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Assessing Vulnerability to Climate Variability and Change

Participatory assessment approach and Kenyan case study

Isabel van de Sand

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German Development Institute (DIE)

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Executive Summary

Climate change has often been referred to as one of the single most important challenges to mankind. While much attention has historically been focused on climate change mitigation, the issue of adapting to the impacts of climate change has increasingly become important, both in the policy and research arena. Although adaptation is now regarded as being of equal importance as mitigation, there are still considerable challenges in implementing adaptation on the ground.

These challenges relate in part to conceptual ambiguities concerning adaptation and related concepts, such as vulnerability, resilience and adaptive capacity, which are partly linked to the evolution of these concepts in different scientific disciplines.

This study uses participatory approaches to assess vulnerability to climate variability in a watershed in Kenya. The purpose of this research is to use the vulnerability assessment as the basis to identify practical measures to enhance the ability of farmers in Sasumua watershed to deal with current climate extremes and variability and future climate change.

Participatory approaches have been applied in the development community for years through the use of participatory rural appraisal techniques and have recently also been advocated in the context of adaptation to climate change. Incorporating the views and perceptions of the community about climate change and climatic stresses is important because adaptation will ultimately have to be implemented at the local level. Only by understanding the perception of those actually affected about the factors that shape their vulnerability can constraints in adaptive capacity and meaningful measures of adaptation be identified and the risk of maladaptation minimized.

In conducting the vulnerability assessment the study broadly followed the framework developed by Smit and Wandel (Smit / Wandel 2006). The framework starts with the analysis of past and current exposures and sensitivities, past adaptation and current coping strategies, before looking at current adaptive capacity, future exposures and sensitivities and the identification of adaptation needs and options. When applying

the framework, considerable attention was put on the analysis of coping strategies and the assessment of adaptive capacity, which provide the basis for identifying adaptation needs and options.

Instead of having researchers pre-determine indicators of adaptive capacity, the community identified important determinants of adaptive capacity and rated the current state as well as the importance of improving the individual indicators for climate variability, droughts and floods, building upon the approach developed by Brown et al. (2010). Ratings were done in group settings and separately for men and women.

The study area, Sasumua watershed, falls into the humid high potential area for agriculture, which produces most of the food and cash crops in Kenya. As agriculture in Kenya is predominantly rain-fed, it is especially vulnerable to any changes in rainfall patterns. The watershed is of strategic importance to the city of Nairobi, providing about 20 % of its potable water supply. The watershed was struck by a drought in 2008, and there are great concerns about climate change both among farmers and the Nairobi City Water and Sewerage Company, which operates Sasumua dam inside the watershed, from which water is channelled to the city of Nairobi.

The study shows that farmers are highly aware of past climatic changes, yet their ability to deal with climate variability and change is constrained. Although farmers employ a number of strategies to cope with the various climate stresses, many of these are perceived to be ineffective and are employed after, rather than before, the event occurs. Part of this can be related back to the history of the watershed.

The watershed is located in the former white highlands of Kenya, which were reserved for the settlement of Europeans during colonial times. The area played an important role in the famous Mau Mau war, which gripped the country in the 1950s. One of the main leaders of the Mau Mau revolt, Dedan Kimathi, comes from the area, and the nearby Aberdare forest provided a popular hideout for Kikuyu fighters. Following independence the area was one of the first to benefit from the redistribution of land from colonialists to Kenyans, partly because of the fear of social unrest among the Kikuyu. The resettlement programmes led to a massive increase in population, associated decreases in land size and interference with the drainage system constructed by the colonialists. The combination of these factors has limited the ability of farmers to deal with floods that affect the lower parts of the watershed.

While most of the coping strategies currently employed are implemented on an ad-hoc basis, farmers are aware of a great number of preventive strategies, which are, however, not yet applied: modern farm management practices, including silage making, zero-grazing, the use of improved livestock breeds and drought-resistant crops, the adoption of greenhouse technology; increased storage of food, seeds and water; irrigation, soil conservation structures, such as gabions, terracing and contour farming; and changing farming practices towards mixed farming. The reasons why these strategies are not yet implemented relate to constraints in adaptive capacity.

Farmers identified a number of indicators for adaptive capacity, which could be grouped according to livelihood assets in terms of human, social, physical, natural and financial capital. For most of these indicators, current levels were perceived to be bad or average, with the lower non-forested areas of the watershed receiving slightly lower ratings in adaptive capacity than the upper areas and areas close to the forest due to differences in topography, water sources and distance to the forest, which is used as a source of fodder and also influences the microclimate.

Within the category of human capital, the indicators of skills, commitment and positiveness tended to get quite low scorings. Reasons provided for the low levels of skills, commitment and positiveness mainly related to ignorance and limited awareness among the farmers to implement coping strategies.

In terms of social capital, cooperative societies gained the lowest score, given the fact that, for instance, the Kenyan Cooperative Creameries collapsed. Welfare groups, in which farmers collectively raise money to lend to members, also gained bad to average scores in most instances. In both areas, farmers complained that not enough people have joined welfare groups, partly due to low levels of trust. This might be linked to bad experiences with the management of the welfare groups that do exist; people in both areas complained about mismanagement and said poorly organized groups lacked a vision and focused on collecting money, rather than implementing activities.

Within the category of natural capital, soil quality tended to get the lowest score, as soil was perceived to be exhausted and of bad quality. In the lower areas, rivers and forest received low scores due to the absence of forests and permanent rivers in that area.

Food store and greenhouses were among those indicators that received the lowest scores under physical capital. The low score of greenhouses is due to the high expenses and lack of knowledge in setting up and running greenhouses. A lack of knowledge about the construction of food stores was also regarded as one reason for their low rating, in addition to the perishable nature of the foods grown.

Within the category of financial capital, savings and bank accounts received the lowest scores. While funds received average scores, farmers complained that they have no money to save due to the high expenses of farm inputs compared to the low prices they obtain for their farm products. In addition, most farmers do not have bank accounts and are afraid of using their security assets to obtain loans.

While farmers see a great need and desirability for enhancing the various elements of adaptive capacity and implementing adaptation measures, their ability to do so is constrained. For many of them, outside assistance is required. In addition, current low levels of positiveness and commitment indicate a limited willingness to implement adaptation strategies. However, both of these factors also received high ratings in terms of priority of action, so farmers are aware of this problem and willing to change their attitudes.

In order to strengthen the various elements of adaptive capacity and implement adaptation options, greater collaboration between farmers and extension officers is required. Group discussions revealed that a disconnect between the services offered by agricultural extension officers and those demanded by farmers. While agricultural officers react to demand, farmers seem to expect more of a supply-oriented approach and complained that agricultural extension officers are frequently not available and do not conduct field visits. Agricultural officers, on the other hand, said that there is a low level of attendance for seminars and training provided for farmers. This disconnect needs to be overcome in order increase the elements of adaptive capacity and foster the implementation of adaptation strategies.

Group discussions with farmers and district government officials have shown that both groups have a shared problem perception about current constraints in adaptive capacity of farmers. In addition, they have also identified a similar set of possibilities for increasing the various elements of adaptive capacity. These shared problem and solution perspectives thus provide a good basis for fostering greater levels of collaboration.

Both groups have, for example, identified trainings and seminars as important actions to increase the various elements of adaptive capacity. The expressed needs for knowledge provision and training are not only limited to improving farming methods, soil conservation and tree planting, but also include setting up and running welfare groups, hygiene and health issues (including diets), and financial management. However, given the current low attendance levels at seminars and training for farmers, additional sessions need to meet the needs of farmers and be accompanied by awareness-raising about the importance of these activities. These steps will help increase commitment and positiveness, thus fostering a greater willingness to implement adaptation measures.

In general, the method of participatory vulnerability assessment revealed constraints in adaptive capacity and practical adaptation options as intended. The workshops were very well attended and discussions were lively and active, with both men and women contributing to group discussions. Some of the advantages of participatory approaches noted in the literature – i.e., the process leads to empowerment of participants and prompts action to implement change – also came about in this study. Farmers, for example, explicitly valued the participatory nature of the workshops, as opposed to the normal kind of seminars/workshop where *“we just sit and listen”*. The workshops also prompted action in that farmers decided to form a self-help group to advance the implementation of preventive strategies.

Farmers were also able to identify indicators of adaptive capacity for drought, flood and climate variability and to rate the status quo and priority for action. As also found by Brown et al. (2010), these indicators included positiveness and commitment, which are often not included in top-down quantitative surveys of adaptive capacity, demonstrating the importance of deriving locally meaningful indicators for adaptive capacity. In the ratings of adaptive capacity, slight differences were found between the ratings of men and women, underscoring the importance of gender-sensitive vulnerability assessments. For the different climate events rated (drought, floods and climate variability), ratings did not differ much at the aggregate level, but there were some differences in terms of individual indicators selected and in the ratings of individual indicators, which justified conducting the rating separately for the different events.

While the method employed provided a relatively quick overview of key constraints in adaptive capacity and revealed practical measures to implement adaptation, it could be further built upon for more detailed assessments of vulnerability. The slight differences in adaptive capacity between the upper and the lower areas of the watershed, for example, could be verified with a more quantitative survey using the indicators identified by the farmers. In addition, multi-criteria analysis could be used to prioritize among the different identified adaptation options. This, however, was beyond the scope of the current study.

1 Introduction

In recent years the importance of adaptation to climate change has increased substantially, both in the international policy as well as in the research arena. In much of the literature on adaptation, adaptation is conceptualised on the basis of vulnerability. However, there are large differences in how vulnerability is conceptualised, interpreted and applied because the concept has its roots in different scientific disciplines (e.g. Füssel 2007). One common distinction has been between impact-oriented research, which interprets vulnerability at the end point of analysis, and research that regards vulnerability at the starting point of analysis; here, vulnerability is regarded as a pre-existing state, driven by a variety of factors that influence the capacity to deal with stress (Eriksen / Kelly 2007; Kelly / Adger 2000). Although research in this second area has greatly increased in recent years, there is still a need for more practical approaches to vulnerability research focusing on the factors that drive or constrain adaptation at a particular place or community (Arnell 2010; Smit / Wandel 2006; Nelson et al. 2010). This is especially the case in the context of agricultural communities in Africa, given the limitations of crop-yield models and the coarseness of and uncertainty surrounding climate models (Thornton et al. 2009; 2010), which are typically used in impact-oriented research.

