Farmers' Perception of Climate Change and their Adaptation Strategies in the Sagana-Gura Sub-watershed in the Upper Tana Catchment Area

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ABSTRACT: *Successful implementation of conservation programs in the Upper Tana Catchment Area (UTCA) can only be achieved through sustainable resource management and use. Thus, understanding farmers' perceptions of climate change is vital for promoting conservation programs. This study sought to understand farmers' perceptions of climate change and their adaptation strategies by comparing meteorological data with farmers' perceptions in the Sagana-Gura sub-watershed. A mixed method research design was used. This involved rainfall data from nine rain gauge stations and primary data on farmers' perceptions of climate change. Farmers' coping strategies were also examined. The primary data was collected through a survey based on a stratified sample of 284 heads of farm households upstream and downstream of the sub-watershed. A standardized precipitation index (SPI) was developed to examine the temporal variation in precipitation. The study found that eight extremely dry months were recorded between 1980 and 2012, with five of these months occurring between 1999 and 2012. This result supports farmers' perception that precipitation has not only decreased but has also become erratic and unpredictable. As a result, farmers are increasingly resorting to irrigation and diversification of their economic activities by engaging in enterprises that also contribute to soil erosion and forest destruction.*

KEYWORDS: *Catchment Area, Climate Change, Perception*

I. INTRODUCTION

According to Vesco et al (2021), the negative impacts of climate change around the world have resulted in spatial agricultural development, which has affected agricultural production, agricultural efficiency, as well as farmers' ability to generate income. According to global gridded data from agriculture-dependent countries, climate change impacts are to blame for the increase in armed conflicts, as climate extremes reduce food supply, leading to deterioration in livelihoods that result in societal fragmentation fuelling conflict. Upstream and downstream farmers in the Upper Tana Catchment Area (UTCA) have recently clashed over water resources. Downstream farmers accuse those upstream of diverting water while upstream farmers do not even have enough water for their farming activities. In these situations where climate change may be the cause, lack of adequate climate change adaptation mechanisms makes it difficult to restore peace (Arshad et al, 2017). As a result of climate change, agricultural production decreases, making agricultural land less valuable. In Pakistan, for example, the value of agricultural land decreased when people noticed indicators of climate change such as temperature fluctuations (Arshad et al, 2017). However, farmland value increased in areas where farmers had access to financial support, extension services, and irrigation facilities, even when people noticed changing climate conditions. Furthermore, adaptive behaviors such as irrigation, crop diversification, and land use changes depend on the extent to which farmers perceive climate change (Ado et al, 2019). While weather data has dominated the climate change debate, the perception of farmers who are expected to combat the negative effects of the changing climate has been largely ignored. This raises the following questions: Do farmers believe that climate change is happening? If so, do they see the need to take action to address it? If they see the need to act, what adaptation mechanisms have they adopted?

Climate change across the globe has caused intense precipitation events, high river discharge, and large-scale flooding (Kundzewicz et al, 2019). One of the driving factors of global climate variability includes spatial oscillations of the system within the ocean-atmosphere, as indicated by climate variability indices such as El Niño-Southern Oscillations (ENSO). In Africa, climate variability and change (CV&C) is responsible for food insecurity (Wossen et al, 2018). For example, Ethiopia and Mozambique have faced increasing volatility in coffee, maize, and livestock yields due to extreme temperatures and precipitation (Woetzel, 2020). Reduced yields mean income fluctuations for farmers. For example, reduced income has been reported in agriculture-dependent regions of Africa due to CV&C. The fact that agriculture is the main economic activity on the continent explains the vulnerability of Africa to the negative effects of CV&C. Agriculture contributes 16-20% of the continent's GDP. In fact, this percentage is greater in some countries like Ethiopia where 33% of its GDP depend on agriculture (Baarsch, et al, 2020; Woetzel, 2020). In terms of job creation, agriculture employs between 57% and 70% of the working population in Sub-Saharan Africa (Baarsch, et al, 2020; Faurès & Santini). Indeed, sub-Saharan Africa's vulnerability to climate change is compounded by high rates of poverty, malnutrition, poor infrastructure development, and slow pace of technology adoption (Ayanlade, et al, 2018). In Kenya, prolonged drought, unpredictable rainfall patterns and poor land use patterns have affected water storage and yield in the Tana Catchment Area (Karienye and Macharia, 2020). For example, human activities in the UTCA have increased with more land being converted to agricultural land where people use poor farming methods (van Beukering et al., 2015). This has led to the disappearance of springs and a decrease in base flow, which poses more challenges given that about 50% of Kenya's hydropower comes from the Tana Catchment Area (McCartney et al, 2019). Despite the critical role that reservoirs in the Upper Tana watershed play, they are threatened by sedimentation (Kitheka, et al, 2019). This problem has been exacerbated by rising human population, illegal and unregulated withdrawal of water resources, point and non-point source pollution, and riparian land encroachment (Iseman & Miralles-Wilhelm, 2021). While Hunink et al (2013) observed that the only solution to minimize reservoir sedimentation is to encourage farmers to adopt soil-conserving farming methods, McCartney et al (2019) and Kamamia et al (2021) noted that only a quarter of farm households adopt various soil conservation methods. The low rate of adaptation to climate change raises concerns about the extent to which people understand climate change and its risks, which is a question that this study sought to answer.

