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Adaptation strategies employed by small-scale farmers to counter the effects of rainfall variability in Uasin Gishu County, Kenya

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Abstract
Rainfall variability is among the problems that hinder sustainable livelihoods and economic development, particularly for developing countries like Kenya. Kenya is seriously affected since it depends primarily on rain-fed agriculture. Yet, there is a dearth of information on agricultural adaptive strategies embraced by small scale farmers in Ainabkoi Sub-County. The purpose of the study was to explore adaptive strategies of small-scale farmers to rainfall variability in Ainabkoi Sub-County. Based on the study this paper explores the adaptation strategies employed by small-scale farmers to counter the effects of rainfall variability and the constraints to those adaptation strategies in Ainabkoi Sub-County. The study adopted a mixed design approach. The target population comprised of household heads, ward administrators and agricultural extension officers. Three ward administrators and three agricultural extension officers from Kapsoya, Kaptagat and Ainabkoi wards were purposively selected. A total of 396 households were sampled to take part in the study. Household heads were selected using proportionate systematic sampling technique. Questionnaire, interview schedule and observation schedule were used to collect data. Open-ended questions were analyzed through reporting of themes and quotas that emerged. Data from household survey were subjected to descriptive analysis to give frequencies and proportions. Findings were presented in form of cumulative frequency tables, graphs and charts. The study established that in their quest to counter the impacts of rainfall variability, small-scale farmers had devised adaptation strategies. Majority (59.7%) of them had diversified crop types and varieties followed by those who had changed planting dates (33.4%) and those who had completely changed crop varieties (27.6%). Most (57.9%) of the farmers cited lack of financial capital as the main constraint to implementing adaptation strategies geared towards countering the effect of rainfall variability. Following these findings, the Ministry of Agriculture needs to enhance opportunities for small-scale irrigation and water harvesting technologies. Similarly, the County government of Uasin Gishu needs to promote formation of local rural institutions and farmer groups and create more opportunities for livelihood diversification of local subsistence farmers.

Keywords: Adaptation Strategies, Small-Scale Farmers, Effects, Rainfall Variability, Uasin Gishu County, Kenya

Introduction

Evidence is emerging that climate change is increasing rainfall variability and the frequency of extreme events such as drought, floods and hurricanes (IPCC, 2007) [15]. Boko *et al*. (2007) predict that Africa is likely to warm across all seasons during the 21st century with annual mean surface air temperatures expected to increase between 3°C and 4°C by 2099, roughly 1.5 times average global temperatures. Projections in East Africa suggest that increasing temperatures due to climate change will increase rainfall by 5-20% from December to February, and decrease rainfall by 5-10% from June to August by 2050 (Hulme *et al*., 2001; IPCC, 2007) [15]. Analyses from General Circulation Models (GCMs) indicate an upward trend in rainfall under global warming over much of Burundi, Kenya, Rwanda, southern Somali and Uganda (Schreck & Semazzi, 2004; van de Steeg *et al*., 2009) [25].

The amount of soil-water available to crops depends on rainfall onset, length, and cessation which influence the success/failure of a cropping season (Ng'etich, 2014). It thus emerges that proper understanding of climatic parameters, rainfall in particular, can aid in developing optimal strategies of improving the socio-economic well-being of small scale farmers. This is particularly important in Kenya where agricultural productivity is principally rain-fed yet highly variable (Kimani, 2009). Drier parts of Kenya's central highlands, eastern Kenya, continue to experience high unpredictable rainfall patterns, persistent dry-spells/droughts coupled with high evapo-transpiration (2000-2300 mm year^{-1}) (Kimani, 2009). Generally, the total amount of rainwater is enough; however, it has been reported to be poorly redistributed over time with 25% of the annual rain often falling within a couple of rainstorms; as a result crops suffer from water stress, often leading to complete crop failure (Kosgei, 2008).

There has been continued interest in understanding rainfall seasonal patterns by evaluation of its variables, including rainfall amount, rainy days, lengths of growing seasons, and dry-spell frequencies in Kenya, particularly because majority of small scale farmers rely on rain-fed agriculture (Kimani, 2009).

Adaptation to Rainfall Variability

Adaptation is widely recognized as a vital component of any policy response to climate change. Studies show that without adaptation, climate change is generally detrimental to the agriculture sector; but with adaptation, vulnerability can largely be reduced (Easterling *et al.*, 2013; Rosenzweig & Parry, 2014). The degree to which an agricultural system is affected by climate change depends on its adaptive capacity. Indeed, adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences (IPCC, 2012) [16]. Thus, the adaptive capacity of a system or society describes its ability to modify its characteristics or behavior so as to cope better with changes in external conditions. Adaptation to climate change requires that farmers first notice that the climate has changed, and then identify useful adaptations and implement them (Maddison, 2006).

Many agricultural adaptation options suggested in the literature encompass a wide range of scales (local, regional, global), actors (farmers, firms, government) and types: (a) micro-level options, such as crop diversification and altering the timing of operations; (b) market responses, such as income diversification and credit schemes; (c) institutional changes, mainly government responses, such as removal-preserve subsidies and improvement in agricultural markets, and (d) technological developments – the development and promotion of new crop varieties and advances in water management techniques (Kurukulasuriya & Rosenthal, 2013). Most of these represent possible or potential adaptation measures rather than ones actually adopted. Indeed, there is no evidence that these adaptation options are feasible, realistic or even likely to occur. Furthermore, they would only be possible with complete and accurate knowledge of future climatic conditions, which is why these were aptly named "clairvoyant farmer" scenarios (Risbey *et al*., as cited in Belliveau *et al*., 2006). Therefore, climate change impact studies often assume certain adaptations and there is little explicit examination of how, when, why and under what conditions adaptation actually occurs in economic and social systems.