In Kenya the agricultural sector is still one of the most important sectors, accounting for about 26 % of GDP and 70 % of informal employment in rural areas. Agriculture is predominantly rain-fed (Government of Kenya 2010) and as such especially vulnerable to any changes in rainfall patterns. The study area, Sasumua watershed, falls into the humid high potential area for agriculture in Kenya, which produces most of the food and cash crops in Kenya (Government of Kenya 2010). Although the high potential areas are in general regarded as less vulnerable to climate change than arid and semi-arid lands, projected impacts of climate change are still expected to be negative. Kabubo-Mariara and Karanja (2007), for example, estimate that projected increases in temperature of between 3.5 °C and 4 °C coupled with reductions in precipitation of 20 % lead to losses in crop production of about 48 $ and 63 $ per hectare by 2100. The watershed is also important as a water resource for the city of Nairobi, providing approximately 20 % of its potable water supply. It is located at the foot of the Aberdare Mountains, one of the 5 “water towers” that are the source of the main river systems in Kenya. These 5 catchment areas are severely degraded, which makes them even more vulnerable to the impacts of flood and drought (World Bank 2004).

The purpose of this research is to identify practical measures to enhance the ability of the community in Sasumua watershed to deal with current climate extremes and variability and future climate change.

The study starts with a brief overview of the concepts of vulnerability, adaptive capacity and adaptation (section 2) in order to explain why the methodology of participatory vulnerability assessment was chosen for the purpose of this research (section 3). Before results from the participatory assessment conducted in Sasumua watershed are presented in section 5, a brief description of the case study area, including a historical overview of Sasumua watershed from the pre-colonial period to the present, is given in section 4. Apart from contextual information, the overview explains some of the constraints farmers face in implementing coping and adaptation strategies, as they are linked to the history of the watershed and its settlement. Results from the participatory vulnerability assessment are presented in terms of the three main components of vulnerability – exposure, sensitivity and adaptive capacity, in addition to the analysis of coping strategies. Future exposures to climate stresses are also considered. This serves as the basis to discuss adaptations needs and options to implement adaptation. The final section of the paper presents a summary of the findings and reflects upon the methodology employed (section 6).

2 The concepts of vulnerability, adaptive capacity and adaptation

Within the context of research on adaptation to climate change, the concepts of vulnerability, adaptation and adaptive capacity are frequently applied. These concepts are closely linked and have their roots in various different scientific disciplines and research traditions (Smit / Wandel 2006; Adger 2006) not directly related to climate change. The application of these concepts in the field of climate change research has, however, not been without problems.

A number of authors, for example, write of a *"plurality of definitions"* linked to the historic evolution of concepts in different scientific disciplines and research traditions (Gallopín 2006, 293). In addition, as climate change research is often multidisciplinary, the different interpretation of concepts in various disciplines frequently leads to misunderstandings among scientists, who use the same terms but interpret them in slightly different ways (O'Brien et al. 2004; Gallopín 2006; Füssel 2007). Although this problem is widely recognized in the literature, Heltberg et al. note, that in the context of vulnerability many studies still do not provide accurate and precise definitions of the concepts used (Heltberg / Siegel / Jorgensen 2009). A possible explanation for this can be found in O'Brien et al. (2004), who maintain that the lack in definitional clarity might also be related to the fact that the term "vulnerability" is so common in everyday language that scientists might be lured into thinking that there is no need for further specification.

In order not to add to this general confusion, it is important to be aware of the historic evolution of concepts and provide specific descriptions about the conceptual frameworks used for specific purposes of research. The following section thus gives a brief review of the concepts of vulnerability, adaptation and adaptive capacity and their application in the climate change arena, before the conceptual framework used for this study is presented in the section afterwards.

2.1 Definitions and historic evolution of the concept of vulnerability

From a linguistic point of view, vulnerability can simply be defined as the capacity to be wounded (Kates 1985). However, it has been used and defined in so many different ways that Liverman already noted in 1990 that *"it would be an exhausting, and probably rather meaningless, task to review all the different ways in which people have used the word vulnerability, or similar studies"* (Liverman 1990, 29).

In this mass of definitions and conceptualizations, Adger (2006) identified commonalities; most definitions conceptualize vulnerability along three main components: exposure and sensitivity to some kind of stressor and adaptive capacity. There are, however, differences in the way these different elements are interpreted and weighted in the different research traditions and fields of application.

Reviews on the historical evolution of the concept of vulnerability generally distinguish between several main approaches that have influenced the subsequent evolution of vulnerability research as well as the treatment of vulnerability in the area of climate change: the natural hazard approach, political ecology and political economy approaches to vulnerability, and research related to resilience (Adger 2006; Eakin / Luers 2006; Füssel 2007; Kasperson et al. 2005). In addition, there is the conceptual evolution of vulnerability in poverty and development literature, which goes back to the work of Sen and Chambers and has largely evolved separately from the other approaches (Adger 2006).

The following section will briefly summarize the main approaches. For a more information, see the respective reviews.

The natural hazard approach has been described as an *"exposure model"* (Cutter / Boruff / Shirley 2003, 242) due to its focus on the impact of the hazardous event occurring. Vulnerability is defined as the potential for loss resulting from the combination of the occurrence of the hazard and its magnitude and impact on the exposed unit (Cutter 1996). Due to its heavy focus on hazards and the major influence of earth scientists, it has also been referred to as *"technocratic paradigm"* (Hilhorst 2004, 52) and has often been criticised for not sufficiently taking into account the underlying social, economic and political structures that also influence vulnerability (Kasperson et al. 2005). As such, the risk hazard approach has often been applied to physical systems rather than to people (Füssel 2007).

In contrast to the natural hazard approach, political economy and ecology approaches place a strong focus on the social unit by looking at the social, economic and political determinants that make people vulnerable to specific events and by explaining differences in vulnerability between social groupings (c.f. Kasperson et al. 2005). As such, the analysis is more geared towards the adaptive capacity side of vulnerability, while less emphasis is given to the exposure element.

The pressure and release model (PAR) developed by Blaikie et al. (1994), is often cited as an example that integrates the natural hazard and the human ecology approach (see e.g. Adger 2006), as it links the impact of the hazards to the underlying factors that shape vulnerability. In the PAR model, the hazard is not part of the vulnerability but is combined with vulnerability to give rise to risk. The PAR model has a strong focus on the vulnerability of people. Their vulnerability is determined by a combination of root causes (economic, demographic and political structures that influence the access to power and resources), dynamic pressures (urbanisation, epidemics, conflicts, global economic pressures, natural resource depletion), which ultimately give rise to unsafe conditions that result from the combination of root causes and dynamic pressures (Wisner et al. 2004). The pressure and release model is complemented by the access model. The access model bears close resemblance to the sustainable livelihoods framework, as it focuses on the assets and resources available to households that determine their livelihoods and ultimately influences their ability to deal with hazards.

The focus on what makes people vulnerable, including the availability of assets to reduce vulnerability, is also characteristic in how the poverty and development literature deals with vulnerability. Scholars that have had a major influence in the poverty and development literature are the work of Sen on entitlement (Sen 1984) and Chambers on vulnerability (Chambers 1989) (c.f. Kasperson et al. 2005). According to Adger (2006), Sen's entitlement theory has shifted the focus from the natural hazard (such as droughts) as the main cause of famine to entitlements, which Sen defines as a *"set of alternative commodity bundles that a person can command in a society using the totality of rights and opportunities that he or she faces"* (Sen 1984, 497). Famines occur when the combination of entitlements (which include both own production of food and the exchange of food for money, labour or reciprocal arrangements) does not result in adequate food provision. Chambers advanced the conceptualization of vulnerability in poverty and development literature by distinguishing between poverty and vulnerability. He described poverty as *"lack or want"* and contrasted this with vulnerability, which he characterized as *"defencelessness, insecurity, and exposure to risk, shocks and stress"* (Chambers 1989, 1). According to Chambers (1989), strategies to reduce poverty are thus not the same as those that reduce vulnerability; in fact, he warns that some strategies aimed to reduce poverty (such as borrowing money) might actually make people more vulnerable in the long term, as this might increase debt. In analysing vulnerability, Chambers also called for a *"decentralised analysis, encouraging, permitting, and acting on local concepts and priorities, as defined by poor people themselves"* (Chambers 1989, 1) arguing that the perception of researchers might differ from those of local people. The strong emphasis on the participation of the local communities is also inherent in his work on participatory rural appraisal techniques (Chambers 1994a; Chambers 1994b) (see also section 3).

The concept of resilience has its roots in ecology and is mostly linked to the work of Holling (c.f. Folke 2006). Holling defined resilience as *"measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist"* (Holling 1973 17). The concept of resilience has also been applied to social and coupled socio-ecological systems. Adger (2000, 361) defines social resilience as *"the ability of communities to withstand external shocks to their social infrastructure"*. Resilience of the socio-ecological system has been denoted as the *"capacity of linked social-ecological systems to absorb recurrent disturbances… so as to retain essential structures, processes, and feedbacks"* (Adger et al. 2005, 1036). In contrast to earlier definitions of ecological resilience that centred around maintaining function in the case of disturbance, definitions have been broadened over time, recognizing that socio-ecological systems also have the potential for self- and re-organization, learning and development in the case of disturbance (Folke 2006; Walker et al. 2004). The focus of resilience thus seems to be more on the capacity element of vulnerability, although the exact nature of the relationship between vulnerability, adaptive capacity and resilience still remains nebulous. As shown by Smit and Wandel (2006) and Gallopin (2006), the concept of adaptive capacity is sometimes equated in the literature with resilience, with resilience occasionally regarded as a subset of adaptive capacity or vice versa.