II. LITERATURE REVIEW

2.1. Theoretical Framework

This study is based on cultural risk theory. Developed by Mary Douglas in 1966, cultural risk theory states that social groups tend to share a consistent way of explaining misfortunes such as those associated with pollution. She argues that "'danger' taboos linked to acts of pollution by primitive groups play an intelligible role in maintaining particular forms of social order" (Tansey & O'riordan, 1999, p. 74). These taboos define gender roles and support certain judgments about what is considered appropriate within a certain community by linking a certain danger to a wrongful act in what can be called the forensic model of danger (Douglas, 1966). In this case, members of a given society share the same trust and fears. Therefore, they tend to select risks through a political process where culture plays a major role in human adaptation to climate change (McNeeley & Lazrus, 2014). For example, Leal et al. (2017) noted that while the culture of the Maasai community in Kenya considers keeping large numbers of animals as wealth, they have begun to reduce the size of their herds due to reduced grazing land and frequent droughts that normally result in huge losses caused by animal deaths. However, Ng'ang'a and Crane (2020) disagree with this argument of a community-based approach in assessing and responding to environmental risks, arguing that adaptation pathways are not dependent on culture but rather on gender, wealth and age. In their view, this amounts to a "false assumption of community homogeneity" (Ng'ang'a & Crane, 2020, p. 478). While CV&C adaptation pathways are politically motivated, those shaping these pathways derive their power to influence from their social position. In fact, a study in northwestern part of Kenya found that hardships associated with climate variability motivate people to engage in political violence (Vestby, 2019). Similarly, farmers in the downstream of Sagana-Gura sub-watershed, which is drier, blame their upstream colleagues for reduced water in the rivers. As a result, some violent clashes have already been observed between the two groups (Mungai, 2018). According to cultural risk theory, the debate over why some people experience water shortage due to climate change require negotiated worldviews that would shape social organization within the communities in order to manage the emerging risks. This justifies the deployment of cultural risk theory to understand farmers' perceptions of climate change.

2.2. Climate Change

Studies involving meteorological data provide evidence of climate change across the globe. Li et al. (2016) investigated how flood-related disasters varied spatially and temporally in Africa and the factors that influenced these variations. The analysis looked at disaster data from 1990 to 2014 in 55 African countries. The results of the study revealed that per capita GDP, high rates of urbanization, declining forest cover, and increasing population caused these disparities in floods' frequency. In yet another study, Ayugi et al (2020) investigated drought and flood occurrences in Kenya. They examined 35 years of rainfall and temperature data since 1981. They found out that rainfall was the main cause of seasonal variations in flood disasters. In a similar study, Langat, Kumar, and Koech (2017) sought to examine the variability, trends, and seasonality of precipitation and river flows in the UTCA. They collected rainfall data from ten stations over the period 1967-2016 spanning 49 years. Similar to the study by Li et al. (2016), Langat et al. (2016) found that streamflow varied with changes in precipitation received in the UTCA. These studies indicate that precipitation changes upstream have serious repercussions downstream.

