Prioritizing Climate-Smart Agriculture Adaptation Options: The Case of Smallholder Farmers at Wiyumiririe Laikipia County, Kenya

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Abstract
This study sought to investigate how Climate-Smart Agricultural adaptation strategies can be identified and prioritized to help the smallholder farmers of Wiyumiririe, Laikipia County, Kenya improve food production and build resilience to climate change. The study adopted a transdisciplinary approach in which various players were engaged through a recursive process. Participating farmers were selected through systematic sampling and affirmative action while the NGO representative, agricultural extension officer, soil scientist and meteorologist were purposefully selected. Initially an assessment to determine the community vulnerabilities to climate change was carried out followed by determination of farmers' perceptions and beliefs towards the changing climate. That information formed a basis for identifying and prioritizing suitable Climate-Smart Agriculture options for adaptation by use of Pair-wise ranking and multi-criteria analysis. Results indicated that the interventions that involved growing Sorghum (a drought tolerant crop) on parcels of land prepared by either double digging or making of Zai pits and which farmyard manure was incorporated, to be the most effective options. The choice of these interventions was based on the ability to capture and retain rainwater sufficient enough to sustain healthy crop growth. This was ideal since the study area falls under Arid and Semi-arid lands of Kenya, characterized by low, erratic rainfall and high temperatures.

Keywords: *Climate-Smart Agriculture, Pair-wise ranking, Multi-criteria analysis, belief typologies.*

I. Introduction

Majority of rural Smallholder farmers resident in Sub Saharan Africa solely depend on rain-fed agriculture. Apparently, Climate Change has emerged as one of the threats affecting such farmers. A study carried out by Waithaka et al., (2013), indicated that Climate Change will impact negatively on Kenya mainly because of reliance on rainfed agriculture and a high population growth rate of approximately 3.7% that has not been matched by a corresponding increase in economic growth, resulting in endemic poverty that affects more than 50% of the population. In order to improve food production and make the community resilience to Climate Change, the capacity and skills of Smallholder farmers in such regions require to be strengthened to ensure innovative adaptation. Innovative adaptation is defined as home-grown or assimilated practices that are capable of being applied to specific locations to aid in food production (Gordon et al., 2010). From a broad perspective, adaptation is conceptualized as the efforts made by man to forestall anticipated future climatic trends. The way communities adapt is a product of how in the first instance they are endowed to deal with negative climatic effects (IPCC 2001; Adger et.al, 2003; IPCC 2007). Even though Climate Change is taken to be a global concern, in reality adaptation is a requirement for developing countries since vulnerabilities are high because of reliance on climate sensitive parameters such as rainfall and temperature (Adger et al., 2003). According to Zelda et al., (2017), the ability of a community to adapt is determined by how in the first place, it is vulnerable to Climate Change as influenced by the amount of exposure and sensitivity.

Remarkably, sound adaptation practices require an understanding of the causes of climate change, the impacts and desire to change behaviours. That is, actions that contributes to an increase in the emission of greenhouse gases or those that will become redundant due to future climate impacts. In that respect, the inducement for adaptation practices is premised on the fact that the climate is changing and urgent actions are a necessity. A study by Ajzen (2011) showed that there was a correlation between knowledge on environmental issues and behavioural change. For Climate Change, previous experience and personal perceptions may influence the uptake of particular adaptation options, and at times the perceptions may be at variance with observed climatic events (Meredith and Nathaniel, 2016). Rightly put, climatic trends may be remembered for the wrong reasons, hence misinterpreted (Meredith and

Nathaniel, 2016). In certain situations, individuals may have incentives to remember certain events in ways that fit their ontological perspective (Myers et al., 2013).

Studies done by Stern et al., (2006); IPCC (2001); and Walthall et al., (2012) despite showing that agriculture as a sector contributes a significant amount of greenhouse gases also showed that the sector is vulnerable to climate. The accompanying effects have profound effects on food security (Amber et al., 2016). Therefore for the sector to remain viable in the face of climate change, then it has to respond with effective adaptation strategies. That will ultimately encompass making adjustments into the agricultural systems and as Smit and Skinner (2002); Withall et al., (2012) suggested, take advantage of any opportunities. Effective adaptation as fronted by Smit and Skinner (2002) is profiled into four categories: Practices that target production at the farm; development of technologies; farm management and government initiated programs and insurance.