Probably the most meaningful way to distinguish between the different approaches and concepts is to differentiate them according to key questions and attributes. Eakin and Luers (2006) nicely illustrate the difference between the three main approaches in terms of focal questions, key attributes, exposure units and definitions. Whereas the main interest of research in the risk hazard approach is on the identification of hazards and impacts, political economy and political ecology approaches focus more on adaptive capacity and on why social units are affected differently by the hazards. Resilience is also closely related to adaptive capacity, but the focus is more on systemic changes (see Table 1).

As noted by most reviews, the major traditions of vulnerability research can also be identified in the climate change literature. Here a distinction is usually made between biophysical and social vulnerability. *Biophysical vulnerability* is defined as *"a function of the frequency and severity (or probability of occurrence) of a given hazard"* and is thus largely consistent with the risk hazard approach of vulnerability (Brooks 2003, 4). Social vulnerabil-

Table 1: Comparison between different approaches to vulnerability

Point of comparison	Risk / Hazard	Political Economy / Political Ecology	Resilience
Focal questions	What are the hazards? What are the impacts? Where and when?	How are people and places affected differently? What explains differential capacities to cope and adapt? What are the causes and consequences of differential susceptibility?	Why and how do systems change? What is the capacity to respond to change? What are the underlying processes that control the ability to cope or adapt?
Key attributes	Exposure (physical threat, external to the system)	Capacity, sensitivity, exposure	Thresholds of change, reorganization, capacity to learn and adapt
Exposure unit	Places, sectors, activities, landscapes, regions	Individuals, households, social groups, communities, livelihoods	Ecosystems, coupled human-environmental systems
Illustrative definition of vulnerability	"The likelihood that an individual or group will be exposed to and adversely affected by a hazard. It is the interaction of the hazards place with the social profile of communities"[1]	"The characteristics of a person or persons in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard"[2]	Resilience "can be thought of as the opposite of… vulnerability"[3] "Resilience is a measure of the ability of… systems to absorb changes… and still persist"[4]

Notes: [1] Cutter (1996, 532)
[2] Blaikie et al. (1994, 9)
[3] Holling (2001, 394)
[4] Holling (1973, 17)

Source: Adapted and modified from Eakin / Luers (2006) supplemented with information provided in Eriksen / Kelly (2007); O'Brien et al. (2004); Berkes / Jolly (2001) ity, on the other hand, is regarded as an *"inherent property of a system arising from its internal characteristics"* (Brooks 2003, 4). The conceptualization of vulnerability in terms of social vulnerability to climate change goes back to the work of Adger and Kelly (1999), Adger (1999) and Kelly and Adger (2000) who have highlighted the need to focus on the social aspects of vulnerability to climate change in addition to the approaches of climate impact assessments dominant at the time. Social vulnerability is defined as *"ability or inability of individuals and social groupings to respond to, in the sense of cope with, recover from or adapt to, any external stress placed on their livelihoods and well-being"* (Kelly / Adger 2000, 328) and is thus closely related to the political economy approach (Füssel 2007). According to O'Brien et al. (2004), a lot of vulnerability studies make use of Sen's entitlement and/or livelihood approaches and are thus heavily influenced by the conceptualization of vulnerability that prevails in the development and poverty literature, which is perhaps not surprising given that adaptation is primarily discussed in the context of developing countries given their perceived lower ability to deal with the impacts of climate change.

Although research on vulnerability or adaptation has evolved quite separately from that of resilience, where papers have been published largely in the field of ecology rather than of climate change or global environmental change (Janssen et al. 2006), the concept of resilience is increasingly being taken up in the climate change community. In a case study on the vulnerability to climate change of a coastal community in Vietnam, Adger (1999), for example, shows that ecological and social resilience are related, with mangrove conversion having led to reductions in social resilience. Berkes and Jolly (2001) have examined the socio-ecological resilience to climate change of an arctic community in Canada. Cannon and Müller-Mahn (2010) even observe a shift in the climate change discourse with the concept of resilience being increasingly adopted at the expense of vulnerability. They see this shift, however, rather critically, arguing that a focus on resilience might shift the attention away from the socio-economic system as the root cause of vulnerability and fearing a *"technocratic, scientistic approach"* in devising appropriate response measures, given the fact that the resilience approach is strongly rooted in natural sciences (Cannon / Müller-Mahn 2010, 632). This fear, however, might be unfounded in the case of social resilience, which also places a strong emphasis on social institutions and learning.

Again, the difference between the main approaches in the climate change literature can be illustrated with the main questions they address. Whereas the question of the biophysical approach tends to be framed as *"What can be done to protect the population?"* or *"What is the extent of the climate change problem?"*, the vulnerability approach tends to focus on *"What can be done to strengthen people's own capacity to respond and adapt?", "Who is vulnerable to climate change and why?"* and *"How can vulnerability be reduced?"* (Eriksen / Kelly 2007, 505; O'Brien et al. 2004, 3). The resilience approach tends to ask how the system's resilience can be increased (see Table 2).

As shown by Adger (2006), Birkmann (2006) and Eakin and Luers (2006), the different approaches were partly merged, giving rise to integrated approaches of vulnerability and contributing to the broadening and widening of the concept. At the same time, climate change is increasingly recognised as just one pressure acting on the system. There has thus been a move away from studying climate change as a single cause of harm towards vulnerability assessments that incorporate multiple causes and stressors of change, which can be captured under the heading of global environmental change vulnerability assessments (Patt et al. 2009).

Table 2: Comparison of different approaches to vulnerability used in the climate change and global environmental change literature			
Climate Change/Global Environmental change			
	End point aproach / biophysical vulner-ability **first generation**	**Starting point approach / social vulnerability** **second generation**	**Social resilience / social-ecological resilience**
Focal questions	What can be done to protect the popula-tion? What is the extent of the climate change problem?	What can be done to strengthen people´s own capacity to respond and adapt? Who is vulnerable to climate change and why? How can vulnerabil-ity be reduced?	How do human societies deal with changes in climate? How can adaptive capacity be in-creased? How can resilience be enhanced?
Key attributes	Exposure (physical threat, external to the system)	Capacity, sensitivity, exposure	Thresholds of change, reorganiza-tion, capacity to learn and adapt
Exposure unit	Sectors, regions	Individuals, house-holds, social groups, communities, liveli-hoods	Social system, ecological system, socio-ecological system
Illustrative definitions	"Biophysical vul-nerability is a func-tion of the frequency and severity (or probability of occur-rence) of a given type of hazard" [1]	"Ability or inability of individuals and social groupings to respond to, in the sense of cope with, recover from or adapt to, any exter-nal stress? placed on their livelihoods and well-being"[2]	"Resilience increases the capacity to cope with stress and is hence a loose antonym for vulnerability"[3] "Social resilience is the ability of commu-nities to withstand external shocks to their social infrastructure"[4] "Resilience as applied to ecosystems, or to integrated systems of people and the natural environment, has three defining characteris-tics:

Table 2 (cont.): Comparison of different approaches to vulnerability used in the climate change and global environmental change literature

Climate Change/Global Environmental change			
			Social resilience / social-ecological resilience
			1) The amount of change the system can undergo and still retain the same controls on function and structure 2) The degree to which the system is capable of self-organization 3) The ability to build and increase the capacity for learning and adaptation"[5]

Notes: [1] Brooks (2003, 4)
[2] Kelly / Adger (2000, 328)
[3] Adger (2000, 348)
[4] Adger (2000, 361)
[5] Resilience Alliance (2011)

Source: Adapted and modified from Eakin / Luers (2006) supplemented with information provided in Eriksen / Kelly (2007); O'Brien et al. (2004); Berkes / Jolly (2001)

2.2 Definitions and historic evolution of the concept of adaptive capacity

The concept of adaptive capacity has its roots in evolutionary biology, where it is defined as the ability to become adapted (Gallopín 2006). Similar to the concepts of vulnerability and adaptation there are a large number of different definitions and conceptualizations on adaptive capacity (Smit / Wandel 2006; Gallopín 2006). Patt et al. (2009, 8) even went so far as describing adaptive capacity an *"intellectual quagmire"*, given the diversity of views on what adaptive capacity is and entails.

Part of the confusion might relate to the fact that the concept of adaptive capacity is related to a large number of different concepts, whose distinctions are often unclear. As Smit and Wandel (2006) note, these include adaptability, coping ability, management capacity, stability, robustness, flexibility and resilience. Gallopín (2006) also uses the term *"capacity of response"* although he leaves the distinction between adaptive capacity and capacity to response open. Furthermore, research on adaptive capacity in the context of climate change is a relatively young field. As Smit et al. (2001, 895, 898) noted in the third assessment report of the IPCC, research on adaptive capacity in the field of climate change has been *"extremely limited"*, with *"little scholarship (and even less agreement) on criteria or variables by which adaptive capacity can be measured"*. In a recent review on adaptive capacity, Engle (2011) also maintains that adaptive capacity is still an under-researched topic in the field of global environmental change. There have, however, been a number of studies that aimed to measure and quantify adaptive capacity (such as Alberini / Chiabai / Muehlenbachs 2006; Adger et al. 2004; Vincent 2007; Brooks / Adger / Kelly 2005). Although measuring adaptive capacity still remains a challenge, these types of vulnerability assessments have helped in gaining a better understanding of adaptive capacity and its determinants (Adger et al. 2007).

Determinants of adaptive capacity are understood as those system characteristics that influence the ability to adapt (Smit et al. 2001), such as technological resources, human capital, social capital, the structure of institutions, managerial abilities of decision-makers, the availability of and access to financial and informational resources, and public perception of climate change (Brooks 2003). A further distinction has been made between generic and specific indicators of adaptive capacity. Poverty, health, inequality, access to resources and social status, for example, are considered as generic indicators, whereas institutions, knowledge and technology are specific indicators to climate impacts (Brooks 2003; Adger et al. 2007). In addition, the determinants of adaptive capacity are scale-dependent: while some determinants (managerial ability, access to technology, perception of climate risk, presence of strong social networks, etc.) operate at the local level, others are broader reflections of macro-level attributes, which can, however, vary at the local level (Smit / Wandel 2006; Yohe / Tol 2002). Furthermore, the determinants are not independent of each other and not necessarily substitutable (Tol / Yohe 2007; Smit / Wandel 2006; Smit et al. 2001).