2.3. Farmers' Perceptions of Climate Change and their adaptation

Globally, the decisions that farmers make to adapt to CV&C depends on their perceptions on the risks posed by these changes on their farm productivity (Arshad et al, 2017). This assertion was evident in a study that Arshad et al (2017) conducted in Pakistan. The study showed that farmers who were aware of climate change were proactive to adopt various adaptation strategies such as irrigation, enterprise diversification and change of land use such as investing in other industries besides agriculture (Arshad et al, 2017). However, meteorological data was found to shape farmers' adaptation to CV&C if only such data was aligned with their perceptions. This was revealed in another study that Fadina and Barjolle (2018) conducted in Benin. The study indicated that 85% of farmers who believed that disturbances in rainfall patterns, changes in the length of the dry season, temperature rise and strength of wind were signs of change reacted by adopting various coping strategies (Fadina & Barjolle, 2018). In a similar study that Kgosikoma, Lekota, and Kgosikoma (2018) conducted in Botswana, it was found out that Botswana and Benin farmers used similar adaptation mechanisms that included; diversification through mixed farming, mulching, increased use of organic fertilizers, acquisition of improved crop varieties and animal breeds, adjustment of dates for planting crops, irrigation, farm shades, increased use of pesticides and insecticides, use of supplementary animal feeds and vaccination of livestock, (Kgosikoma, Lekota, & Kgosikoma, 2018; Fadina & Barjolle, 2018). These adaptation methods pointed to several challenges that farmers faced such as high temperatures, delay in rainfall season or inadequate amount of rainfall, inadequate water supply, lack of adequate animal feeds, and increased pests and diseases that are all associated with climate change.

2.4. Factors that determine farmers' adaptation to CV&C

Researchers have been examining what motivates farmers to adapt to CV&C, and the results reveal wide range of factors that have similarities as well as differences across the globe. For example, Trinh et al (2018) carried out a study that explored factors that determine CV&C adaptation in Vietnam. The results revealed that farmers' training, size of farms, level of damage from extreme weather, farmers' level of education, farmers 'experience in farming, credit access, as well as gender were key determinants of farmers' decisions on CV&C adaptation (Trinh et al, 2018). Similar results were found in a study that Khanal et al (2018) conducted to investigate factors influencing rice farmers' decisions on adopting to CV&C in Nepal. However, Khanal et al (2018) also revealed that farmers' belief that climate change is actually taking place and their conviction that adaption to CV&C was necessary played a major role in shaping their adaptation decisions. Similar results were obtained in studies conducted in Africa. For example, Belay et al (2017) investigated what determined CV&C adaptation decisions in Ethiopia. Results of the study indicated that farmers adaptation dependent on their education level, size of family, gender, experience in farming, age, whether they owned livestock, availability and access to extension services, access to climate information and their income levels (Belay, et al, 2017). Other studies that generated similar outcomes were conducted by Awazi and Tchamba (2018) in Cameroon, Alemayehu and Bewket (2017) in Ethiopia highlands, Shikuku et al (2017) in Ethiopia, Kgosikoma et al (2018) in Kenya, Stefanovic et al (2019) in Kenya's Laikipia County, and Kaua (2020) in Tharaka Nithi County, Kenya.

Although many studies have been conducted on CV&C, the link between weather data and farmers' perceptions has been largely ignored. Ironically, farmers whose views have been ignored face many challenges related to climate change. Moreover, they are one of the key stakeholders in the war against the negative effects of climate change. To address this gap, this study combined rainfall data with primary data collected through a survey to examine farmers' perception of climate change and their adaptation strategies in the Sagana-Gura Sub-watershed in the UTCA.

III. MATERIALS AND METHODS

Mixed-method research design was used in this study where qualitative and quantitative data were collected and analyzed. Monthly rainfall data that spanned from 1957 to 2017 was collected from nine meteorological stations spread across the UTCA. A questionnaire was used to obtain information about farmers' perception and adaptation to change. In collecting the primary data, the study focused on the Sagana-Gura sub-watershed of the UTCA (see the map in Fig. 1 below). This sub-watershed comprises of four agro-ecological zones that include the humid zone, the sub-humid zone, the semi-humid zone and the semi-humid to semi-arid zone (Wambua, *et al.*, 2015).