Agricultural change does not involve a simple linear relationship between changes in a farmer's decision-making environment and farm-level change. One important issue in agricultural adaptation to climate change is the manner in which farmers update their expectations of the climate in response to unusual weather patterns. Referring to Kolstad *et al.* (1999), Maddison (2006) has discussed what he calls "the transitional cost" of adapting to climate change. The transitional cost is the difference between the maximum value of net revenues per acre following perfect adaptation and the net revenues actually experienced by farmers given that their expectations of (and therefore response to) climate change lag behind actual climate change. A farmer may perceive several hot summers but rationally attribute them to random variation in a stationary climate.

One could argue that farmers engage in simple Bayesian updating of their prior beliefs according to the standard formula. If so, the process of updating is likely to be slow, and therefore one should not expect decades of information to be thrown out overnight. However, there is evidence that farmers did not update their priors in this way. Indeed, farmers place more weight on recent information than is efficient. Another important issue related to adaptation in agriculture, as pointed out by Bryant *et al.* (2008) [2], is how perceptions of climate change are translated into agricultural decisions. If farmers learn gradually about the change in climate, Maddison (2006) argues that they will also learn gradually about the best techniques and adaptation options available. According to him, farmers learn about the best adaptation options through three ways: (1) learning by doing, (2) learning by copying, and (3) learning from instruction. There is recognition that farmers' responses vary when faced with the same stimuli. Such varied responses, even within the same geographic area, are partly related to the variety of agricultural systems involved and the different market systems in which farmers operate (Bryant *et al.*, 2008) [2].

A more important factor of varied farmers' responses is the differences between farmers in terms of personal managerial and entrepreneurial capacities and family circumstances. Moreover, farmers can be influenced by their peers' perceptions and by values present in their communities as well as their professional associations. Existing literature on adoption of new technologies has identified farm size, tenure status, education, access to extension services, market access and credit availability, agroclimatic conditions, topographical features, and the availability of water as the major determinants of the speed of adoption (Maddison, 2006).

Adaptation to environmental change is a norm rather than exception. Throughout human history, societies have adapted to natural climate and environmental changes by altering settlement and agricultural patterns and other facets of their economies and lifestyles (McCarl *et al.*, 2001; Easterling *et al.*, 2004; Burton *et al*., 2006; Adger *et al*., 2007; Heltberg *et al.*, 2008) [6, 3, 1, 12]. As such, most societies are reasonably adaptable to changes in average conditions, particularly if they are gradual (Burton *et al.*, 2006) [3]. However, communities are more vulnerable and less adaptable to human-induced climate change. Adaptation to climate change has become one of the focal points of current development discourse, particularly agriculture. As a result, it has found expression as a response strategy in the UNFCCC and the resulting Kyoto Protocol in 1997. Article 4.1 (f) of the UNFCCC commit parties to:

> Take climate change considerations into account, to the extent feasible, in their relevant social, economic and environmental policies and actions,…, with a view to minimizing adverse effects on the economy,…, to mitigate or adapt to climate change.

The rise of climate change adaptations to political currency is two-fold: developing countries are extremely vulnerable to climate change impacts, because a large proportion of their economies are climate sensitive, and they have less adaptive capacity (IPCC, 2007) [15]. This paper is premised on the concept of adaptation of people and their livelihoods to climate change.

Adaptations are adjustments in ecological-social-economic systems in response to actual or expected climatic stimuli, their effects or impacts (IPCC, 2001; Smit & Olga, 2011) [14]. Thus, adaptation can reduce adverse impacts of climate on human health and well-being, and increase the capacity to take advantage of the opportunities (IPCC, 2007; Smit & Olga, 2011) [15]. Regarding human dimensions, adaptation to climate change entails adjustments in socio-economic arrangements that reduce the vulnerability of households, communities, groups, sectors, regions, or countries to changes in the climate system (Smith, 1997; Smit & Wandel, 2006; Fussel, 2007). The goal of climate change adaptation is to build the resilience of communities towards different kinds of changes in their environment.

Resilience is the capacity to maintain competent functioning in the face of major life stressors (Adger, 2000). Thus, it demonstrates the capacity of human systems or entities to bend without breaking in the face of disturbance and, once bent, to spring back to its pre-disturbance steady state (Easterling *et al*., 2004) [6]. Unlike natural ecosystems, human systems have the capacity of foreseeing and adapting to possible environmental changes (Adger, 2000; Folke *et al.*, 2002; Easterling *et al*., 2004) [8, 6].

When a social or ecological entity loses resilience, it becomes more vulnerable to changes that previously could be absorbed and adapted to (Folke *et al*., 2002) [8]. Sustainability of humans on earth is linked to resilient socio-ecological systems, which is influenced by human capital and institutional arrangements (O'Brien *et al*., 2012). The terms "coping" and "adaptation" are often used interchangeably to reflect strategies for adjustments to changing climatic and environmental conditions (O'Brien *et al*., 2012). However, the two are associated with different time scales and represent different processes (Eriksen & Kelly, 2007). Whereas, coping is a short term reactive response to climate variability, adaptation is associated with longer time scales and points at adjustments as fundamental changes of the systems practices, processes or structures to changes in mean conditions (ibid.). With adaptations, new coping range is established (Smith & Wandel, 2006) [23, 3].

Nonetheless, coping strategies may become adaptive strategies when people are forced to use them over a run of bad years and across seasons rather than just at the worst time of the year (Anderson *et al*., 2010). Besides, the way households cope with crises either may enhance or constrain the future coping strategies, as well as their possibilities to adapt in the longer term (O'Brien *et al*., 2012). Adaptation types have been differentiated according to numerous attributes.