Ordinarily, practices at the farm level are geared towards production and entail: practicing irrigated agriculture, the use of improved crop varieties, modifying inputs, conservation tillage, integrating, tree planting, diversifying in farm activities; change in planting date and engaging in income generating activities (Madison 2006; Udin et al., 2014). The process of Adaptation entails a four-stage iterative learning cycle as described in the PROVIA guidance (UNEP, 2013). That is, determining vulnerabilities to climate change, identifying and choosing appropriate options for adaptation, putting the options into practice and carrying out monitoring and evaluation. This article presents findings on an adaptation process to Smallholder farmers premised on Climate-Smart Agriculture, structured on the first two stages. In the first stage, the community gave an account of how they were vulnerable to Climate Change as well as their perceptions towards climate change. In the second phase, suitable CSA adaptation options were identified and prioritized through a participatory Pair-wise ranking and Multi-criteria analysis. The processes ensured that the selected strategies were relevant and socially acceptable to stakeholders Paloma, (2018).

According to Abrham et al., (2017) effective adaptation necessarily involves bringing onboard a number of players in collaborative research who might include; farmers, NGOs, policy makers and extension officers. Before any adaptation options are put on trial, it's of the essence to capture what the farmers believe about climate change and determine at the onset how these perceptions are in harmony or at variance with observed trends. That will work as (Meredith and Nathaniel, 2016) observed, a basis to addressing their future concerns, behaviour patterns and the kind of support they would require. While numerous studies have been conducted to assess the views of farmers to Climate Change such as in Australia, United Kingdom and Southern United states of America as documented by several scholars (Fleming and Vanclay 2010; Haden et al, 2012; Hogan et al., 2010; Higginbotham et al., 2013; Rejesus et al., 2013 and Donnelly et al., 2009), none has been carried out at Wiyumiririe Laikipia County Kenya. In Australia, farmers were sceptical of anthropogenic induced Climate Change (Donnelly et al., 2009 and Higginbotham et al., 2013), while in Ethiopia (Abraham et al., 2017) observed that farmers attributed Climate Change to deforestation and soil degradation. Determining how farmers of Wiyumiririe Laikipia County perceived Climate Change and how those perceptions mirror observed climatic trends was important because studies done elsewhere especially in Australia, showed farmers' perceptions did not reflect observed changes (Meredith and Nathaniel, 2016). The choices farmers make to adapt to the Climate Change (real or imagined) are a factor of their perceptions and may additionally be influenced by the existence of infrastructure to support adaptation (Meredith and Nathaniel (2016). The target farmers in the current study were crucial in understanding Climate Change adaptation due to their vulnerability to climatic risks which had exposed them to food insecurity. A preliminary survey of the area showed that there were no tangible CSA measures in place that could significantly improve the farmer's adaptive capacity in a way that would make them food secure. For instance, mechanisms to harness rainwater were ineffective while soil amendments to improve soil fertility and physical properties were lukewarm. What the farmers had were shallow retention ditches and water pans which were not effective in harvesting rainwater. Besides, irrigated agriculture was absent and there was no weather forecast advisory service. Apart from maize, farmers had not diversified their crops to include drought tolerant varieties. Interviews with the area chief showed that the county government of Laikipia was active in addressing issues of food security for the residents, by encouraging them to use drought escaping crop varieties and practicing conservation agriculture. However, such measures required to be captured into a workable CSA model to avoid some of the bottlenecks observed in previous interventions such as lack of appropriate methods of selecting farmers in decision making organs giving room for speculations as to the credibility of the choices they made.

The report derived from IPCC (2007) defines vulnerability as the extent at which a particular system of interest is disposed to and incapable of coping with negative effects brought by Climate Change. Put differently, vulnerability refers to the relative sensitivity of a system when exposed to hazards, and how well it can cope with the situation (the adaptive capacity). Consequently, the vulnerability of an agricultural system is described as the exposure of crops to low amounts of rainfall, how sensitive crops