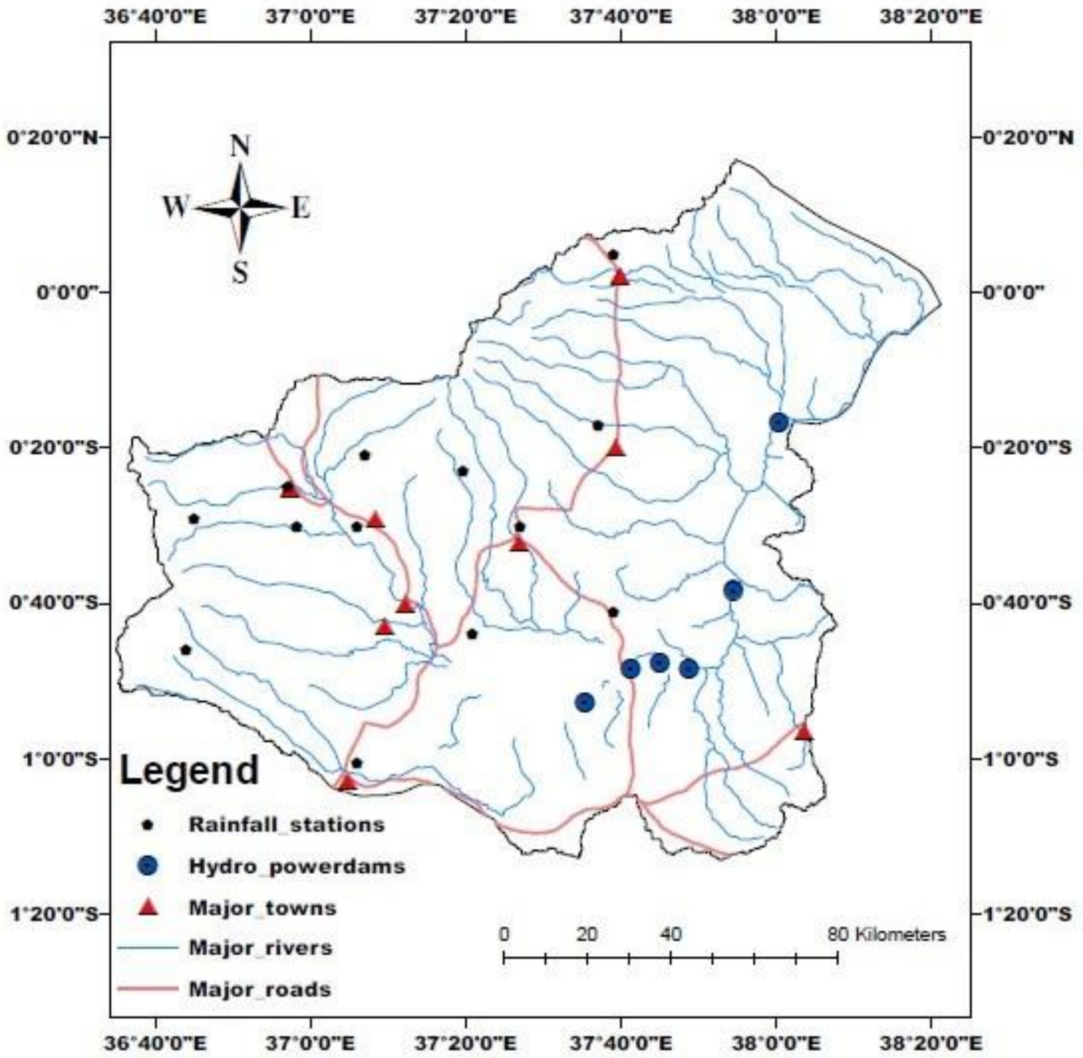

Figure 1: Sagana-Gura sub-watershed of the UTCA

The sample size for the study was 284 heads of farm households, which was 73.96% of the target sample size of 384. According to Badger & Werrett (2005) and Birtwistle et al (2002), this is an adequate response rate to generate reliable and valid results in this study. After conducting a pilot test, stratified sampling was used where the sample was drawn from two strata of the target population: upstream and downstream. The upstream sample was drawn from various villages including Ebenezer, Gatagati, Giathieri, Gitubururu, Kabaru, Kairi, Karandi, Kimahuri, Mitero, Ndathi and Warazo. The downstream villages from which the participants came were Githagaiya, Ngonda, Sagana, Kairo, Gatumbi, Gituri, Karima, Ngando, Ngoka, Gacharu, Gitumbi, Mucagara, Gakindu, Kanja, Mjini, Maganjo and Thanju.