Commonly used distinctions are purposefulness and timing (Smit & Olga, 2001). The IPCC (2007) [15] recognizes three types of adaptation: First, autonomous, or spontaneous adaptations are considered to be those that take place – invariably in unconscious and reactive response – after initial impacts are manifest to climatic stimuli as a matter of course, without the intervention of public policy. Second, anticipatory, or proactive adaptation takes place before the impacts of climate change are apparent. Third, planned adaptation is based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

However, due to institutional constraints, planned adaptation has been slow in forthcoming in many developing countries, and populations are most vulnerable to disrupted agricultural production (Maddison, 2006). Whereas planned adaptations are intervention strategies, autonomous adaptations occur naturally without interventions by public agencies (Smith *et al.,* 1996). Thus defined, autonomous and planned adaptations largely correspond with private and public adaptation, respectively. However, it is the autonomous adaptation that forms a baseline against which the need for planned anticipatory adaptation can be evaluated (Smit & Olga, 2001).

Agricultural Adaptation

Agricultural adaptation is a vital policy response that will shape the future severity of climate change impacts on food security. Studies indicate that adaptation can lessen the yield losses that might result from climate change, or improve yields where climate change is beneficial (Adams *et al.,* 2008). Although relatively inexpensive adaptation options such as crop diversification and altering the timing of operations, may moderate adverse impacts, the biggest benefits will likely result from more costly measures including institutional strengthening and technological developments (Easterling *et al*., 2004; Smith & Wandel, 2006) [23, 6]. These adaptation measures, alongside other competing interests, will require substantial resource allocation by farmers, national and county governments, scientists and development partners.

Adaptation occurs at two main levels: the farm-level and macro-level (Kandlinkar & Risbey, 2010). While the farm level is focused on micro analysis of farmer decision making, the macro level deals with national agricultural production and its relationships with domestic and international policy (ibid.). Farm-level decisions are short-term and made in response to seasonal climatic shifts, and therefore, determined by socioeconomic variables such as household characteristics, household resource endowments, access to information and availability of formal institutions. Contrastingly, macro-level analysis is long-term strategic national decisions and policies made in response to long-term changes in climatic and market conditions.

Determinants of Adoption of Adaptation Strategies

The literature on adoption identifies a range of household and farm characteristics, institutional factors, and local climatic and agro-ecological conditions as the key the determinants of the speed of adoption (Maddison, 2006; Gbetibouo, 2009) [11]. The adaptation options taken by most farmers are not only those that build adaptive capacity and enhance climate resilience, but also those that will address conservation of natural and environmental resources (SEI, 2009).

The household characteristics which have significant impact on adoption decisions include age, education level, gender of the head of the household, family size, years of farming experience, and wealth. The age of a farmer may positively or negatively influence the decision to adopt new technologies (Gbegeh & Akubuilo, 2012). Older farmers have more experience in farming and are better able to assess the characteristics of modern technology than younger farmers, and hence a higher probability of adopting the practice. On the other hand, older farmers are more risk-averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of adopting new technologies (Adesina & Forson, 2005). Younger farmers are likely to incur lower switching costs in implementing new farming practices since they have limited experience and therefore, adjustment costs involved in adopting new technologies may be lower for them (Marenya & Barrett, 2007) [17].

Education and human capital endowments are often assumed to increase the likelihood of embracing new technologies. This is because they enhance the ability of farmers to perceive climate change (Nkonya *et al.,* 2008) [19]. Similarly, education enables households to access and conceptualize information relevant to making innovative decisions (Adesina & Forson, 1995; Daberkow & McBride, 2003; Shiferaw *et al.,* 2009; Ochieng', Owuor & Bebe, 2012; Gbegeh & Akubuilo, 2013) [4, 13]. However, higher educational attainment can present a constraint to adoption because it offers alternative livelihood strategies, which may compete with agricultural production.

The effect of gender of the household head on adoption decisions is location-specific (Gbetibouo, 2009) [11]. In many parts of Africa, women are often deprived of property rights due to social barriers (Gbegeh & Akubuilo, 2013) [13]. Consequently, they have fewer capabilities and resources than men (Quisumbing *et al*., 1995; De Groote & Coulibaly, 1998; Marenya & Barrett 2002; OECD, 2009; Gbegeh & Akubuilo, 2012) [5]. This often undermines their capacity to embrace labour-intensive agricultural innovations. However, female-headed households are more likely to take up climate change adaptation measures (Nhemachena & Hassan, 2007; Gbetibouo, 2009) [18, 11]. The possible reason for this observation is that in most rural, small scale farming communities in Africa, more women than men live in rural areas where much of the agricultural work is done. In this respect, women have more farming experience and information on various management practices and how to change them, based on available information on climatic conditions and other factors such as markets and food needs of the households (Nhemachena & Hassan, 2007) [18]. Asset endowments and wealth have a significant influence on the ability of small scale farmers to adopt certain technological practices (Reardon & Vosti, 1995; Nkonya *et al*., 2008; Gbetibouo, 2009) [20, 19, 11]. Households with higher income and greater assets are less risk averse than lower income households, and therefore in better position to adopt new farming technologies (Shiferaw & Holden, 2008).

The influence of household size on the decision to adapt is uncertain. Household size as a proxy to labour availability may influence the adoption of a new technology positively as its availability reduces the labour constraints (Marenya & Barrett, 2007; Teklewold *et al*., 2006) [17]. Given that the bulk of labour for most farm operations in sub-Saharan Africa is provided by the family rather than hired, lack of adequate family labour accompanied by inability to hire labour can seriously constrain adoption practices (Nkonya *et al*., 2008) [19]. Nonetheless, households with many family members may be forced to divert part of the labour force to off-farm activities in an attempt to earn income to ease the consumption burden imposed by a large family size (Tizale, 2007; Gbetibouo, 2009) [11].