are prone to reduced rainfall and the corresponding capacity of farmers to cope/adapt with the situation; for instance, by planting crops that require less amount of rainfall or switching to another crop. Therefore in the context of climate change, vulnerability is described by exposure, sensitivity and adaptive capacity (IPCC, 2007). According to Smit et al., (1999), a system is said to be vulnerable if it is unprotected, thus exposed to the effects brought by Climate Change and is also low in adaptive capacity (Smit and Wandel, 2006), and vice versa. According IPCC, (2001), exposure represents the background conditions and stimuli against which a system operates and any changes in those conditions. Adger (2001) further described exposure as encompassing both the climatic variations and the degree and duration of those variations. Sensitivity is the extent at which a system is affected either positively or negatively by a particular climate stimulus. It's a measure of how a system responds due to internal or external stimuli. Therefore, a system that's very sensitive will exemplify huge changes to minor climatic variations and vice versa. Nonetheless, a highly exposed and sensitive system doesn't necessarily mean that the system is vulnerable because on the contrary it could be having a high adaptive capacity. Adaptive capacity is defined by IPCC (2007) as the latent of a system to adjust successfully due to Climate Change (moderate potential damages), take advantage of opportunities and cope with consequences. Additionally Adger et.al., (2007) indicated that adaptive capacity takes into account adjustments in behaviour, resources and technologies. Vulnerability is the net effect after taking into account adaptive capacity from a system that's exposed and sensitive.
Basically two approaches are available for carrying out vulnerability assessment: the Top-down approach and Bottom-up approach. The former mainly focuses on biophysical effects of Climate Change, which by default, are readily quantifiable. Ordinarily, such an exercise may involve the application of simulation models by experts with some degree of stakeholder participation, to validate model data generated by the researchers commensurate to their objectives. The latter is a participatory process that focuses on what makes people in a particular community vulnerable to climate related hazards. Thus, the approach is location specific and relies on information collected on the site. Integration of the two approaches is feasible as was evident in this study to bring in the transdisciplinarity aspect of the research. Determination of climate related vulnerabilities was achieved in four steps: Defining the purpose of vulnerability assessment, planning the vulnerability assessment, assessing current vulnerability and assessing future vulnerability.

II. Materials and Methods

A. Vulnerability Assessment of the farmers to Climate Change

The purpose of vulnerability assessment for this study was to identify climate risks brought by Climate Change for the target community. Thereafter, the information obtained was used in a bottom-up approach to identify and prioritize suitable CSA approaches, to help the community overcome food insecurity and adapt to Climate Change. The PRA and RRA tools used were: Resource mapping, community mapping, seasonal calendars, climatic trends, focus group discussion, key informant interviews and pair-wise ranking. The same tools had been successfully used in Uganda and Tanzania (Mwongera et al., 2017). In this study, these tools allowed the farmers to share information and analyse their food security status in light of Climate Change. Moreover, they encouraged farmers to plan and act on knowledge created iteratively in such a way that there was ownership to the process. The researcher also used a resource map which helped in defining the Agro ecological zones as well as the distribution of resources within the community. To prepare the resource map, farmers were first divided into two groups, of men and women. Then each group while guided by the main researcher gave a general locality of resources; rivers, streams, dams and boreholes. A discussion followed to build consensus and provide insights on the use of the resources over time. Seasonal calendars were prepared mainly during focus group discussions which included a crop and a climatic calendar respectively. The purpose of the crop calendar was to identify types of crops cultivated during the whole year. That in turn helped to develop crop consumption patterns, characterize periods of food shortage and their corresponding threats affecting the livelihood of the farmers. Guided by the lead researcher, farmers drew rainfall and temperature patterns for the perceived past and current climatic conditions. The calendar laid the foundation for discussing the impacts of Climate Change to agricultural production. Through Focus group discussions the researcher was able to identify and rank perceived problems faced by the farmers, capture perceptions of farmers about Climate Change and impacts and, identify and prioritize Climate-Smart Agriculture practices. Further the FGDs were used to discuss livelihood options and generally how the perceived climatic changes had affected their lives. Individuals sampled by the study were interviewed to gather basic information about food security, levels of education and training, off-farm income and loans. To assess the current vulnerability, the study first assessed the profile of the system of interest which in this instance was: the status of natural resources available, the environmental issues that are of concern, the kind of social-economic dynamics that exist, and the developmental issues that were of immediate concern to the community. Determination of current vulnerability was achieved through the bottom-up approach by engaging farmers and other stakeholders. In the subsequent step, the study assessed the observed climate (exposure). To achieve that, once again the study employed the bottom-up approach by using climatic trend analysis, timelines and seasonal calendars. To assess sensitivity, the study additionally used stakeholder consultations and community mapping. Key questions in assessing sensitivity were: how the observed or perceived climatic conditions had affected the system of interest, and how the current climatic variability and extremes had impacted the livelihood of the farmers. Response to extreme weather events (adaptive capacity), was assessed too at the community level. Key questions included: What response measures had farmers tried in dealing with climate variability and hazards? How effective had the response measures been? The tools mostly used for that were: focus group discussions, community mapping and timelines. Finally the study appraised the overall current vulnerability by combining the outputs from the preceding steps namely: assessing the profile of the system of interests, assessing exposure, assessing sensitivity and, assessing adaptive capacity. Key questions were: What were the impacts of Climate Change to food security of Smallholder farmers? Which groups were greatly affected? What was the level of adaptive capacity? Which were the non-climatic factors that exacerbated vulnerability and, how was the adaptive capacity distributed among the various groups within the community?