Using SPSS, the percentage of farmers who believed that climate change was actually taking place was calculated. The factors that determined the opinions of those farmers who believed that climate change was taking place were examined by running a probit regression analysis using R. A binary variable of farmers' perception on climate change was the dependent variable (Y). In this case, farmers perceived climate change (coded with one (1)) or they did not perceive it at all (coded with zero (0)).

Using a mean monthly precipitation data, a one-month standard precipitation index (SPI) was computed to measure drought's rarity in the UTCA. It was used to compare precipitation as a percentage of the month's normal precipitation. Senay et al (2015) states: "SPI values that are greater than 0 indicate conditions wetter than the median, whereas negative SPI values indicate drier than median conditions" (p. 239).

The percentage of farmers who used adaptation strategies to climate change was computed using SPSS. In addition, a probit regression was used in examining farmers' choice of adaptation strategies to change in the Sagana-Gura sub-watershed of the UTCA. The question that the study sought to answer was: what determines whether a farmer will use adaptation strategies? A farmer may use adaptation strategies or not, which was the dependent dichotomous variable. In this case, the factors that determine whether a farmer would use some adaptation strategies (Croppractices) were the independent variables.

IV. RESULTS AND DISCUSSION

4.1. Farmers' Perception on Climate Change in the UTCA

Out of the 284 participants, 90.1% believed that there have been changes in weather patterns over the last 30 years. However, 69.5% of those who believed that climate change is taking place were from downstream as compared to 30.5% from the upstream. Moreover, 55% of all the respondents agree that rains have become unpredictable or inconsistent while 54.6% of them cited prolonged drought or increased dry spells as a major threat to their farming activities. Additionally, 48.9% of the 284 people who participated in this study believe that the number of rainfall days have decreased as compared to the past.

The study results revealed that two variables were significant in explaining the likelihood that a farmer believed that climate change is happening (see Table 1 below).

Table 1: Statistically Significant Variables on Farmers' Perception

Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)
Experience	6.353e-02	2.929e-02	2.169	0.03010 *
Nearestwater	-4.712e-04	1.461e-04	-3.226	0.00126 **

The study indicated that the z-score increases by 0.06353 for every unit increase in the number of years of farming experience. Converting the z-score of 0.06353 to probability yields 0.4747, which means that for every unit increase in the number of years of farming experience increases the probability that a farmer believes that climate change is happening by 0.4747. This implies that farmers who have longer farming experience are more likely to notice climate change. This affirms the assertion that farmers with experience of over 30 years have a higher likelihood of noticing changes in rainfall patterns due to climate change (Gbetibouo, 2009). There was a significant difference in the mean of the number of years of experience of household heads between downstream and upstream regions ($t_{174.887} = -8.914$, $p < .001$). Specifically, the average experience of household heads in downstream was 13.646 years less than their counterparts in upstream. In fact, the average age of household heads in downstream was 11.243 years less than the average age for those in upstream ($t_{236} = -7.491$, $p < .001$). Those farmers in downstream of the Sagana-Gura sub-watershed were found to easily notice reduction of rainfall as compared to those in upstream. For instance, 85.7% of respondents from downstream (Sagana) reported prolonged drought as compared to 40.2% of those from upstream (Ndathi). In addition, the study results indicated that more farmers in downstream (39.6%) reported unpredictable rains as compared to 23.5% of farmers in upstream. Furthermore, 55.5% of respondents from downstream believed that rains started late and ended early as compared to 17.6% of the respondents from upstream. Moreover, more downstream farmers (45.6%) reported erratic incidences of very wet season as compared to 14.7% of those from upstream. In addition, the study results indicated that 39% of farmers in downstream believed that rainfall has been inconsistent while 3.9% of farmers upstream reported inconsistency in rainfall patterns. More farmers in downstream (41.2%) believed that dry spell had increased as compared to 14.7% of those in upstream. Since the household heads in downstream were much younger than those in upstream, it can be deduced that younger farmers with less farming experience and lower education level (mainly up to primary level) are less likely to understand that the water shortage problems that they faced were caused by climate change. This explains the water-related conflicts where farmers in downstream blamed those in the upstream for diverting river water.