The farm characteristics that could influence the adoption decisions include farm size and soil fertility. Farm size influences both the access to information and the adoption decisions. More crop acreage is likely to enhance the information exposure to site-specific crop management technologies because these technologies would likely be marketed to larger farms (Marenya & Barrett, 2007; Daberkow & McBride, 2003) [17, 4]. Given the uncertainty and the fixed transaction and information costs associated with innovation, there may be a critical lower limit on farm size that prevents smaller farms from adapting (Daberkow & McBride, 2003; Gbetibouo, 2009; Gbegeh & Akubuilo, 2012) [4, 11]. Thus, large mechanised farms will probably be the first to adapt to climate change.

Institutional factors that influence adoption of new technologies includes access to credit, information provision, off-farm employment, and land tenure. Institutional strengthening via access to formal and informal institutions and meteorological capability increases the likelihood of uptake of adaptation techniques. Households with access to formal agricultural extension, farmer - to - farmer extension and information about future climate change are more likely to adjust their farming practices in response to climate change (Smit *et al*., 2001; Mariara & Karanja 2007; Yesuf *et al.*, 2008; Nkonya *et al*., 2008) [26, 19]. In addition, farmers with access to extension services are likely to perceive changes in the climate because they have information about climate and weather changes (Gbetibouo, 2009) [11].

However, certain information sources can be more effective “change agents” than others and various information sources can influence the probability of adoption differently (McBride & Daberkow, 2003) [4]. Similarly, different sources of information become influential during different stages of adoption process. The mass media for instance, are important in the early awareness stage, while interpersonal information sources such as extension officers and other farmers are critical in transferring more technical and adoption-promoting information (ibid.).

Although technical information from extension services is shown to be most important to the potential adopter, the extension-farmer linkages are extremely weak in some parts of Sub-Saharan Africa and most agricultural information is obtained via farmer-farmer contacts (Adesina & Forson, 1995). This suggests that farmers are also important as sources of technology information and agents of technology transfer. Studies also reveal that adoption technologies flow through social networks, and do not necessarily spread because of geographical proximity (Maddison, 2006). Thus future extension should engage farmer cooperatives in research process and on-farm trials for a variety of evaluation and demonstrations. The trained farmers will then be able diffuse the adoption technologies since heterogeneity of farm situation invariably makes it difficult to provide government extension (Pannell, 2009).

Studies have shown that under conditions of imperfect credit, small-scale farmers and resource users will adopt certain conservation practices (Reardon & Vosti, 1995; Gbetibouo, 2009) [20, 11]. This is because the adoption of new technologies requires borrowed or owned capital. Thus lack of borrowing capacity may hamper any efforts to embrace adaptation strategies that require heavy investment upfront such as irrigation, terracing, tree planting and fertilizer use. The other institutional factor conditioning the adoption of adaptation technologies mainly relate to the prevailing system of property rights (Gbetibouo, 2009; Shiferaw *et al.*, 2009) [11].

Tenure security can contribute to adoption of technologies linked to land such as irrigation equipment or soil conservation practices. Farmers lack economic incentives to invest their time or money if they cannot capture the full benefits of their investments (ibid.). This condition may prevail when they have insecure rights to land or when the natural resource is governed by open access property regime.

Factors influencing Successful Adaptation to Rainfall Variability

It is often assumed that adaptation is both possible and desired with the right technology and funding, but there exist limits and barriers to the capacity of individuals and communities to adapt (Alston, 2013). According to Frankhauser and Tol (1997), successful adaptation requires: 1) timely recognition of the need to adapt and 2) the ability to adapt

i) Recognition of the Need to Adapt

Even though the IPCC (2011) state that adaptations can be performed unconsciously, being aware of the necessity to adapt is important for timely and successful adaptation to climate change (Frankhauser & Tol, 2007). According to Maddison (2007) farmers unaware of climate change are less likely to apply agricultural measures that are effective in adapting to climate change than farmers who are aware of climate change. He, therefore states that successful adaptation to climate change involves a two-stage process in which it is first necessary to perceive that climate change has occurred before deciding whether or not to apply an adaptive measure.

The concept of perceiving entails becoming aware of something directly through any of the senses. The perception of climate change is an important prerequisite to becoming aware of climate change, especially in areas where information on climate change is limited. However, perceiving climate change does not necessarily imply recognition of the need to adapt (Maddison, 2007). Similarly, Eisenack and Stecker (2012) note that adaptations to climate change are not applied if there is no operator to perform the adaptation. They define an operator as an individual or collective actor (i.e. individual, a private household, a group, a government) that performs the respond and is part of a social entity. An operator will be missing if none of potential operators are aware of climate change or recognize the problem and thus the necessity to adapt. Unawareness of climate change or its impact can occur if social habits and normative standards prohibit an understanding of the climatic stimulus. Furthermore a situation of a missing operator will occur if potential operators ignore the impact of the climatic stimulus on the exposed unit. Ignoring the problem can occur if potential operators prioritize other issues (Eisenack & Stecker, 2012).

ii) The Ability to Adapt-Adaptive Capacity

The second requirement to successful adaptation is the ability to adapt, also referred to as adaptive capacity. Adaptive capacity can be defined as the potential or ability of an individual or a social system to cope with a wide range of environmental conditions by developing genetic or behavioural characteristics (Fullan & Loubser, 1972; Smit & Pilifosova, 2003; Smith & Wandel, 2006) [23, 3]. The concept of adaptive capacity has its source in evolutionary biology, and in an anthropological context the term genetic characteristics can be replaced by cultural practices. Likewise to evolutionary biology, the adaptive capacity of a society or culture determines its survival. Cultures or societies who are able to respond to and adjust to changes quickly and easily are considered to have a high adaptive capacity (Smith & Wandel, 2006) [23, 3]. Adaptive capacity has also been termed "coping capacity", "coping ability" or "capacity of response" (Gallopín, 2006) [9]. Combined, the two terms, therefore, create a function that presents a measurement of the ability to adjust to climate change. The adaptive capacity of a system is often confused with the term resilience. Resilience is different in the sense that it refers to "a systems ability to absorb change and disturbance while undergoing change so as to still retain essentially the same function, structure and identity" (Walker *et al.*, as cited in Gallopín, 2006) [9]. The adaptive capacity of a system can thus be seen as a component of resilience since adaptations can be performed to maintain a current state, but adaptive capacity can also determine adaptations to achieve a new function, structure and identity (Gallopín, 2006) [9]. Marshall *et al.* (2013, p. 13) define adaptive capacity as the human potential to convert existing resources into successful adaptation strategies.