B. Determining Farmers Perceptions about Climate Change and possible CSA Options for Adaptation

To achieve the above objective, the study relied on qualitative and quantitative methods described by (Neuman, 2014). Semi structured interviews were conducted for individual farmers as well as key informant interviews and focus group discussions. Focus group discussions were conducted with residents who have been there for more than 20 years, both women and men. The researcher moderated the sessions using a checklist including vulnerabilities, perceptions and beliefs about Climate Change, climate parameters significant for the area, impacts and plausible CSA adaptation options. Key informants were conducted with knowledgeable people including: the area Agricultural extension officer, the area chief and a representative of CARITAS, an NGO working in the area. They were purposively selected to get information on: vulnerabilities, profile of the population, government policies, soil characteristics, innovations, weather forecast, climatic impacts and community development. The local administration aided the study in profiling and sampling of the residents to cater for female headed households, educational background, economic status, gender and age groups. In village Shalom (D) each household was allocated a number ranging from 1-200. From that, each household identified with numbers 20,40,60,80,100,120,140,160,180 and 200 with the presence of one mature adult was selected. If the number corresponded to an already selected criterion, affirmative action was done within the cluster of households, e.g. between numbers 20 and 40 to get a female headed household. In the neighbouring Nyambugishi village, nine farmers resident in the place for more than 30 years were purposely selected and interviewed individually for their perceived greater experience in weather trends.

To assess farmers' perceptions about Climate Change, the study created six belief typologies: 1. Perception that there's climate change and it's a global phenomenon. 2. Perception that there's climate change and it is a local phenomenon. 3. Perception that there's climate change and humans are not responsible. 4. Perception that there's climate change and humans are responsible. 5. Perception that there has not been any climate change and humans do not contribute to Climate Change. 6. Perception that there has not been any climate change but humans contribute to Climate Change. In part two of the interview, farmers recited recent and past observed extreme weather events. Fundamentally, two weather parameters, rainfall and temperatures, were found to be important. Based on that, a possibility of scenarios was presented to the respondents: 1.Has the total amount of rainfall increased/decreased/remained the same? 2. Has the long rainfall season occurred on time/delayed/came unusually too early/failed altogether? 3. Have the short rains occurred on time/delayed/came unusually too early/ failed altogether? 4. Have the temperatures increased/decreased/ or remained the same? In the third part, farmers were interviewed in focus group discussions based on the following themes: Vulnerabilities, Perceptions about Climate Change, the effects of the changing climate to the agriculture sector, status of food production, coping mechanism and, CSA adaptation options. To determine their vulnerabilities, they were probed on: what are the main challenges to food production? How does climate affect their access to water? What is their source of farm inputs? On the changing climate the groups were asked to enumerate how changes in climate had affected growing of crops, observed extreme weather events and frequency.