2.3 Definitions and historic evolution of the concept of adaptation

The concept of adaptation is much older than the concept of vulnerability (Young et al. 2006) and can be related back to Darwin s work on natural selection (c.f. O'Brien / Holland 1992; Engle 2011). In the human sciences, the concept dates back at least to the beginning of the 1900s, when it was introduced in anthropology as cultural adaptation (Janssen et al. 2006; Smit / Wandel 2006). According to Smit and Wandel (2006), the term has also been taken up in the fields of natural hazards, political ecology, resilience and development and poverty literature, which shows how closely the concepts of adaptation and vulnerability are linked. In the area of climate change, adaptation has long been neglected at the expense of mitigation but has increasingly drawn attention among scientists, with the number of publications focusing on adaptation increasing substantially from the mid-1990s onwards (Wilby et al. 2009). Nevertheless, confusion about the meaning of adaptation and its implementation into practice still prevails.

Confusion about the meaning of adaptation is also evident in the older literature on adaptation and still prevails in the different disciplines. According to O Brien and Holland (1992, 39) Darwin already *"wrestled extensively with adaptation"* and developed his theory from a notion of perfect adaptation to one of relative adaptation. Darwin assumed that organisms are perfectly adapted to their environment, given their inherent structural constraints, and that it is only through changes in the external environment that variation occurs and the process of natural selection sets in until another perfect adaptation state is reached (see Ospovat 1980). In the notion of relative adaptation, however, Darwin acknowledged that some species are better adapted than others and that variation can occur without changes in the external environment (Ospovat 1979). In the field of ecology, Begon et al. (1996), illustrate that, even for an biologist, adaptation can refer to genetic, phenotypic changes or a combination of both that enable an organism to deal with changes in the environment. Furthermore, it can be interpreted positively – as the ability to live in certain environments – or negatively – as being constrained to live in certain environments but not in others. In the area of cultural adaptation, Denevan (1983, 401) also notes that *"there is confusion as to the meaning of the term 'adaptation' and over what the adaptive unit is – the individual, the community, the culture or a system"*. He defines cultural adaptation as *"the process of change in response to a change in the physical environment or a change in internal stimuli, such as demography, economics and organization"*. O'Brien and Holland (1992) also define cultural adaptation as a process and distinguish it from the concept of adaptedness, which they see as the state of an organism that resulted from evolutionary history in context of its fellow species.

Given that confusion about the concept of adaptation is common in much of the different fields of literature, it is astonishing that, as noted both by Schipper (2007) and Janssen et al. (2006), there is little acknowledgement of these debates in the literature on adaptation. Indeed many of the questions in the literature on evolutionary biology and cultural adaptation (what is adaptation, what is the appropriate unit of analysis, adaptation to what?) are also evident in the field of adaptation to climate change. Smit et al. (2000), for example, frame adaptation to climate change in terms of the following questions: Adaptation to what? Who or what adapts? How does adaptation occur and how good is adaptation? They also show that these questions are addressed differently in various definitions in the area of climate change.

As also illustrated in Box 1 there is, for example, disagreement between various definitions in terms of what to adapt to. The UNFCCC's definition, for example, refers to climate change, whereas the IPCC's definition includes both *"actual"* as well as *"expected"* climate stimuli. The definition by Pielke deliberately refers to *"climate"* as opposed to climate change, which he considers to be *"the entire range of society/climate interactions (e.g. variability, extreme events etc.)"*, arguing that it does not make much sense to distinguish between climate impacts and climate change impacts (Pielke 1998, 168).

In the majority of definitions across disciplines, adaptation is described as a process, either explicitly or implicitly through the word adjustment[1], rather than as a state, thus corresponding more to Darwin s concept of relative rather than perfect adaptation. Differences occur in the specification of the unit of analysis. Whereas definitions in the natural sciences – naturally – specify the unit of analysis, in terms of organisms, species or systems, the focus of analysis in cultural adaptation is the human system. Most definitions in the field of adaptation to climate change refer to both natural and human systems, paralleling perhaps the evolvement of the concept of vulnerability to become more comprehensive.

Other key differences identified in the literature between the treatment of adaptation across the various disciplines concern the timing and nature of the process through which adaptation occurs (e.g. Smit et al. 2000; Schipper 2007). As noted by Adger et al. (2007) biological systems are limited to reactive adaptation, whereas human systems can both employ reactive as well as anticipatory, planned adaptation. Here, Begon et al. (1996) even go so far as to suggest replacing adaptation with abaptation or exaptation to distinguish between a predictive, forward-planning notion commonly associated with adaptation in human systems and the process occurring in organisms, which is rooted in the past.

Notably, many of the definitions in Box 1 make reference to the concept of vulnerability, which again demonstrates how closely the concepts are linked, although the exact nature of this linkage is still contested (c.f. Gallopín 2006; Smit / Wandel 2006) and also depends on the conceptual approach taken.

Box 1: Illustrative definitions of adaptation in different disciplines
Definitions of adaptation related to ecology and natural systems Adaptation is a confusing word used to mean quite different things. i) characteristics of organisms evolved as a consequence of natural selection in its evolutionary past … ii) changes in the form or behavior of an organism during its life as a response to environmental stimuli … iii) changes in the excitability of a sense organ as a result of continuous stimulation (Begon / Harper / Townsend 1996, 953)

1 The Miriam Webster Thesaurus for example defines adjustment as *"the act or process of changing something to fit a new use or situation"*.

Adjustment in natural or human systems to a new or changing environment. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (Hassan / Scholes / Ash 2005, 893).

Definition of adaptation related to cultural adaptation

Cultural adaptation is *"the process of change in response to a change in the physical environment or a change in internal stimuli, such as demography, economics and organization"* (Denevan 1983, 401)

Definitions of adaptation related to climate change

Adaptation is a process through which societies make themselves better able to cope with an uncertain future. Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes (UNFCCC / 2007, 10).

Adaptation refers to adjustments in individual, group, and institutional behavior in order to reduce society s vulnerability to climate (Pielke 1998, 159).

Adaptations are manifestations of adaptive capacity, and they represent ways of reducing vulnerability (Smit / Wandel 2006, 286).

Adaptation is a process by which strategies to moderate, cope with and take advantage of the consequences of climate events are enhanced, developed and implemented (Ebi / Lim / Aguilar 2004, 36).

Adaptation refers to adjustments in ecological-social-economic systems in response to actual or expected climatic stimuli, their effects or impacts (Smit et al. 2000, 225).

Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation:

Anticipatory adaptation – Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.

Autonomous adaptation – Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.

Planned adaptation – Adaptation that is the result of a deliberate policy decision, 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 (Parry / Canziani / Palutikof 2007, 869).

2.4 Relationship between vulnerability, adaptation and adaptive capacity

In general, adaptations are regarded as a way of reducing vulnerability (Smit / Wandel 2006). The framing of vulnerability in terms of biophysical or social vulnerability, however, has important implications on how this relationship is portrayed and ultimately on the kind of adaptation measures proposed (Füssel 2007; O'Brien et al. 2004). Building upon the work of Burton et al. (2002) and Kelly / Adger (2000), O'Brien et al. (2004) distinguish between the two by referring to an *"end point"* and a *"starting point"* approach to vulnerability. The end point approach is characteristic for much of what Burton et al. classified as *first generation* or *type one research* on adaptation (Burton et al. 2002). It makes use of climate change scenarios from Global Climate Models, which are then used to assess biophysical and socio-economic impacts. Only after these impacts have been identified is adaptation considered in terms of its potential to reduce or moderate these impacts (Smit / Wandel, 2006). Vulnerability is then interpreted as the *"net impact of the climate problem […] after the process of adaptation has taken place"* (Kelly / Adger 2000, 327) and thus considered at the end of the analysis.

The starting point approach, on the other hand, frames vulnerability in terms of social vulnerability and looks at the multiple underlying factors that shape vulnerability to current climate extremes and variability. The findings are then used as the basis to identify adaptation measures to reduce vulnerability. In addition, the assessment of current vulnerability can then be supplemented in a second step by also taking into account the expected changes in climate and future socio-economic changes in order to identify viable adaptation strategies for the future (Burton et al. 2002; Smit / Wandel 2006). The two types of vulnerability assessments also differ with respect to the type of adaptation measures they propose. Whereas the adaptation measures identified in type one research tend to be rather technological and engineering-based (O'Brien et al. 2004; Ford et al. 2007), adaptation measures identified in social vulnerability assessments tend to be much broader and include social measures in addition to technical measures (O'Brien et al. 2004). Furthermore, adaptation measures in social vulnerability assessments tend to be more practically oriented in contrast to those identified in type one research, which have been described as assumed, hypothetical or potential (Füssel / Klein 2006; Burton et al. 2002; Smit / Wandel 2006).

According to Young et al. (2006) a key difference between adaptation and vulnerability is that, unlike adaptation, vulnerability focuses on the underlying causes and processes that make systems vulnerable, from which the need for adaptation can be inferred. Thus, in order to devise effective adaptation measures, an in-depth understanding of vulnerability is necessary.

Adaptive capacity can be regarded as the main link between the concepts of vulnerability and adaptation. It is a core component of vulnerability in most definitions and conceptualizations and can also be regarded as a prerequisite for adaptation. Smit and Wandel (2006, 286), for example, describe adaptations as *"manifestations of adaptive capacity"*, and Adger and Vincent (2005, 400) refer to it as the *"asset base"* from which adaptation actions can be made. A number of authors have, however, stressed that the presence of adaptive capacity is no guarantee that adaptation will actually take place (e.g. Burton / Lim / Huq 2001; Brooks 2003). It is thus regarded as potential rather than actual adaptation (Brooks 2003). Adger et al. (2005) nevertheless maintains that adaptation can include both increasing adaptive capacity and converting adaptive capacity into action. A similar distinction is made by Füssel und Klein (2006), who distinguish between two types of adaptation responses: adaptation as facilitation, which aims to increase adaptive capacity through awareness raising, capacity building, institution building, etc.; and adaptation as implementation, which describes measures that reduce exposure and sensitivity to climatic hazards. Factors that promote adaptation are the recognition of the need for adaptation, the belief that adaptation is possible and desirable, the willingness to undertake adaptation, the availability of resources necessary for implementation of adaptation strategies and the ability to deploy resources in an appropriate manner (Adger et al. 2004).