Concerning proximity to water source, the study results showed that the z-score decreased by 0.0004712 for every unit increase in the distance from the farm to the nearest water source. This means that for every unit increase in the distance from the farm to the nearest water source decreased the probability that a farmer believes that climate change was happening by 0.4998. The fact that farmers near the water source are able to monitor the water levels in the stream closely explains this. As the level of water reduces, they are the first to notice. This explains allegations from the people downstream that farmers in the upstream were diverting water thereby denying them the opportunity to irrigate their farms. These findings on the two statistically significant variables on farmers' perception generated the following model for predicting farmers' perception on climate change in the UTCA.

Probit(Changesweather=1) = 0.06353Experience-0.0004712Nearestwater + e, where Changesweather is farmers' perception on climate change, Experience is participant's farming experience in years, Nearestwater is the distance from the farm to the nearest water source and e is the error term.

4.2. SPI Results

The SPI results showed that rainfall in the UTCA was erratic. While 1997 was extremely wet, extremely dry weather was recorded in 2000. A severely dry weather in 1987 preceded very wet weather that was recorded in 1988 (see Fig. 2 below). Compared to normal, the study revealed that two incidences of extremely wet weather in the UTCA were recorded in 1988 and 1997 with SPI values of 1.55 and 2.18 respectively. In addition, two severely dry weather incidences were recorded in 1987 and 1998 as indicated by SPI values of -159 and -273 respectively. Data from only two out of the nine rain gauging stations had statistically significant negative trend. This finding corroborates farmers' perception that rainfall has not only declined but also become erratic and unpredictable.