Identifying and prioritizing Climate-Smart Agriculture adaptation options

Multi-criteria analysis and pair-wise ranking were used. The process began by identifying and specifying Climate-Smart Agriculture strategies considered by various stakeholders. Given the importance of agriculture and its vulnerabilities to Climate Change, the stakeholders required to evaluate and prioritize CSA practices relevant for Wiyumiririe. Following advice from experts, literature review and stakeholder consultations, a list of plausible CSA adaptation options were developed together with criteria for evaluating the options. The criteria were: I. Capacity to generate adequate crop yields ii. Legal and political implementing feasibility. iii. Capacity to withstand dry spell. iv. Financial feasibility. v. Capacity to improve soil fertility. vi. Speed of implementation. Farmers in FGDs and using maize grains did pair-wise ranking to prioritize the CSA options. The same was done by the NGO group, practitioners and scientific wing of the transdisciplinary team. Eventually, the findings from the various groups were consolidated during recursive meetings involving all stakeholders where the options for this study were adopted

III. Results and Discussion

A. Vulnerabilities of the Smallholder Farmers to Climate Change

The findings of the study showed that the farmers were indeed vulnerable to Climate Change which had greatly affected their ability to engage in meaningful agricultural activities to address food security. Problem identification through focus group discussion listed food insecurity, drought and lack of water as their most pressing problems. The other concerns raised were, housing, limited credit facilities, inadequate government support and rising poverty. The resource map (figure 1), shows the spatial distribution of farmland, forests, location of rivers, streams, boreholes and other sources of water. It further shows infrastructure, market, security and administrative offices. The community had three sources of water: a borehole, Suguroi River, and the dam shown. These sources of water were insufficient to meet the water demand for the entire community. Apart from Suguroi River which anyway is far from most households, the other sources were found wanting.

Figure 1: Resource Map for the Study Area

The dam is seasonal, occasionally drying up completely during prolonged periods of drought. The borehole was the primary source for clean water serving more than 400 households. Water was not enough to meet the household domestic requirements hence necessitating frequent rationing. With the water deficit meant there was no irrigated agriculture apart from rainwater harvested in water pans. The forest cover was confined along the river banks comprised mainly of acacia woodland, and mostly privately owned. The implication of that was, access and utilization of resources therein was limited. However, because most of the owners were absentee landlords, the Smallholder farmers often took advantage of the situation to collect firewood and graze livestock.

Focus group discussion revealed annual crops grown for food were the most important, with sporadic cultivation of bulb onions for sale. There were two cropping seasons: The (March-July) long rainfall growing season and the (October-December) short rainfall growing season. Based on that, the periods associated with adequate food was during harvest time, August-September and January- February. Still substantial food was expected in the month of June and July from the harvest of potatoes and beans. As per the crop calendar, periods of food insecurity was in the months of March-June and October – November coinciding with the time when crops were ordinarily in the field growing. However, from focus group discussions, it was clear food security did not necessarily follow the crop calendar. Due to unpredictability of rains and subsequent crop failure, periods of food insecurity had, in most occasions lasted the entire year and sometime extending beyond. The months of April and November were listed as the most food secure primarily because the presence of an indigenous vegetable, amaranthus, that often colonized crop fields few weeks after onset of rains, appeared to spur a variety of diets for many homes.

The climate calendar developed from focus group discussion had a similar pattern to the crop calendar in which participants identified two rainfall seasons: March- July and October –December, long and short rainfall seasons respectively. From focus group discussion, farmers recounted driest years, wettest years and what would constitute a normal year. Participants identified 1984 as the driest year, followed by 2000 then 2016. Similarly, 1997 2003 and 2008 were listed as wet years in that order. Figure 10 summarizes the historical climatic trend line showing how the farmers in focus group discussion provided over a period of 40 years

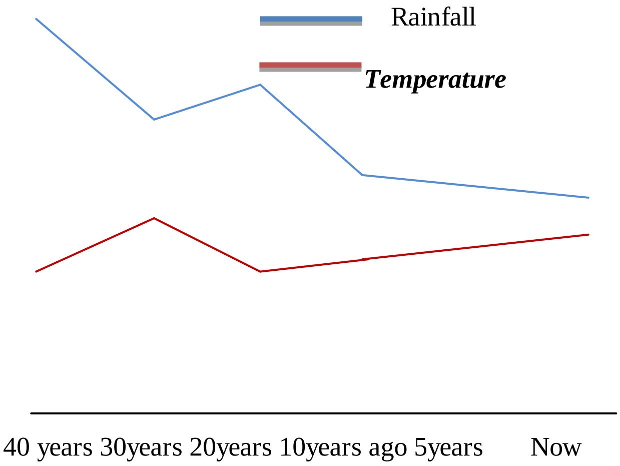

Figure 2: Historical Climatic Trend. (Source. Focus Group Discussion at Wiyumiririe)