2.5 Conceptualization and operationalization of vulnerability, adaptation and adaptive capacity for the purpose of this research

Although, as shown above, the concepts of vulnerability, adaptive capacity and adaptation go back a long way in history and have been applied in different scientific disciplines, the operationalization of these in the context of research on adaptation to climate change still poses several challenges. The multitude of different definitions and partly competing conceptual frameworks has given rise to confusion among academics, and there is no convincing overarching framework for conducting vulnerability assessments. The absence of such a framework has been identified as a considerable challenge in vulnerability research as it leaves researchers with little guidance on how to choose appropriate methodologies for operationalizing the concepts (Hinkel 2011; Preston / Yuen / Westaway 2011). To make things worse, even for those conceptual frameworks and definitions specifically developed in the context of adaptation to climate change, these frameworks and definitions have been found to be too broad and vague to provide clear guidance for their operationalization (c.f. Hinkel 2011). One suggestion has been to frame operationalization and determine the choice of methodology according to the research purpose (Hinkel 2011; Smit / Wandel 2006).

As Table 3 shows, the literature distinguishes between several kinds of purposes for vulnerability assessments and adaptation research, each implying different methodologies. However, while this provides some form of guidance, Preston et al. (2011) found out in a review on vulnerability assessments that even studies using the same conceptual model use different methodologies. Ultimately the choice of methodology is thus up to the individual researcher but requires justification; the choice should be explicit.

Table 3: Purposes and methodologies for vulnerability assessments and adaptation research

Purpose	Methodologies
Adaptation research	
Purpose	**Methodologies**
Estimating impacts of climate change	Modelling
Evaluating specific adaptation options and measures	Cost-benefit analysis, cost effectiveness analysis, multiple criteria analysis
Comparing adaptive capacity of countries, regions, communities	Indicator based approaches
Contributing to practical adaptation initiatives	Participatory approaches
Vulnerability Assessments	
Purpose	**Methodologies**
Identification of the determinants of vulnerability	Indicator based approaches Qualitative approaches (interviews, focus group discussions)
Advance the development of assessment methods/conduct scientific research	Various
Provide decision support	Various
Identifying mitigation targets	Integrated assessment models
Identifying particular vulnerable people, regions or sectors	Indicator based approaches Model based approaches Vulnerability mapping
Raising awareness of climate change	Stakeholder consultation Communication
Allocating adaptation funds to particular vulnerable groups, regions or sectors	Use of indicator based approaches problematic as it requires a normative approach
Monitor the performance of adaptation policy	Indicator based approaches possibly have a role

Source: Based on Smit / Wandel (2006); Preston et al. (2011); Hinkel (2011)

As mentioned above, the purpose of this research is to identify practical measures to enhance the ability of the community in Sasumua watershed to deal with current climate extremes and variability and future climate change. This type of purpose falls into the category of what Smit and Wandel (2006) have termed *"practical adaptation"* research. Practical adaptation research is defined as *"research that investigates the adaptive capacity and adaptive needs in a particular region or community in order to identify means of implementing adaptation initiatives or enhancing adaptive capacity"* (Smit / Wandel 2006, 285).

The identification of practical adaptation measures requires an in-depth understanding of the factors that shape the current vulnerability to climate variability and extremes. The main focus is on adaptive capacity here. Vulnerability is thus conceptualized in terms of the starting point interpretation of vulnerability and framed in terms of social vulnerability rather than biophysical vulnerability.

For the purpose of this research, I define social vulnerability in line with Adger (2000) as the limited capacity of individuals and social groupings to respond to – that is, to cope with, recover from or exploit positive opportunities associated with climate variability and change affecting their livelihoods and well-being. This capacity will vary depending on the type of climate stimuli experienced and the degree of affectedness placed on livelihoods.

The definition places the main focus on the capacity element and is thus consistent with the main purpose of research. In line with Adger and Vincent (2005) and Nelson et al. (2007) cited in Brown et al. (2010), I regard adaptive capacity as the *"asset base"* or *"preconditions necessary"* for enabling coping and adaptation strategies. Increasing adaptive capacity thus reduces vulnerability and facilitates coping and adaptation. Coping is understood as the *"manner in which people act within the limits of existing resources … to achieve various ends"* (Wisner et al. 2004, 100). I distinguish between coping and adaptation in that I use the term coping for current strategies to deal with climate stresses and adaptation for strategies that also entail past and expected future changes, a distinction often made in the literature (see e.g. Cooper et al. 2008). Coping and adaptation strategies can be differentiated according to the timing of their implementation, i. e. whether they are implemented before (ex-ante), during, or after (ex-post) an event occurs (Cooper et al. 2008; Smit et al. 2000; Wisner et al. 2004). In addition, a distinction can be made as to whether the strategies refer to farm management practices or to practices aimed to minimize the impacts of climatic events on other aspects of livelihoods (Cooper et al. 2008). Climate variability and change affect livelihoods and thus constitute the exposure element of vulnerability. The definition also entails the third main element – sensitivity – defined according to the IPCC as the *"degree to which a system is affected, either adversely or beneficially, by climate variability or change"* (Parry / Canziani / Palutikof 2007, 881).

I also adopt the definition of the IPCC s fourth assessment report on adaptation (Parry / Canziani / Palutikof 2007) and regard adaptation as ways of reducing vulnerability. This can include both facilitating adaptation through increasing adaptive capacity and implementing adaptation strategies. As noted by Adger et al. (2004), the implementation of adaptation strategies is influenced by a number of factors, including recognition of the need for adaptation, the belief that adaptation is possible and desirable, and willingness to undertake adaptation measures. In the analysis of adaptive capacity and the identification of adaptation options for farmers in Sasumua watershed, special attention will thus be given to those factors. In line with Chambers (1989), who stressed the importance of involving local people in the assessment of vulnerability, the methodology employed will make use of participatory vulnerability assessments. The next section will give a brief overview of participatory vulnerability assessments in the context of adaptation to climate change, before the analytical approach taken in this study is outlined.

3 Method: Participatory Vulnerability Assessments

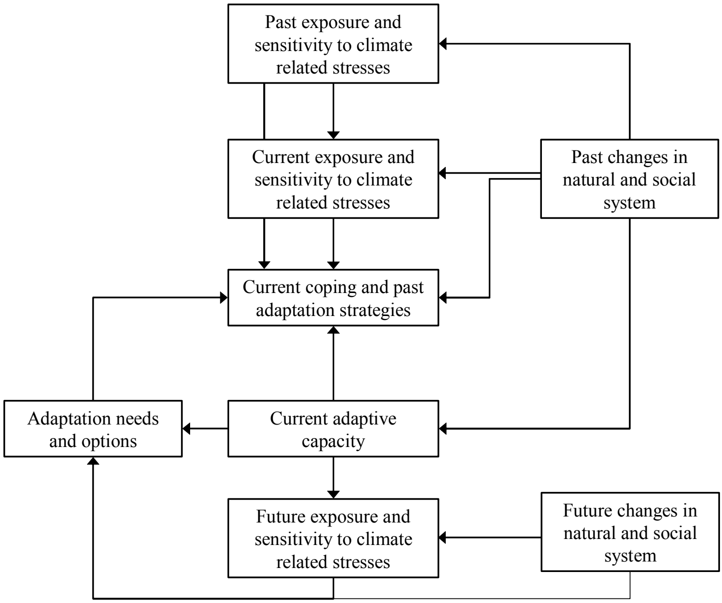
Participatory vulnerability assessments can be understood as *"a systematic process that involves communities and other stakeholders in an in-depth examination of their vulnerability and at the same time empowers or motivates them to take appropriate actions."* (Action Aid 2005, 11). The determinants of vulnerability and its components (exposure, adaptive capacity and sensitivity) are thus identified by the community itself, based on their experience and knowledge rather than through the researcher (Smit / Wandel 2006).

Understanding the perceptions of the community is important because adaptation will ultimately have to be implemented at the local level by the community. Only by understanding the perception of those actually affected about the factors that shape their vulnerability can constraints in adaptation and meaningful measures of adaptation be identified and applied and the risk of maladaptation minimized. The active involvement of the community in identifying determinants of vulnerability is important, because it has been shown that perceptions of determinants can differ markedly between the community and researchers, both with regards to the selection of determinants and their respective weights (Brown et al. 2010; Pulhin et al. 2008). Not taking the perception of the community into account thus entails the risk that important determinants of vulnerability might be overlooked or that the focus for vulnerability reduction might be put on those factors that the community itself does not consider to be important.

Smit and Wandel (2006) have provided a framework for participatory vulnerability assessments: The framework starts with the analysis of exposures and sensitivities past and current along with current adaptive strategies before looking at future exposures and sensitivities, future adaptive capacity and the identification of adaptation needs and options. This approach has been slightly modified and adopted for this study.

When applying the framework for the purpose of this research, considerable attention was paid in examining past exposures to climate stresses and past changes in the natural and social system because vulnerability and the factors shaping them are not static, but dynamic, requiring a historical assessment (Wisner et al. 2004). Past climate exposures in addition to other changes in the natural and social system are also likely to have influenced the type and effectiveness of current coping and past adaptation strategies employed in dealing with climate stresses and trends. When identifying constraints in adaptive capacity and options on how to overcome these constraints, it is thus important to take these historical factors into account. Figure 1 shows the framework for participatory vulnerability assessment used for this research.

Figure 1: Framework for vulnerability assessment



Source: Modified after Smit / Wandel (2006)

In order to identify past and current exposures and sensitivities to climate related stresses, to analyse current coping and past adaptation strategies and to identify adaptation options, a number of different participatory rural appraisal (PRA) techniques were used.