These resources or factors that determine one's adaptive capacity are, among others: natural and man-made resources, information, social networks, technology, infrastructure, human capital, institutions, governance and an equal access (Adger & Tompkins, 2004; IPCC, 2007; Smit & Pilifosova, 2001) [15]. The availability and access to means will especially increase an individuals' adaptive capacity; likewise, lack of these can cause barriers to his/her coping range. According to Eisenack and Stecker (2012), means can be of three notions: available, employed and necessary. Available means refers to means that are disposable by the operator, employed means refer to the part that is actually used for a specific adaptation, and necessary means are those who are necessary in order to make an implementation effective. A barrier to implying adaptations occurs if the necessary means are not available. Furthermore, they group means into: 1) resources, 2) knowledge/information and 3) power. Resources are here defined as natural or man-made resources while knowledge and power sometimes are categorized as resources as well; when speaking of resources in this context it only refers to material values (Eisenack & Stecker, 2012). Both natural and human-made resources are often essential to apply an adaptation measure and their lack therefore highly reduced ones adaptive capacity. Likewise, the broader an individuals' access is to different resources, the greater his/hers adaptive capacity will be (IPCC, 2007b) [15]. Knowledge/information on beneficial adaptation strategies is needed in order to adapt to climate change successfully (Frankhauser & Tol, 1997). When used in the context of farmers the term refers mainly to knowledge/information on agricultural adaptation strategies. Power as mean refers here to the power to decide.

Apart from access to resources, knowledge, and decision power the adaptive capacity of an individual is further linked to social and economic development with financial, technological, institutional, and political factors influencing the capacity to adapt to climate change, but also culture, society and behaviour can highly influencing the adaptive capacity. Finally, individual adaptive capacity is further determined by individual characteristics defined as human capital (IPCC, 2007b) [15].

iii) Human Capital

According to Verhoglyadova (2006) human capital is the "incarnated fund of human abilities, knowledge, skills and motivations to encourage human productivity" (p. 250). Fullan and Loubser (2012) state that individual adaptive capacity is highly influenced by personality factors associated with mental strength (such as self-esteem, self-competence, etc.) and skills, which are influenced by an individuals' capacity for variation and retention. Variation capacity is an individual's ability to generate new ideas and alternative solutions to problems. The retentive capacity refers to the ability of an individual to evaluate and therefore be able to select and apply new ideas to solve the problem. Variation and selective retention are complementary processes, and selective retention can only occur after an amount of ideas have been generated. Further, the two functions can differ in their range and therefore having the ability to generate various possible solutions does not imply the ability to order and select the most effective one out of the generated ideas (Fullan & Loubser, 2012). The variation capacity of an individual, hence the ability to generate new ideas and solutions to problems, is based on intuitive thinking and formed by three critical functions stipulated by Guilford (as cited in Fullan & Loubser, 2012): 1) The ability to retrieve or recall information from the memory storage; 2) Flexibility, and 3) Openness to new experiences.

The ability to retrieve or recall information from the memory is fundamental to generating ideas and alternative solutions. Theoretically, the magnitude of memories increases with time and age of an individual. Similarly, the more educated a person is, the broader range of knowledge and information for retrieval would be available (Fullan & Loubser, 2012). However, the ability to recall these memories and retrieve information from them differ among individuals and might depend on age and other individual factors. It can be argued that the individual's ability to retrieve memories increases until a certain age, after which it declines naturally.

The second function contributing to the variation capacity is flexibility, which refers to the ability continually to modify or redefine information in order to view them in new situations. With other words, flexible thinking is the ability to shift reflectively from imagining one situation to another. Fullan and Loubser (2012) suggest that flexible thinking can be trained and increased especially through education.

The third function critical for an individual's variation capacity is openness to new experiences. Fullan and Loubser (2012) state that underlying this quality trait is the believe in one's own judgment and the perception that the environment is manipulable and controllable. A person who is open to new experiences will, therefore, be more likely to question traditional practices and develop new or alternative ways instead of passively accepting traditional ones. Retention capacity involves the ability to order different experiences and ideas, relate them systematically on the basis of logical reasoning and select from these in order to solve a problem. It is based on analytical thinking and depends on the individual's ability to analyze, abstract and combine new elements and their logical interrelations (Fullan & Loubser, 2012). Variation and retention capacity are equally important in order to achieve a high individual adaptive capacity. A high variation capacity will not create a high adaptive capacity if the individual has a low retention capacity and therefore is unable to sort his generated ideas to achieve the optimum solution. Likewise, having the ability analytically to sort out the best solution will not result in a high adaptive capacity if the individual cannot generate a variation of ideas to solve the problem.

Adapting to Climate Change at Farm Level

Several adaptation options on farm level exists, i.e. diversifying the farming system, the use of new crop types and varieties, the use of new livestock species and breeds, the adjustment of planting dates, altering cropping location, improved land management, expanded rainwater harvesting, and improved water use efficiency. However, implementation of these individually will only have limited effect and therefore a combination of several of the options should be applied. Furthermore, it is important to highlight that not all adaptations may be beneficial to an agricultural system in the long-term.

i) Crop Adaptation Options

In areas where climate change leads to an increase of drought frequency and/or duration, an adaptation option for the farmer is to use crop types or varieties that are more drought-tolerant and can withstand temperature and water stresses better (Howden *et al*., 2007). Another adaptation strategy is to avoid critical crop growth stages to coincide with periods of harsh climatic stresses. This can be ensured through altering the length of the growing period by varying planting and harvesting dates and/or by changing to crop types with a more appropriate thermal time is an adaptation option (Howden *et al*., 2007). For example using crop types with a shorter growing period than the previous crop can be applied in areas where climate change results in an earlier end of the rain period. This strategy will similarly ensure that the new crop is fully matured and thus not in a critical growth period when the period of rain deficit starts.