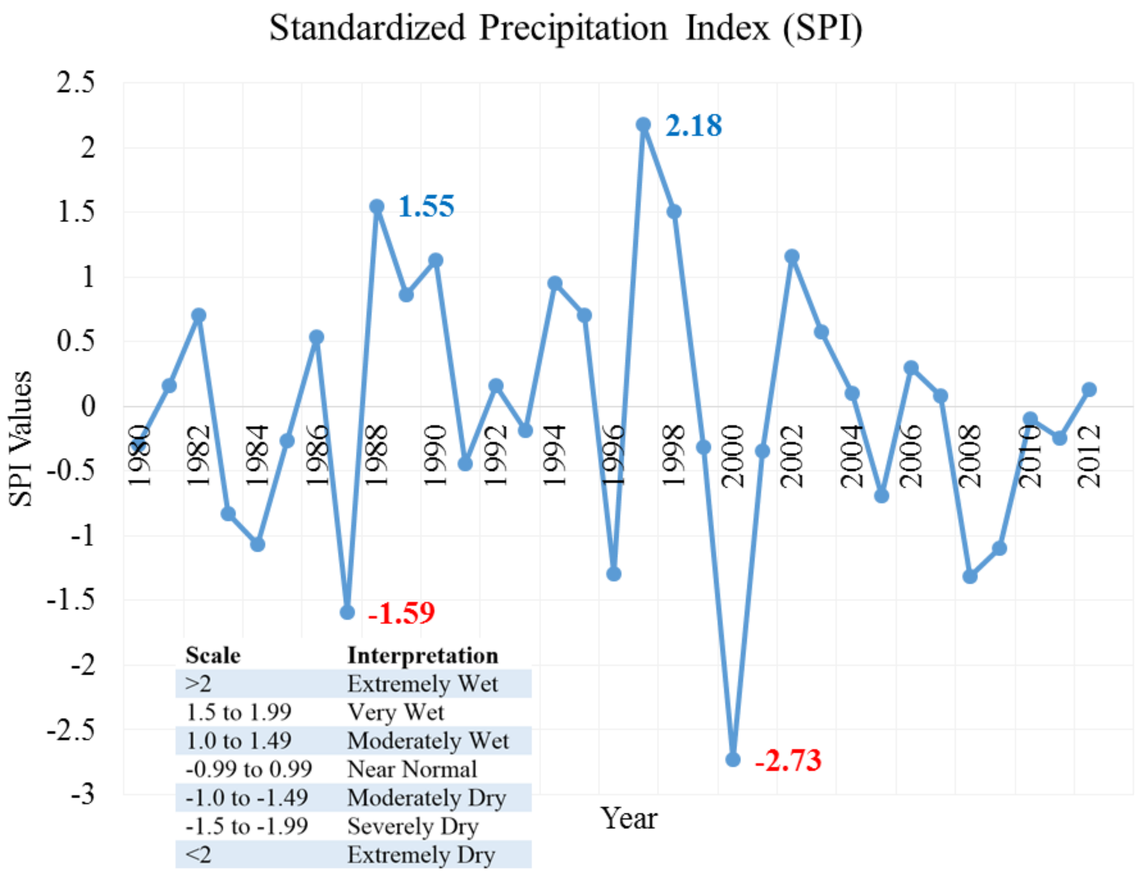

Figure 2: Standard precipitation index (SPI)

4.3. Adaptation Strategies

While 90.1% of all participants believe that climate change is taking place, 76.4% of them did not have deliberate adaptation strategies to climate change. Surprisingly, out of those farmers who have adopted adaptation strategies to climate change, only 22.4% of them are in downstream (which is much drier) while the remaining 77.6% of them are in the upstream. The most popular strategies that farmers used to overcome the challenge of reduced number of rainfall days were use of water pumps in irrigation (26.76%), growing crops that mature within a short period (4.58%), harvesting and storage of rainwater (2.11%), and use of certified seeds (2.11%). While certified seeds were expensive and unaffordable to many households, their use was meant to get early maturing and drought resistant crop varieties. The most popular adaptation strategies to overcome prolonged drought as farmers mentioned were pump irrigation (30.30%), harvesting of rainwater (4.90%), planting drought resistant crops (4.90%), and storing food during times of bumper harvest (4.20%). In order to deal with the unpredictable or inconsistent nature of rains, farmers took some measures such as use of pump irrigation (30.3%), harvesting and storage of rainwater (4.9%), planting drought resistant crops (4.9%) and storing more food during bumper harvest (4.2%).

The study revealed other adaptation strategies that farmers used and that were quite unpopular ten years ago that include the following. Some people bought food when their harvest was inadequate to meet their needs. This, according to the study participants, was not the case 10 years ago. Other farmers found farming to be a risk business prompting them to diversify by venturing in other economic activities to supplement the incomes they generated from their farms. Few farmers dug water pans for storage of rainwater. This meant that many farmers relied on water from the rivers to irrigate their farms. Furthermore, some farmers did not have water pumps because they relied on the use of water pipes that utilized the force of gravity in areas that have sloppy land terrain. During the data collection process, sprinklers were observed in many farms especially in the upstream area. In addition, farmers argued that they invested more money in animal health and prevention of crop pests and diseases as compared to the amount of money that they spend on the same ten years ago. Few farmers, especially those in downstream, dug drainage channels to control flooding. Others in downstream, increased the proportion of their farm allocated for crop production. Nevertheless, some farmers complained about lack of market for their perishable farm produce especially during rain seasons when many roads are impassable and the transport cost is high.

4.4. Choice of Farmers' Adaptation Strategies to Climate Change

The age, availability of food to households, highest education level attained by heads of households and their income levels were found to be significant factors that shaped farmers' perceptions on adaptation strategies to climate change (see Table 2 below).

Table 2: Statistically Significant Variables on Choice of Adaptation Strategies

Coefficients:				
	Estimate	Std. Error	z value	Pr(>|z|)
Age	-0.2301	0.08178	-2.813	0.00490 **
Agebracket46 - 55	3.694	1.586	2.329	0.01986 *
Agebracket56 - 65	5.324	2.258	2.357	0.01840 *
AgebracketOver 65	9.408	3.246	2.898	0.00375 **
FoodavailabilitySame	-2.002	0.9772	-2.048	0.04054 *
EducationPrimary school	-1.976	0.9399	-2.102	0.03552 *
IncomeSame	2.447	0.9597	2.55	0.01077 *

The z-score decreases by 0.2301 for every unit increase in the age of farmers. This means that for every unit increase in a farmer's age decreases the probability that he or she would embrace adaptation strategies to climate change by 0.409. This finding was consistent even when the age was broken down into age brackets. For instance, the probability that a farmer would embrace adaptation strategies was highest between the ages of 46 to 55, but it tended to zero as the age increased to 65 years.