Participatory rural appraisal techniques emerged in the late 1980s and early 1990s in response to the often top-down, centralized and expert-driven approaches to rural development that did not sufficiently take into account the needs, knowledge and resources of local people (Narayanasamy 2009; Chambers 1994a). PRA places a strong emphasis on sharing and learning *"by, with and from"* rural people about their conditions in order to enable them to plan and act accordingly (Chambers 1994a, 953). While PRA techniques have become especially fashionable among development NGOs, they are also increasingly being adopted by universities and research institutes (Chambers 1994b), for example in the field of community risk assessments (Wisner 2006; van Aalst / Cannon / Burton 2008).

Through their focus on local level knowledge and participatory assessment, PRA tools have also been recommended for use in adaptation assessments. Based on a review of several case studies on community risk assessment conducted by the Red Cross, van Aalst et al. (2008, 177), for example, conclude that PRA *"provide valuable tools for climate change adaptation, especially to inform bottom-up approaches to climate change adaptation…"*. Some of the advantages of PRA tools noted are that they enable a focus on vulnerability (including adaptive and coping capacity) and livelihoods at the local level and allow us to analyse trends in climate hazards, climate change, and their impacts on livelihoods. An additional advantage of PRA methods is that impacts of climate variability and change can be examined in conjunction with other stressors in in-depth discussions with local stakeholders, which is especially important because it is increasingly recognized that *"successful climate change adaptation and vulnerability reduction is rarely undertaken with respect to climate change alone"* (Smit / Wandel 2006, 289). While it is recognized that climate change and climatic hazards present just one of many stresses determining the vulnerability of communities, the main focus in analysing exposure, sensitivity and adaptive capacity in this study is laid on climatic stresses and trends. Nevertheless, non-climatic stresses and trends are also considered during the analysis in order to gain a deeper understanding of the interaction between them and the ability to implement coping and adaptation strategies.

Table 4 presents the main PRA techniques used in conjunction with other methods during the participatory vulnerability assessment. Timeline analysis was used to identify past *exposures to climate stresses*. This technique involved asking the community to remember important events in local history, which were then recorded on a timeline on a sheet of paper. The discussions were left deliberately open and not limited to climate stresses in order to also identify other key stresses in the natural and social system that had an impact on the community.

Past changes in the natural and social system were further analysed by using trend lines and change in trend matrixes, in which the community presented trends in key natural and social parameters visually over time. The trends examined included rainfall, temperature, frost, tree cover, water availability, forest cover, soil erosion, soil conservation, water conservation,

Table 4: Methods used to analyse the various determinants of vulnerability and adaptation

Determinants of vulnerability and adaptation	Focal questions	Methods used
Past exposure to climate hazard	What climate stresses has the community been exposed to? What were the impacts of those stresses?	Timeline Group discussions
Past changes in natural and social systems	What other key changes in the natural and social system occurred in the community? What were the impacts of these changes?	Timeline Trend line Change in trend matrix Literature sources Group discussions
Current exposure and sensitivity to climate stresses	To which climate stresses is the community currently exposed? What are the impacts of these stresses?	Group discussions Community mapping
Current coping and adaptation strategies	What coping and adaptation strategies does the community employ? Are they effective? When are they implemented? What are constraints in implementing the strategies? Are these constraints related to past changes in the natural and social system? Is the community aware of any other strategies? Why are they not employed?	Group discussions
Future exposure and sensitivity	What would be the impact if past climatic trends continued? What would be the impact if current extremes became more severe?	Envisioning exercise

Table 4 (cont.): Methods used to analyse the various determinants of vulnerability and adaptation

Determinants of vulnerability and adaptation	Focal questions	Methods used
Current adaptive capacities	What assets does the community deem to be important for implementing coping and adaptation strategies? How are these currently rated?	Rating of adaptive capacity Group discussions
Adaptation needs	Is climate change perceived as a problem by the community? Are current coping strategies perceived to be adequate to deal with future changes? Is there a perceived need to enhance current elements of adaptive capacity? Is there a willingness to employ these coping and adaptation strategies?	Problem-ranking Group discussion Rating of adaptive capacity
Adaptation options	What measures would be needed to enhance adaptive capacity? What measures would be needed to deal with expected change in climate?	Group discussion with farmers Group discussion with district government officials

Source: Author's own compilation

population, land size, poverty, and crop and livestock production. The graphs produced served as the basis for discussions of reasons for changes and the interrelationship between different trends observed.

Current exposures were identified through group discussions, in which the community was asked to identify climate stresses affecting them and the impact that they have on their livelihoods.

Sensitivity was captured by asking farmers to identify the degree of affectedness that these climate events have on their livelihoods in terms of yield reductions and/or increases in production. In addition, farmers were asked to identify areas particularly hit by these events and to discuss the reasons. These areas were also marked visually on the maps that the community produced as part of the community mapping exercise.

After having identified the key climate stresses and their impacts, farmers were asked to identify *coping strategies* that they employ to deal with these stresses. Discussions were guided through a set of structured questions, in which farmers were asked to reflect on the timing of the implementation, the effectiveness of the strategies and whether they were aware of any other strategies that could be used but are currently not used. The adequacy of the coping strategies was also assessed not only with respect to current climate stresses but also with regard to *expected future changes*. Here, a short envisioning exercise was conducted; based on past trends identified in rainfall and temperature and experience with current climatic stresses, possible future climatic scenarios were discussed in terms of their impacts and the suitability of current coping strategies.

The discussions on coping and adaptation strategies also served as the basis to identify determinants of *adaptive capacity*, described as the assets/preconditions needed in order to implement the strategies. These determinants were subsequently rated, broadly following the approach as outlined in Brown et al. (2010) and Roth et al. (2010), who have used focus group discussions to self-assess and rate adaptive capacity of natural resource managers in Australia and of farmers in Bangladesh and India.

The identification of *adaptation needs* involved several steps. Prior to any discussions on climate stresses, exposures, and coping strategies, etc., farmers were asked to identify and rank problems in their area. Pairwise ranking was then conducted in order to identify the perceived importance of each of these problems. The purpose of the exercise was to establish whether climate problems were perceived to be important and how they rated compared to other problems. Adaptation needs were also looked into by examining the adequacy of coping and past adaptation strategies both with regard to current and future climate stresses. Finally, adaptation needs were captured by rating the importance of increasing the determinants of adaptive capacity. The rating exercise revealed how determinants of adaptive capacity could be increased. In addition, farmers were asked during the envisioning exercise to identify adaptation measures to deal with expected changes.

Participatory exercises were conducted in five different areas of the watershed in the period from 26.11. to 11.12.2009: two in the lower lying areas of the watershed (Kwaharaka and Kinamba) without forest nearby; two in the more upwards lying areas of the watershed (Sasumua Kiamweri and Sasumua Churiri) bordering the forest; and one around the town of Njabini. The participatory workshops were held for two days in Kikuyu. Around 10-15 participants were selected per group with the help of a local coordinator, a former chief in the area. Care was taken that participants came from a mixed socio-economic background and that groups were approximately gender-balanced and had a good age spread. The results of participatory exercises were discussed with local actors in a joint workshop held on 8.12.10 to reflect upon differences in sensitivity between the various areas of the watershed. The last part of the workshop series consisted in the rating of adaptive capacity for climate variability, drought and floods. The rating was conducted in two different areas of the watershed (the more lower lying areas without forest nearby [Kwaharaka and Kinamba, lower parts of Njabini] and the more upper lying areas and areas near the forest [Sasumua Kiamweri, Sasumua Churiri and upper parts of Njabini] respectively) in the period from 13.12. – 14.12.2010 and was done separately for men and women.

4 Case study description

4.1 Geographical location and hydrological importance of Sasumua watershed

Sasumua watershed is located in Kinangop district of Nyandarua County, approximately 80 km north of the capital Nairobi between 36.58° and 36.68° east and 0.65°S and 0.78°S, covering an area of approximately 107 km^2 (Gathenya / Thiong'o / Mwangi 2009). The altitude ranges from around 2,350 m to up to 3,850 m in the northern forested part of the watershed. Agriculture is practised up to an altitude of approximately 2700 m. The population is predominantly rural, with cabbages and potatoes being the main types of crops grown. In addition, there is also a small town, Njabini, located in the watershed with a current population of around 6,000 people (KNBS 2010).

The watershed is of strategic importance to the city of Nairobi, providing approximately 20 % of its potable water supply. Although the importance of the watershed as the main source of water for Nairobi has somehow diminished over time due to the construction of additional dams (in 1968, the Sasumua scheme accounted for 75 % of Nairobi s water resources [Berry 1968]), some areas within the city – such as Kyuna, Karen Loresho, Kabete, Kibagare, Upper Dagoretti, and Kenyatta hospital – rely almost exclusively on water from Sasumua watershed (Sangira / Mango 2008; Neacsu 2003; NTV Kenya 2008). The dependence of the city of Nairobi on the water provided by Sasumua watershed became also evident in 2003, when a landslide destroyed parts of the dam, decreasing its capacity from 16 million m^3 down to around 7 million m^3 (Githinji 2009; Mwaura 2009), which further aggravated water shortage problems in Nairobi (Nairobi Chronicle 2008; Kumba 2008; BBC News 2003; Sangira / Mango 2008).

Apart from being of hydrological importance for the city of Nairobi, the importance of water for the inhabitants of the watershed is also evident in many of the local names of places within the watershed (such as Njabini[2], Kinangop[3], Churiri[4] and Sasumua[5]) that have strong connotations to water and demonstrate that the watershed has traditionally been considered as a wet place. However, the situation has changed drastically in recent years with water shortage becoming a serious problem affecting both the inhabitants of the watershed and the Nairobi City Sewerage and Water Company, which operates the treatment plant and Sasumua dam located inside the watershed. Indeed, all three major rivers within the watershed (Sasumua, Chania and Kiburu) have been classified as being in a state of alarm by the Water Resources Management Authority (Republic of Kenya 2007)[6]. Other

2 The name Njabini originates from the splashing noises that are made when walking through a marshy area, which are described as "Njabi, Njabi, Njabi" in Kikuyu.