Irrigation is another method to adapt to changes in precipitation and generally seen as effective method to increase agricultural productivity in rain-fed systems by supplementing rainwater during dry periods (Gebrehiwot & van der Veen, 2013). However, broad-scale irrigation can have destructive side effects and can therefore also be viewed as mal-adaptation (Smithers & Smit, 1997).

ii) Livestock Adaptation Options

Adaptation to climate change in field-based livestock includes altering animal species and breeds, giving adequate water supply, producing pasture, altering rotation of pastures, and modifying the time of grazing and reproduction. Furthermore, using different and/or adapted forage crops, supplementary feeds and concentrates are agricultural adaptation options (Howden *et al*., 2007). Mixing animal and cropping systems is another adaptation option which diversifies the farm and thus increases the farmers' adaptive capacity. Changing the animal species or breed can especially be an effective adaptation option, since some animal species and breeds are better suited to heat stress than others (Gebrehiwot & van der Veen, 2013). However, more heat-tolerant livestock breeds often show lower levels of productivity (Howden *et al*., 2007).

Agro-ecological Practices

Agro-ecology is a sustainable farming approach that combines the two disciplines agronomy and ecology. It is defined as a way of farming that protects natural resources by using new, modified, or adapted practices or techniques that contribute to a more environmentally friendly, ecological, organic or alternative agriculture (Wezel *et al*., 2009).

An important strategy to manage negative impacts of climate change on farm level is to focus on diversifying the farming system so it decreases its vulnerability to stresses from outside (Nelson, 2010). These practices and techniques are rooted in traditional small-scale agriculture (Altieri, 2009). Agro-ecology focuses especially on soil fertility and organic matter management, on the conservation of natural resources, and on creating a divers farming system by using practices such as poly-culture, raised fields, terraces, and agro-forestry (Altieri, 2009; Wezel *et al*., 2009). Therefore traditional agro-ecosystems are less vulnerable to climatic stresses since they grow a wide range of different crops in various spatial and temporal arrangements (Altieri, 2009). Using agro-ecological practices similarly focuses on the conservation of natural resources, which is another option to decrease the vulnerability and thus adapt to climatic changes. Specifically, soil and water have an important function in agricultural systems and, therefore, soil and water management and conservation are crucial to improve resilience. Soil conservation methods include vegetative soil coverage and control of soil erosion through, i.e. planting trees, building terraces and optimizing drainage channels. Water management and conservation is similarly important and closely linked to soil conservation. It involves optimizing the current use of water and creating new water sources (Gebrehiwot & van der Veen, 2013). To diversify the farming system the farmer can choose to grow different crops on different fields or on the same field and/or by mixing crop and livestock systems.

The practice of cultivating different crops in the same field is referred to as poly-culture (Altieri, 2009), whereas the cultivation of wooden perennials combined with crops and/or animals is defined as agro-forestry (Atangana, Khasa & Chang, 2014). According to Altieri (2009), the cultivation of poly-cultures can increase the yield of harvestable products per unit area by 20%-60% compared to mono-cultures, since poly-cultures reduce losses by weeds, insects, and diseases, and are more efficient in using the available natural resources. The production of each commodity will be less compared to a monoculture production, but the farmer gets a higher total and more divers output per field unit (Altieri, 2009). Agro-forestry is defined as a land-use system where woody perennials are integrated with agricultural crops and/or livestock in the same land unit, in a spatial arrangement or temporal sequence (Atangana *et al*., 2014).

In both systems the growing of different crop types reduces the farmer's risk of complete failure, since different crop types in general are affected differently by climatic events. Furthermore, mixed holding of several livestock species and plant based systems will increase the resilience of the farming system, since likewise animals and plants are affected differently by climatic stresses. The more divers the cropping system is, the less vulnerable the farming system will be to climatic impact and stresses (Gebrehiwot & van der Veen, 2013). Furthermore, in agro-forestry systems the farmer can influence the microclimate, since trees can reduce temperature, wind velocity, evaporation, and direct exposure to sunlight and hail (Altieri, 2009).

Other Options to Adapt to Climate Change

In addition to diversifying the farming system, the farmer can increase his adaptive capacity by including non-farming activities into his livelihood (Howden *et al*., 2007). Households, in which one or more members contribute to the economy of the household, by working with non-farming activities, will be less dependent on the farming output and therefore less vulnerable to harvest failure due to climatic stresses. Migration is another adaptation option to climate change, since mobility can function as method to escape environmental threats. Migration can be temporally or permanent, and occur within the country or between countries. It can bring opportunities, but also challenges. Migration can enable people to diversify their income and migration of some individuals can benefit a whole community if money is sent back to the village. However, migration to other climate change vulnerable areas or to areas that already face population pressure entails challenges rather than opportunities (Black *et al.,* 2011).

Statement of the Problem

Rainfall variability affects weather patterns and seasonal shifts with serious repercussions on poor rural households and communities in Kenya (ROK, 2010). Since agriculture is intimately linked to climate, policy makers have expressed concerns regarding the potential effects of climate change on agricultural production systems. Ainabkoi Sub-County, like many other regions in the argely agricultural Uasin Gishu County, has been vulnerable to rainfall variability. This is indicated by the fluctuating precipitation patterns in the region over the past ten years and which have adversely affected crop yield.

