create a balanced and effective farming system (Kanter et al., 2018). Its benefit is that it lessens reliance on outside resources like fertilizers because the farm's agricultural and animal components complement one another (Chavula and Petros, 2022).

Terracing System

Crops are planted on graduated terraces carved into the slope as a method of growing them on the sides of hills or mountains. Although labor-intensive (Yang et al., 2018), the technique has been used successfully to increase arable land area in challenging terrains and to lower soil erosion and water loss (Deng et al., 2021).

Contour Ploughing Practices

Contour ploughing improves soil quality and composition while minimizing soil erosion by up to 50%, regulating runoff water (Nouari, 2020), boosting moisture infiltration and retention, and decreasing crop damage from floods, storms, and landslides (Karuku, 2018). This method describes contour beds and contour ploughing, which can be done manually with farm machinery. Any contour farming technique can benefit from adding strip cropping's guiding principles to increase soil conservation (Bhat et al., 2019).

Agroforestry

The traditional practice involves the integration of trees and shrubs into farmland either through planting or natural regeneration (Bettles, 2021). The techniques aim to improve agricultural yield, resilience to climate variability (for instance, by providing shade during hot spells), and the development of favourable microclimates for specific crops (Udawatta et al., 2019). Address issues with soil fertility, soil erosion, and diversification of farm produce (Chavula, 2022; Rosati et al., 2021). incorporating perennial plants into agricultural areas utilized for grazing as well as crop production (Kitalyi et al., 2011).

Water Diversion Ditch

Traditional techniques like building water diversion canals are used to lessen soil erosion from runoff (Song et al., 2018). It is built across slopes and along contour lines with the intention of intercepting surface runoff and rerouting it to proper outlets. These ditches are the primary soil conservation structures to control runoff in highland areas.

Improved Grazing

Improved grazing is a traditional strategy or technique that indigenous farmers and pastoralists employ to feed their cattle and manage their habitats, despite the fact that it is not widely adopted (Thompson et al., 2020). Reduced soil erosion, improved air and water quality, better plant diversity, vigor, and production, and improved fish and wildlife habitat are just a few of the environmental advantages of well-managed

pasture (Wilkinso et al., 2020). A more complete vegetative cover and improved soil structure brought about by better grazing management enable a greater proportion of rainfall to permeate the soil where it can be used for plant growth as opposed to running off where it may cause problems with soil erosion and sedimentation. The overall soil quality improves with improved grazing management.

Mulching

Mulching is the process or practice of covering the soil/ground to make more favorable conditions for plant growth, development, and efficient crop production (Gao et al., 2019). The precise definition of mulch is "coating of soil." While organic mulches like compost, leaf, straw, and dead leaves have been utilized for generations (Mendonca et al., 2021), the methods and advantages of mulching have changed over the past 80 years with the introduction of synthetic materials (El-Beltagi et al., 2022).

4. CONCLUSION

Sub-Sahara Africa region and other least developed countries are exposed to climate change risk owing to increased temperature, changes in precipitation patterns and wind direction, and the recurrence of unusual climate events like surges and the dry season. This is entirely accurate because rural inhabitants in Africa, particularly in the SSA, are slightly more helpless to the effects of climate change than in other areas. The following action steps are suggested for integrating indigenous knowledge for climate-smart agriculture based on the study's literature review. Action points reviving IK's role in managing climate change impacts are likely to advance SSA's smallholder farming communities' adaptation to climate change. The benefits of accelerated adoption and scaling of climate-smart agriculture advances are likely to be significant.

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