3 Kinangop is a Masai word for "marshy area".

4 Churiri is located close to the Sasumua dam and received its name from the sound of the river flowing across different heights, which has been described as "churiri, churiri, churiri" in Kikuyu.

5 Sasumua itself originates from a tree species "mithathinua", which is endemic to the area and grows along the river banks of Sasumua river. As the colonialists were unable to pronounce the name of the tree species correctly, the name Sasumua emerged.

6 The category alarm is used for surface water where the resource is periodically scarce and/or the water reserve is threatened.

problems currently affecting the watershed are unsustainable land use practices leading to siltation and erosion, population pressure, degradation of natural vegetation and increasing levels of poverty in parts of the watershed. In addition, climate change has been identified as a major problem both by the local inhabitants of the watershed and the Nairobi City and Water Sewerage Company, which operates Sasumua dam.

4.2 Historical overview on past developments in the watershed

As vulnerability is dynamic and not only influenced by exposure, but also by underlying social factors rooted in the past, it is important to consider past developments and the historic context in which they took place. For this purpose, timeline and trend analysis coupled with further information from the literature were used. The analysis revealed that many of the current problems affecting the watershed have their roots in the period of British colonialism, with settlement of the white settlers, the subsequent Mau Mau uprising during the 1950s, and resettlement programmes initiated following the independence of Kenya having a profound impact on the way land and natural resources were managed within the watershed.

The magnitude of these changes has already been anticipated in the literature of that time and is also reflected in the historical accounts given by farmers. Belshaw (1964, 30), for example, describe the consequences of resettlement schemes in the former white highlands following independence as *"the most rapid change in the economic and human geography of an area this size ever experienced in East Africa"*. As the initiation of the resettlement scheme is invariably linked to the Mau Mau war and the displacement of ethnic groups from their traditional land during the period of British colonialism, the following section provides a short overview of that period and its implications for the watershed.

4.2.1 Sasumua watershed under British colonialism and during the Mau Mau war

According to local inhabitants of the watershed and a local historic account written by Ndiritu (s. a.), the watershed was originally inhabited by the Masai, the Kikuyu and the Ndorobo, who all engaged in different activities and used different parts of the watershed to support their living. As pastoralists, the Masai grazed their cattle in the lower marshy grasslands of the watershed, whereas the Kikuyu, who were mainly engaged in agriculture and trade, lived in upper areas more suitable for farming. The Ndorobo, on the other hand, were forest dwellers mainly engaged in hunting and gathering wild fruits, herbs and honey in the forested part of the watershed.

The ethnic composition of the watershed inhabitants changed during colonialism as the place became part of the *"white highlands"*, agricultural areas in Kenyan highlands exclusively reserved for European settlers (Morgan 1963). According to Ndiritu (s. a., 3), the Masai and the Ndorobo were displaced from the area, while the Kikuyu were retained as agricultural labourers working as *"self-motivated robots who needed no regular servicing to replacement of costly body parts"*. This account is confirmed in the wider literature on the white highlands, which describes in more detail such legislative provisions as the 1904 Masai Agreement, the 1915 Crown Land Ordinance and the 1918 Resident Native (Squatters) Ordinance that underpin the dispossession of land occupied by the Natives and allowed them to live in the white highlands only under the status of a squatter on the settler's farm in exchange for labour (cf. Leo 1984; Morgan 1963; Syagga 2006).

As described by Leo (1984) the economic situation of the squatters deteriorated during the 1930s and 1940s, leading to discontent among the Kikuyu and culminating in the famous Mau Mau war, a Kikuyu-dominated revolt that gripped the country in the 1950s and ultimately lead to Kenya's independence in 1963. The area in and around Sasumua watershed played an important part in the war and had a profound impact on the life of both Europeans and Kikuyus living in the area. The nearby forest of the Aberdare Mountains provided a popular hide out for the Mau Mau supporters, including field marshal Dedan Kimathi, a leading freedom fighter and main leader of the Mau Mau revolt; he was captured in the forest in 1956 and executed in 1957[7]. The watershed was thus home to clashes between Mau Mau fighters and Europeans. There is at least one report of an attempted attack by Mau Mau gangs on Grimwood farm within the watershed in January 1954 and several reported murders of European settlers within the wider Kinangop area, which deepened the animosity of Europeans against the Kikuyu (Kitson 1960; Anderson 2005). In 1952, the government responded by declaring a state of emergency, which lasted until 1960 and involved the

7 Njabini, the major town in the watershed is still home to the widow of Dedan Kimathi.

eviction of Kikuyu squatters, who were sent to African reserves. In addition, detention camps for Mau Mau fighters and alleged supporters were set up (c.f. Leo 1984); they have been compared to concentration camps by some of the older farmers and in the newer literature on the Mau Mau war (Anderson [2005] and Elkins [2005] cited in Dowden [2005]), demonstrating the dire situation that prisoners faced there.

The change in land ownership during colonialism initiated great shifts in the way natural resources were managed and used. The arrival of the white settlers in the Kinangop area essentially transformed the dry season grazing system under the Masai to *"one of the most thickly settled of the white mixed-farming areas"* (Lonsdale 1986, 310), with farmers engaging in the production of wheat, pyrethrum, barley, oats, dairy products, and sheep (Morgan 1963; Ndiritu s. a.; Thompson 1964). This transformation of land use went along with the construction of an extensive drainage system to enable agricultural production on the waterlogged soil (Lonsdale 1986; Leo 1988). The British also recognized the importance of the watershed in terms of a source of water supply for the city of Nairobi. Construction of Sasumua dam, a treatment plant and a pipeline channelling water by gravity to the outskirts of Nairobi, began in 1950 and was completed in 1956, following delays due to the Mau Mau uprising (Abbott cited in Dixon et al. 1958; Dixon / Robertson 1970; Berry 1968). Due to the rising water demand in the city of Nairobi, both dam and purification facilities were later enlarged, raising the capacity of the reservoir from around 9 million m^3 to 16 million m^3 by 1968 (Berry 1968; Government of Kenya / City Council of Nairobi / United States of America 1964).

4.2.2 Sasumua watershed in the aftermath of independence

As it became clear that Kenya was heading towards independence, the redistribution of land in Kenya and within the white highlands became central. In 1960, changes made to Crown Land Ordinance effectively ended the exclusive rights of Europeans to the white highlands in that it also allowed non-Europeans to manage or own land, provided that transfer of ownership was based on a willing seller and willing buyer arrangement (Morgan 1963; Syagga 2006). In the early 1960s, various settlement schemes were established to facilitate the transfer of land between Europeans and Africans, including the yeoman farmer scheme and the assisted farmer scheme targeting experienced farmers in addition to the million acre scheme, which superseded the earlier schemes and distinguished between high and low density areas for settlement (Belshaw 1964).

The area in and around the watershed is mentioned in several sources of the literature as one of the first areas on which the high density schemes concentrated (e. g. Belshaw 1964; Leo 1984) although the area was widely regarded as being of low agricultural value. Leo (1984, 136), for example, notes that *"much of the land on the high plateau called the Kinangop was waterlogged, frost-prone and relatively infertile"*. Wassermann (1973) also cites various government documents and technical advisors of that time that strongly spoke against using the South Kinangop area for settlement for economic and financial reasons, but also due to the climatic and soil conditions. Most sources also emphasize the speediness and unplanned nature in which these settlement programmes occurred; these schemes are also referred to as crash programmes or jet schemes (Belshaw 1964; Wasserman 1973; Kanyinga 2009a).

As elaborated by Leo (1984) and others (Wasserman 1973; Kanyinga 2009b; Kanyinga 2009b) there are several reasons for this great rush, most of which have their roots in the Mau Mau conflict and the events surrounding the state of emergency described above. The division of Kenya along ethnic boundaries and the decision that the newly created Nyandarua district (of which South Kinangop is part) was to be reserved for the settlement of Kikuyu only initiated a great influx of land-hungry Kikuyu in the area. There was thus a great danger of social unrest, which combined with threats made by Kikuyu to forcibly to take over white farms and fears of a resurgence of the land and freedom army to explain the focus on Nyandarua and the speed with which the settlement programmes were conducted. While it helped to stabilize the political situation around the years of independence (Leo 1984), it is also regarded as one of the main underlying factors behind the ethical conflicts that gripped Rift Valley and the rest of Kenya in 1993, 1997 and the post-election violence in 2007, as much of the land reserved for settlement for the Kikuyu historically belonged to the Kalenjin and Masai (Kanyinga 2009b). Although Leo (1984) convincingly argued against the misconception that Kikuyu were favoured over other ethnic groups during the settlement period, Kanyinga (2009b) shows that this alleged favouritism lies at the heart of the matter and still continues to shape animosities between Kalenjin and Kikuyus today.

The most immediate effect of the initiation of the high density settlement schemes was a massive population increase in the area. Current population levels within the watershed are estimated to be around 17,500 people or 3,700 households (J.K. Mwangi, personal communication, February 22, 2011), corresponding to a population density of around 164 persons per km^2 compared to a national average of around 66 persons per km^2 (KNBS 2010). Table 5 shows the increase in population between 1999 and 2009 for the two divisions of Njabini and Nyakio, parts of which fall into the area of the watershed. Although there has been an increase in population and population density, the number of persons per household has slightly decreased.

Table 5: Population growth in the divisions of Njabini and Nyakio

Njabini					
Division	Population	Households	Area (km^2)	Population density	Persons per household
1999	30,486	6,625	154.2	198	4.6
2009	34,719	8,402	153.2	227	4.1
Nyakio					
Division	Population	Households	Area (km^2)	Population density	Persons per household
1999	27,446	5,723	109.3	251	4.80
2009	37,342	8,571	111.7	334	4.4

Source: Jaetzold et al. (2006); KNBS (2010)

4.3 Farmers' account of changing trends

Some of the negative consequences of the resettlement programme, especially the massive influx of population and the shaping of animosities between the Kalenjin and the Kikuyu, can still be felt today and are also reflected in farmers' accounts of changing trends from independence onwards. According to farmers, tribal clashes between Kalenjin and Kikuyu in 1992, 1997 and 2008 in Rift Valley caused Kikuyu to migrate into the watershed, thereby contributing to the already growing population pressure.