The manifestation of rainfall variability has resulted in unpredictable and depressed crop yields and loss of livestock leading to perennial food shortages. While small-scale farmers in Ainabkoi Sub-County use more diversified crops, maize is the main rain-fed crop cultivated throughout the region reflecting cultural dependence on it as a staple food. There is, however, dearth of information on agricultural adaptation strategies embraced by the small scale farmers in response to rainfall variability in Ainabkoi sub-county. As such, there was need to examine explicitly the how, when, why and what conditions adaptation actually occurs in economic and social systems and implications for future climatic conditions. This is crucial in designing and implementing integrated policies that will enable the small-scale farmers to operate sustainable agricultural production systems. This paper explores the adaptive strategies used by small-scale farmers in the wake of rainfall variability in Ainabkoi Sub-County.

Materials and Methods

The study adopted a mixed design approach. It was carried out in Ainabkoi Sub-County which is located in UasinGishu County in the west of the Rift Valley. The County borders Elgeyo-Marakwet County to the East, Trans Nzoia to the North, Kericho to the South, Baringo to the South East, Nandi to the South West and Bungoma to the West. Uasin Gishu county lies between34^0 $50^/$ and 35^0 $37^/$ East and latitude South and 0^0 $55^/$North. It's a highland plateau with altitude which ranges between1500-2100meters above sea level. Ainabkoi sub-county was chosen because it is experiencing a declining yield on crop production over the past ten years (Kosgei, 2008).

At the time of the study, according to the National Population and Housing Census results (ROK, 2009), the population of Ainabkoi Sub-County stood at 118,689 with 39,112 households. The Sub-County had three wards; Kapsoya, Kaptagat and Ainabkoi with respective populations of 38,421, 41,705 and 38,563 and households of 12,661, 13,743 and 12,708 (ROK, 2009). A sample frame was drawn from the target population. Using Yamane's sample size for proportions (1967, p. 886) at 95% confidence level, p = 0.5, the sample size for households of farmers was computed to obtain a sample of 396 households. Therefore, 396 household heads were selected to participate in the study. In total, therfore, 402 respondents took part in the study.

For the study, data was collected using a questionnaire, structured interview schedule and observation techniques. Questionnaire was used to solicit data from household heads. Interviews were carried out to collect data from ward administrators and agricultural extension officers. Based on the data collection instruments, data was analyzed both quantitatively and qualitatively. Responses to open-ended questions were analyzed thematically. Data from household survey was subjected to descriptive analysis to yield frequencies and proportions.

Results

Adaptation Strategies employed to counter Effects of Rainfall Variability

The study sought to establish the strategies that were employed by small-scale farmers to adapt to and counter the effects of rainfall variability in Ainabkoi Sub-County. To achieve this objective, respondents were asked to indicate if they had made any adjustments in their farming practices in view of the variability and change in rainfall patterns. Most, 299 (78.7%), of th respondents indicated that they had made adjustments in their farming practices to counter the effects of rainfall variability. These finding was as presented in Figure 1 below.

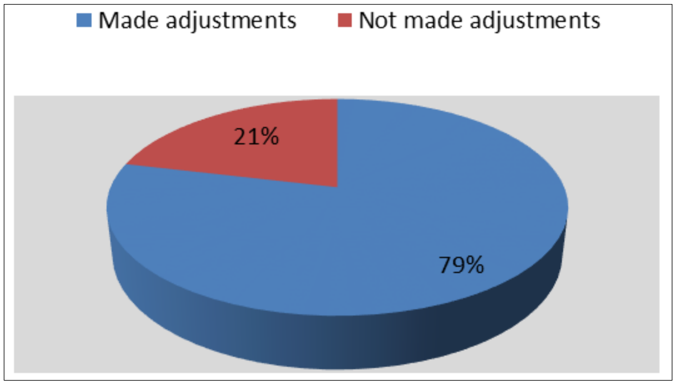

Fig 1: Adjustments in farming practices to rainfall variability

The study sought to establish the specific adjustments made by small scale farmers in Ainabkoi sub-county in view of the variability in rainfall patterns. The majority, 227 (6.5%), of the respondents indicated that they had diversified crop types and varieties as a way of countering the effects of rainfall variability in the area. Plate 1 below illustrates one of the crop varieties grown in Ainabkoi to justify crop diversification.

***Source*:** Field Research (YEAR?)

Fig 2: Pepper growing for crop diversification

These were followed by those who had changed planting dates, 127(3.6%), and those who had completely changed previous crop varieties to new ones which were more resistant to variability in rainfall patterns. The other forms of farmers' adjustments to rainfall variability were as summarized in Table 2.

Table 2: Adaptation strategies employed by Small-Scale Farmers

Adaptation strategy	Frequency	Percentage
Change in crop variety	105	27.6
Construction of water harvesting schemes	9	2.4
Implementing soil conservation schemes	27	7.1
Diversification of crop types and varieties	227	59.7
Diversification of livestock types and varieties	10	2.6
Changing planting dates	127	33.4
Changing size of land under cultivation	9	2.4
Irrigation	10	2.6
Reducing the number of livestock	15	3.9
Diversifying to non-farming activities	5	1.4

Percentages do not add to 100% because there were multiple answers

Commenting on the adaptation strategies that farmers employed in Ainabkoi Sub-County, an agricultural extension officer posited that:

> …it has been tough for farmers considering that majority of them are peasant farmers who entirely depend on rain fed agriculture. We have advised them to diversify crop types…to plant resistant crops to rainfall variations such as millet, sorghum, and even cassavas as opposed to maize and beans which rely heavily on consistency in rainfall patterns. Majority of them have heeded the call….