Table 1: Crop Calendar for Wiyumiririe

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Maize	Harvesting	Land preparation	Planting	Weeding, pest and disease control				Harvesting and land preparation		Planting	Weeding, pest and disease control	
Beans	Harvesting	Land preparation	Planting	Weeding, pest and disease control		Harvesting	No activity		land preparation	Planting	Weeding, pest and disease	
Sorghum	Harvesting	Land preparation	Planting	Weeding, pest and disease control			Harvesting		Addition of manure for the ratoon crop ratoon crop		Weeding, pest and disease	
Onions	Harvesting	Land preparation	Planting	Weeding, pest and disease control		Harvesting	Marketing		Land preparation	Planting	Weeding, pest and disease	

Kales	Raising of seedlings	Land preparation	Transplanting	Weeding, pest and disease	Harvesting and Marketing			Manure application	Harvesting Marketing
Potatoes	Harvesting	Land preparation	Planting	Weeding, pest and disease	Harvesting Marketing	Marketing	Land preparation		Weeding, pest and disease

Source: Focus group discussion at Wiyumiririe

According to the farmers, approximately forty years ago, the climate was characterized by high rainfall and low temperatures. However in due course, rainfall declined and temperatures increased. But about 30 years ago the trend changed a bit with rainfall increasing gradually and temperatures beginning to fall once again.But around twenty years ago, the trend changed again with rains beginning to decline and temperatures rising again, a trend that has persisted ever since.

B. Perceptions and Beliefs of Farmers on Climate Change

Results showed that 90% of the farmers were aware of Climate Change and 83.3% believed humans are responsible. The remaining 14% though aware of Climate Change believed its occurrence was by natural processes. Three residents representing 10% of the sample believed climate wasn't changing, arguing that the place has always been like that. They however pointed out that untrammeled increase in human population coupled by failure to plant more trees was affecting natural water cycle. An overwhelming majority 70% believed Climate Change was a local/regional phenomenon and not global as widely conceived by many evident in the literature reviewed. They acknowledged the weather was changing but the link with increase in anthropogenic greenhouse gases was not succinct. Results from the FGDs (focus group discussion) concurred with what majority of the farmers said, describing Climate Change as a local/regional phenomenon and mainly caused by human activities such as: encroachment to the forest, reckless cutting down of trees, forest fires, charcoal burning and cultivation along river banks. Still some farmers associated Climate Change to an act of God and ancestral curses. The findings of this study were almost similar to studies done elsewhere. For instance Grimig et.al., (2013) observed that unlike the American public, farmers in the state of Indiana were less likely to believe in anthropogenic gases as the main contributor to global warming with 79% associating it to natural processes. Similarly Arbuckle et.al.,(2013b) observed that a paltry 8% of Midwestern corn farmers in USA were in agreement that climate change was as a result of human induced activities compared to 49% of the American citizens (Leiserowitz et.al.,2013). Additional findings from FGDs indicated that the majority of farmers pointed out inadequate infrastructure, such as irrigation, improved seeds, and credit facilities to support adaptation influenced their perceptions about climate change. Accordingly, these findings were in congruent to a previous study done in Australia in which perceptions of farmers to Climate Change were found to be influenced by the presence of infrastructure to support adaptation (Meredith and Nathaniel, 2016).

Table 2: Perception and Beliefs of Farmers on Climate Change (N=30).

Belief typologies	Number	Percentages
Perceptions that climate is changing and it's a global phenomena	6	20
Perceptions that climate is changing but it's a local phenomena	21	70
Perception that climate is changing and humans are responsible	25	83.3
Perception that the climate is changing and humans are not responsible	2	0.067
Perceptions that climate is not changing and humans contribute to Climate Change	2	0.067
Perceptions that climate is not changing and humans do not contribute to Climate Change	1	0.033

With regard to rainfall, 90% of the respondents reported a decrease in the total amount. Others reported that the onset of rains had changed greatly with the long rains delaying, and then breaking early before crops had reached physiological maturity. Consequently, crop failure had become the norm rather than the exception. Eighty three percent (83%) of the respondents reported short rains were more predictable compared to the main March-July rains, views that were collaborated by the FGDs. The challenges were that at times, the short rains came unusually too early before they had prepared land. A proposal to consider the October -December to be the main cropping season was inconclusively discussed. On temperatures, 70% of the farmers believed temperatures had increased, 23.3% had reduced, 0.03% believed temperatures hadn't changed while the remainder 0.03% didn't know whether temperatures had changed or not.