If food availability remained the same (no increase and no decrease), the study findings indicated that the probability that a farmer would adopt strategies for climate change would decrease by 0.022642. The fact that farmers, especially those who practiced subsistence farming, saw no need for climate change adaptation strategies can be attributed to having enough food to eat and failure to foresee a situation where they would be food insecure.

Acquiring primary education as one's highest academic qualification decreases the probability that a farmer would adopt strategies for adapting to climate change by 0.024077. The need to understand, choose and adopt climate change strategies, according to this finding, requires education level beyond primary school. This finding emphasizes the need to promote education in the region and integrate it with training on good farming practices at this time when climate change is shaping farming practices.

The study indicated that having stable income increased the probability that a farmer would adopt strategies for adapting to climate change by 0.007203. This may explain why farmers cited lack of adequate funds as a reason for failing to use farming practices that would improve their production when rains fail and water in the rivers decline.

Based on these study findings, the change in the likelihood that a farmer would start embracing adaptation strategies to climate change in the Sagana-Gura sub-watershed of the UTCA can be predicted using the following probit model.

Probit(Croppractices=1) = [2.447IncomeSame] + [3.694Agebracket46–55] + [5.324 Agebracket56 – 65] + [9.408 AgebracketOver 65] – [0.2301Age] – [1.976EducationPrimary school] – [2.002 FoodavailabilitySame] + e

V. CONCLUSION

Farmers in the Sagana-Gura sub-watershed described rainfall patterns as erratic and inconsistent. They noted that start and end of the rain seasons are no longer predictable. As a result, they no longer understand the best crops varieties to plant as well as the best time to plant. This explains their increasing reliance on irrigation farming. Buying food and the rising habit of storing more of their harvest for use in times of uncertainties, which was not the case 10 years ago, show their belief that food insecurity has increased due to water scarcity, extreme weather conditions, rapid population growth rate and high costs of inputs. However, the current study indicated that many people are not well equipped to deal with the effects of climate change even though they have observed such changes for over three decades. In fact, many farmers in downstream did not seem to understand that decrease in water in rivers was because of climate change. Rather than adapting sustainable methods of farming, they blamed those in upstream for 'overusing' the water and diverting it. This means that conflicts between farmers in upstream and those in downstream may escalate if awareness creation about climate change is not conducted to reach out to those who do not understand the consequences of climate change. While farmers upstream concentrate on growing crops for sale, many complained about lack of market for their products. They argued that their intention was to generate money through sale of farm products that they would use to buy food. However, the contradiction arises when the cash crops are wasted in the farms because of lack of buyers and poor roads. In the past, younger and upcoming farmers have been targeted in promoting sustainable farming as a way of dealing with climate change. However, the current study revealed that farmers with many years of experience are more likely to understand how significantly the climate has changed. In addition, farmers living far away from water sources are less likely to understand that climate change is the main reason for the fluctuations in streamflows that the region is experiencing. This finding is important in constituting community-owned projects that seek to minimize the negative impacts of climate change. On one hand, young farmers are likely to benefit from older and more experienced colleagues in identifying the mistakes that led to environmental degradation. On the other hand, the young farmers are more likely to use innovative ways of evading similar mistakes and coming up with solutions to solve the challenges associated with climate change. In fact, the study revealed that middle-aged farmers between the age of 46 and 56 years were more conscious on adaptation of strategies on climate change. This contradicts the expectation that younger farmers who are expected to have greater knowledge on climate change through academic and technological access to information should lead the way in promoting sustainable farming. As the pressure of increasing population continue to mount on the limited land, more people in upstream may focus on other income generating activities such as mining, and lumbering that may worsen the already deteriorating environment of the Sagana-Gura sub-watershed. As a result, water scarcity downstream may increase even as farmers' demand for the commodity increase as irrigation farming continues to grow. This may eventually deplete the Sagana-Gura sub-watershed. This shows how important it is for farmers to make proper choice of adaptation strategies for change.

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