Supporting this response, a ward administrator indicated as follows:

We are marshalling resources from the county for purposes of facilitating sensitization of rainfall variability issues for our farmers…we want them to be aware of the changing weather patterns and adapt to better strategies that will not put them at the losing end…

In view of the study outcomes, it is imperative to note that the relationship between agriculture and rainfall variability is serious and have potentially consequences. The World Bank (2011, 2012) reports concurs with the outcome of the study by indicating that in low income countries integrated approaches of food security, adaptation and mitigation has the potential of countering rainfall variability. Agriculture remains the principal livelihood of the rural poor. A FAO (2010) report states that livelihood security requires more resilient production systems and that transiting to such systems could generate significant mitigation benefits to rainfall variability. This is the essence of climate-smart agriculture. Climate-smart agriculture seeks to increase productivity in an environmentally and socially sustainable way, to strengthen farmers' resilience to climate change indicators including rainfall variability. The FAO (2010) [7] report indicates that climate-smart measures includes proven techniques, such as mulching, intercropping, integrated pest and disease management, conservation agriculture, crop rotation, agro forestry, integrated crop-livestock management, aquaculture, improved water management, better weather forecasting for farmers, and innovative practices, such as early warning systems.

It also entails embracing new technologies – such as diversifying genetic traits of crops to help farmers edge against an uncertain climate – and creating an enabling policy environment for adaptation. In the absence of climate-smart agriculture, marginal areas may become less suited for arable farming as a result of land degradation through deforestation, soil erosion, repetitive tillage and overgrazing.

Climate-smart agriculture is location-and production system-specific. As such, its precise nature is influenced by local factors including the climate, types of crops grown and livestock reared, available technologies and knowledge and skills of individual farmers (FAO, 2010) [7]. However, there is recognition that climate-smart efforts must have at their heart small scale farmer who is key to change across the entire agricultural system. Therefore, policy makers have continued to explore options for adaptation strategies to rainfall variability as a lever to promote sustainable agricultural practices that have many other direct benefits for small scale farmers and the environment.

Constraints to Adaptation Strategies

The study also sought to find out the constraints to adaptation strategies to rainfall variability encountered by small scale farmers in Ainabkoi Sub-County. To achieve this objective, respondents were asked to indicate main constraints that small scale farmers in Ainabkoi Sub-County face in their quest to adapt to strategies geared towards countering the effect of rainfall variability.

More than 56% of farmers cited lack of financial capital and hence poverty as the main constraint to implementing adaptation strategies to rainfall variability. Despite perceiving a decrease in the amount of rainfall, only 9% of the respondents perceived lack of access to water to be a barrier to adaptation. Likewise, 3% believed they lack man-power to carry out labour intensive adaptation strategies. However, 28% felt that they lacked education, information and training about appropriate adaptation strategies. Poor health among some of the respondents was also cited as significant barrier to adaptation. This information is illustrated in Figure 2.

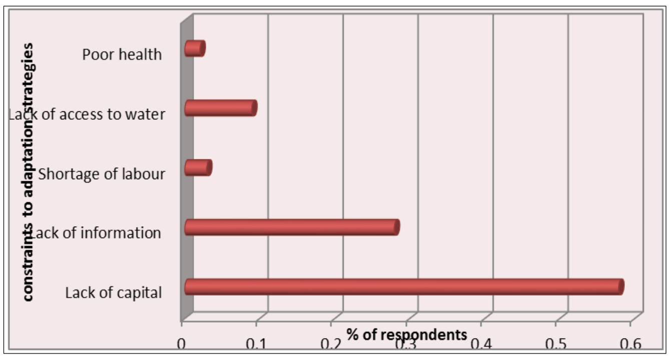

Fig 3: Constraints to adaptation strategies

While there is heterogeneity with regard to factors that influence uptake of eight adaptation choices, this study underscores the importance of information on rainfall variability and potential adaptation strategies. Improved farmer access to extension service and hence information increases the probability of perceiving and adapting to rainfall variability. Studies in Nigeria (Gbegeh & Akubuilo, 2012) and several other African countries (Maddison, 2006) have shown that farmers who have access to extension services are more likely to be aware of changing climatic conditions, and have knowledge of the various management practices that they can use to adapt to changes in climatic conditions. Promoting awareness to changes in climatic conditions would therefore have greater impact in enhancing adoption. This would be attained through appropriate communication pathway available to farmers such as extension service.

Access to water reduces the likelihood of adopting crop varieties in the wake of variations in rainfall variability. This suggests that farmers who are situated close to water sources are less likely to adopt water efficient technologies, and will therefore grow different crop varieties regardless of their individual water needs. A similar study in South Africa (Nhemachena & Hassan, 2007) [18] has shown that access to water increases the likelihood of adopting farm management practices, in particular, growing crop varieties that suit the prevailing soil moisture content. While not an end itself, exchange of information could enhance opportunities for livelihood diversification in view of varying rainfall patterns.

Conclusion

Majority of small-scale farmers in Ainabkoi Sub-County have adopted diversification in crop types and crop varieties as the main adaptation strategy to rainfall variability. The farmers have also adopted a change in planting dates and a change in crop variety. However, the fact that most farmers have taken up these adaptation measures to their agricultural practices does not necessarily mean that these adaptations are appropriate to local context. Finally, majority of the farmers cited lack of financial capital as a major constraint to adopting adaptation strategies geared towards countering the effect of rainfall variability in the study location. Besides, lack of information on appropriate adaptation strategies was also cited as a main constraint.

Recommendations

The Ministry of Agriculture needs to enhance opportunities for small-scale irrigation and water harvesting technologies. However, irrigation investment should guarantee high water use efficiency with emphasis on water pricing, besides building farm level managerial capacity. This will require revision of existing policies and institutional frameworks in water and agricultural sectors.

The County government of Uasin Gishu, through its appropriate departments, needs to promote formation of local rural institutions and farmer groups and create more opportunities for livelihood diversification of local subsistence farmers. However, available institutions and organizations within the County should well define their objectives to local farmers and work together in order that there is no duplication of efforts.

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