Table 3: Farmers' Perceptions about Weather Trends

Belief typology	% Respondents (n=30)
Rainfall had increased	0.03
Rainfall had decreased	90
Rainfall had remained the same	0.03
Do not know whether rainfall had increased or decreased	0.03
Onset of long rains had changed	93.3,_comes late
Onset of short rains had changed	66.7 comes early
Temperatures had increased	70
Temperatures had decreased	23.3
Temperatures had not changed	0.03
Do not know whether there had been any changes on temperatures	0.03

C. Impacts and effects of Climate Change to Agricultural Production

Results from individual farmers, key informants and FGDs indicated Climate Change had impacted negatively to the Agriculture sector in a number of ways. Seventy four percent of farmers reported crop failure due to erratic and inadequate rainfall. In three out of five years, farmers indicated they hadn't received any harvest. For instance, between January 2016 and February 2018, only one cropping season was successful for farmers who employed conventional cultivation methods. Consequently crop and livestock production activities were adversely affected making it hard for the farmers to attain food security. In a few isolated cases, farmers reported an increase in crop pest and diseases, but the study was unable to associate that to Climate Change. Remarkably 82% of farmers who had been there for more than 30 years reported an increase in the incidences of frost in the months of January which they attributed to Climate Change. Arable and pasture crops were the main casualties in the form of frostbite. As a result, the affected crops did not recover afterwards exacerbated by dry spells that are common in the months of January. From the FGDs, reports indicated an increase in hailstones, during the months of July and November that caused huge crop losses. Flash floods were adversely mentioned that caused soil erosion, and uprooting of crops on sloppy areas in the month of April. With the food aid from the government and well-wishers having stopped, the majority of the households were dependent on off-farm income to make ends meet.

Table 4: Extreme weather events for Wiyumiririe

Climatic variable	% Respondents(n=30)
Unpredictable weather pattern	80%
Prolonged dry spell/drought	90%
Increase intensity frequency of hailstorms	83.3
Flash floods	86.7
Increase in intensity and frequency of frost	90

According to reports from key informant interviews these Climate Change associated hazards, greatly undermined the capacity of the residents to produce enough crop yields to meet their family food requirements. The compounding effects of poverty and lack of infrastructure to support adaptation were triggers to social economic and psychological problems. Divorce, family feuds and community infighting had intensified. As some family members left home to seek off -farm income, a number of those left behind were accused of engaging in extramarital affairs in exchange for food and scouting for food in funeral and wedding ceremonies where it was guaranteed. Balanced diet was an alien concept and animal sources of protein considered a luxury. The findings of this study to a great extent agree to a previous one done in the Lawra district of Ghana where Climate Change was found to cause social economic and psychological problems to farmers (Ndamani and Tsumeni, 2015). In the face of aforementioned impacts, farmers in FGDs and feedback from key informants reported using a variety of primary adaptation strategies which included: use of water pans to irrigate vegetables in the kitchen gardens, change in planting date, use of drought escaping crop varieties, rearing of indigenous poultry and use of farmyard manure to conserve soil moisture and address soil fertility.

D. Climate-Smart Agriculture Adaptation Options Prioritized For the Study Area

The process was carried out using Multi-criteria analysis during iterative meetings with all stakeholders. In the same forum, weights and scale for criteria and options used were agreed upon. Pair-wise ranking for the different categories of stakeholders preceded that.

Table 5: Multi-criteria Analysis for selecting Climate-Smart Agriculture Options

	Criteria						Score	Rank
Options	Capacity to increase crop yield	Capacity to withstand dry spell	Financial feasibility	Legal and political feasibility	Capacity to improve soil fertility	Speed of implementation		
Improved maize variety in Zai pit	3	3	3	3	2	2	2.65	6
Improved maize variety in Double digging	3	3	2	3	3	2	2.60	7
Indigenous Sorghum variety in Zai pit	3	4	3	3	3	2	3.3	4
Indigenous Sorghum variety in Double digging	3	4	3	3	3	2	3.3	4
Improved maize variety in Zai pits plus farmyard manure	4	4	4	3	4	1	3.6	2
Maize variety In double digging plus farmyard manure	4	4	4	3	4	1	3.6	2
Seredo sorghum variety in Zai pits plus Farmyard manure	5	5	4	3	4	1	4.1	1
Seredo Sorghum variety in Double digging plus farmyard manure	5	5	4	3	4	1	4.1	1
Improved maize variety plus change in planting date	3	3	3	3	3	4	3.1	5
Indigenous Sorghum variety plus change in planting date.	3	4	3	3	3	4	3.35	3

Taking the discussion to the criteria, capacity to increase crop yields and to withstand dry spell were given the highest weight (0.25 each). Food security and inadequate rainfall were unanimously agreed as the most important issues requiring attention. Next was financial feasibility with a weight of 0.15. Majority of farmers are resource poor, depending on family labour to cultivate land and using previous season's harvest as source of seeds for the subsequent season. Without access to any form of credit to finance adaptation options, finances were of primarily concern to them. Soil fertility was equally important to all hence a weight also of 0.15. Accordingly, any measures to address food security as the majority of the participants said, need to take into account soil fertility. Fatigued from receiving food donations which by the way had become irregular, farmers attention had shifted to growing their own crops, a decision that carried the day during iterative meetings. Both political feasibility and speed of implementation had a weight of 0.10, meaning that, adaptation measures required conformity to the government regulations, for farming and environmental protection as well as to be implemented rapidly so that benefits could be realized.

All the prioritized CSA options were given a scale of 1-5 in relation to each criterion. From the consultative forum involving all stakeholders holders, cultivation of Seredo Sorghum variety, on parcels of land prepared by double digging and Zai pits in a field management involving addition of farmyard manure at various rates were the most preferred options. These choices were grounded on the ability of sorghum crops to withstand drought compared to maize. From expert knowledge, double digging and construction of Zai pits were considered more appropriate technologies for harvesting and retaining rainwater at the root zone. Water pans and soak pits were hitherto widely used by farmers as rainwater harvesting technologies. However the technologies were becoming obsolete because of water loss through seepage, evaporation and menacing mosquito breeding grounds. Contrary to expectations, use of improved Gadam drought escaping sorghum variety was not a favourable option as it was said to be highly susceptible to bird attack. Compared to the indigenous variety, the improved varieties were found to contain high concentrations of sugars which made them highly susceptible to bird attack. The ability of indigenous Sorghum variety to tiller and form a ratoon crop was a huge advantage compared to the improved varieties. However their slow growth rate and eventual low yields had made farmers forfeit them.

E. Barriers to Adaptation for Smallholder Farmers

The barriers to adaptation identified most pressing to farmers included;: Unreliability of rainfall, long distance to farms, water scarcity, poor soils, lack of suitable drought escaping crop varieties and untimely weather information. Access to agricultural subsidies and high cost of farm inputs were cited as moderate constraints. Inadequate farmers' advisory services, lack of market for agricultural products were found to be less important barriers. The findings of these results were corroborated with FGDs in which erratic and inadequate rainfall, coupled with lack of water resources made it impossible for farmers to employ appropriate CSA practices for Climate Change adaptation. Discussion with FGDs and interviews with key informants identified lack of policy framework, conflict of interest between county and national government as pertinent. Generally, similar findings were reported in other studies, (Deressa et.al., 2011: Bryan et al., 2009: Yibekal et al., 2013: Madison 2007 and Ndamani and Tsunemi 2015).

IV. Conclusion

This article has presented findings on the effectiveness of prioritizing climate smart agricultural options to build the resilience of smallholder farmers to adaptation to climate change. The findings show that the target community was indeed vulnerable to climate change because of dearth of resources and sole dependence on rainfed agriculture. The target farmers had mild knowledge about Climate change which they associated with increased occurrence and intensity in extreme weather events such as droughts and frost. Nevertheless the farmers had the impression that Climate Change was a local phenomenon and that it could be addressed by putting in place mechanisms to support adaptation such as rainwater harvesting technologies and use of drought resistant crop varieties. By adopting a transdisciplinary approach that was truly recursive, it was possible to identify and prioritize appropriate Climate-Smart Agriculture options by employing simple yet very accurate pair-wise ranking and Multi-criteria analysis tools. Hence this study recommends their use especially for future CSA prioritization initiatives in Arid and Semi-arid areas in Kenya..

V. References

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