The increase in population was identified as one of the main drivers for a number of other changes, most notably a reduction in land sizes, a change in farming practices and an accompanied increased pressure on natural resources. Farmers described a shift from livestock production to food and horticultural farming, which they attributed to a decrease in land size in addition to the occurrence of long dry spells in 1980 and 1984/85, the incidence of foot and mouth disease in the mid-1980s and the collapse of cooperative societies, such as Kenya Cooperative Creameries and a wool factory in Nakuru. As a consequence, the natural grassland of the Kinangop plateau – which supports at least two endemic frog species (Bennun and Njoroge (1999) cited in Ndang'ang'a et al. 2002) and a range of endemic and globally threatened bird species including the Sharpe s Longclaw (*Macronyx sharpie*), Jackson s Widowbird (*Euplectes jacksoni*) in addition to endemic and restricted range species such as the Aberdare (*Cisticola Aberdare*) and Hunter's Cisticola (*Cisticola hunteri*), and has been classified as an important bird area by BirdLife International (2009) – has declined substantially. Within the wider Kinangop area, of which the watershed is part, natural grassland is now estimated at one third to one half of its historical context (World Land Trust / Nature Kenya 2009).

The decline in natural grassland cover and corresponding increase in the area of crop cultivation, especially on steep slopes, together with an increase in agricultural intensification were also regarded as some of the main reasons behind the increasing trends in soil erosion described by farmers over the past 50 years. Further reasons distilled from the discussion were interference with the drainage system and soil conservation structures constructed during colonial times due to land subdivision, agricultural intensification, and a lack of knowledge about soil conservation techniques.

Similar reasons were also provided to explain the decreasing trends in water availability, which farmers say has decreased markedly from the 1970s onwards in all parts of the watershed, leading to water shortage. In particular increased siltation of dams and ponds resulting from increased levels of cultivation, the collapse of the piped water system, increasing levels of population, reductions in rainfall and interference with the drainage system were identified as the main reasons for the decreases in water availability.

5 Results from participatory vulnerability assessment

As mentioned above, the main focus in analysing the exposure, sensitivity and adaptive capacity elements of vulnerability has been on climate trends and stresses. However, it is clear that they do not act in isolation, but interact with other factors. The description of the watershed above and key changes in non-climatic trends provide a rich contextual understanding of some of the key developments in the watershed. As will be shown below, some of the past developments in the watershed have also influenced the ability of farmers to implement coping and adaptation strategies and thus shaped the vulnerability of farmers to climate trends and stresses.

5.1 Exposure to past and current climate related trends and stresses

Using trendline analysis and discussions, farmers identified a clear increasing trend in temperatures, a decreasing trend in the amount of rainfall and a decrease in the intensity of frost and gathano[8] from the 1960s onwards. The decreasing intensity of gathano was attributed to a combination of increases in temperature and land use changes, with the clearing of vegetation and decreases in water level having lead to reductions in fog. The impact of these trends was perceived to be both positive and negative. Positive impacts associated with the increase in temperatures, for example, related to the ability to diversify crop production, as it allowed crops to be grown for which it was previously too cold, increased milk production and reduced fertilizer use. Reductions in the intensity of gathano had positive impacts in terms of crop production. However, the farmers also described negative aspects of the temperature increase, which included increased water shortage and the increased incidence of pests and diseases (such as east coast fever and rinderpest). Furthermore, although reductions in the intensity of gathano were perceived to be beneficial, farmers also noted that the timing of gathano changed, leading to increased occurrence of crop diseases. With regards to changes in rainfall patterns, the farmers described an overall decrease in the amount of rainfall, a reduction in the amount of rainy days and a reduction in the intensity of rain: *"Nowadays, you get rain for 2-3 days, then sun for a week, before rain used to fall continuously.*

8 Gathano describes a cold, foggy and misty condition.

Nowadays, you have more days of sun than rain". "Before it used to rain for a long time heavy rains, but nowadays it rains for a short time and also the intensity is not too high". In addition, they described a change in the seasonality of rainfall, with the timing and duration of the rainy seasons having become unpredictable. *"The rain has changed, now we have short rains for a short time". "We used to expect the short rains and the long rains. Now the rainfall has reduced, so even for the long rains we experience it for a shorter time"*. Concurrently with a reduction in rainfall, farmers also noticed increases in the occurrence of dry spell and drought. Unlike the changes in temperature, changes in the patterns of rainfall were largely negative, with reductions in the amount of rainfall leading to a lack of fodder for livestock, reduced crop production, drought, and an inability to predict appropriate planting and harvesting times. Reductions in the intensity of rain were perceived to be both positive in terms of increased availability of fodder and negative in terms of water availability.

In addition to changes in climatic trends, the community in Sasumua watershed has been exposed to a variety of different climatic events, including delayed rain, dry spells, droughts, heavy rains, floods and frost. In most cases, the impacts of these events have been quite severe, with crop failure and the death of animals leading to hunger. Heavy rain and floods have also caused damage to infrastructure (see Table 6).

Among current climate related stresses farmers identified early and delayed onset of the rainy season, drought, frost, gathano, flood, wind, dry spell and heavy rain as events negatively affecting them.

The various types of climate variability and extremes have partly serious impacts on the livelihood of communities. Most events impact livelihoods through reductions in food availability, decreases in the production of crops and livestock and hence reductions in income, and negative effects on the level of education, transport and health.

Crop yield is negatively affected, either because the event destroys the crop directly (drought leading to withering, frost and flood causing root and crop rot, etc.) or indirectly through the occurrence of pests and diseases (potato blight occurring during heavy rain, floods and gathano; cutworm and aphids occurring during delayed onset of the rainy season and drought, etc.). In the case of early and delayed onset of the rainy season, crop yield is also reduced when farmers are caught unprepared, leading to distortions in the farming calendar.

Table 6: Timeline – climate related stresses and their impacts identified by farmers

Year	Event	Impact
1943	Delayed rain (Prolonged dry spell)	Famine "*Ng'aragũya mĩanga*" = famine of cassava Shortage of staple food (only cassava was available)
1960	Heavy rains (heavier than El Niño)	Joblessness Hunger
1964	Floods	Joblessness Hunger
1972	Frost (*"Mbaa"*)	Destruction of trees and crops
1978	Heavy rains Invasion of locust	Collapse of chania bridge affecting transport and communication Flooding leading to destruction of crops Crop diseases High milk production Low food availability
1980	Dry spell	Famine *("Ng'aragu")* Relief food was distributed
1984-1985	Outbreak of foot and mouth disease Frost *("Mbaa")* with high intensity Prolonged dry spell	Famine *("Ng'aragu")* Migration of Masai into the watershed to search for food and pasture
1988	Cyclone in Naivasha	Fish from Lake Naivasha were lifted up by the cyclone and deposited in the watershed so that it was *„raining fish"*
1997/ 1998	El Niño	Floods Soil erosion Crop damage Hunger
2003	Heavy rains	Floods Collapse of Sasumua dam wall Shortage of water in storage and thus water shortage in Nairobi Crop damage Soil erosion in Kinamba, leading to soil infertility
2008	Drought	Death of animals Shortage of water Major reductions in crop yield Relief food was distributed Migration into the watershed from outside due to post election violence and because people were moving in to search for food

Source: Author's own compilation

The impact on livestock is largely indirect, either through the effect on fodder availability or the increased incidence of diseases. Other indirect effects are livestock losses or damage from wildlife attacks (hyenas and wild dogs) in periods of drought and dry spells.

In many cases the events also have severe social consequences. Increases in theft have been reported in the case of early onset of the rainy season, drought, dry spell and frost. These consequences also affect farmers not directly hit by the event, as their seedlings are uprooted and crops are stolen from their farms. Farmers also reported that during drought and dry spell domestic conflicts worsen. Social conflicts also arise especially during these periods when people in need of support are not being helped. Conflicts have not been mentioned in the case of gathano, wind and heavy rain, suggesting that the impact of these events is less severe. In addition, idleness has been reported for most of the events, as they prevent farmers from conducting work. In some cases, this idleness also has psychological effects leading to *"madness"* and *"insanity"* due to *"too much thinking"*.

All events have some sort of health impacts, in many cases associated with malnutrition due to lack of food. Water-borne diseases, such as cholera and typhoid, are common during periods of floods and heavy rain. Colds, pneumonia, flu and whooping cough occur during the cold periods of gathano and frost. In many cases, the elderly and children are most affected.

A detailed analysis of the various impacts of the different climatic events as described by farmers is provided in Table A1 in the Annex.

5.2 Current sensitivity

Sensitivity was captured by asking farmers to identify the degree of affectedness that these climatic events have on their livelihoods in terms of yield reductions and/or increases in production. In addition, farmers were asked to identify areas particularly affected by these events and to discuss the reasons.

Despite its relatively small size of just 107 km^2, the watershed features areas of differential sensitivity with the lower lying areas without forest nearby (Kwaharaka and Kinamba, around 2,500–2,550 m) of the watershed generally showing a higher degree of affectedness to the various climatic events as compared to the upper lying areas and areas with forest nearby

(Sasumua Kiamweri and Sasumua Churiri, around 2,500–2,700 m). Indeed, farmers also reported that people from the lower areas go to the upper areas in search for fodder and food when food shortage results from frost, drought or delayed onset of the rainy season.

As shown in Table 7, differences in sensitivity within the different areas of the watershed mostly relate to the distance to the forest and differences in topography and soil texture. Differences in soil texture and topography, for example, explain why heavy rain has a negative impact on food production in Sasumua Kiamweri (crops are affected by stagnant water in the low lying areas), but less of an impact on Sasumua Churiri (more affected by erosion in the steep areas) (see Table 7). The forest acts as an important buffer against frost and wind and also acts as a buffer against the impacts of drought and dry spell as it provides a source of fodder for animals. The same features were also cited as reasons when discussing differences in sensitivity between the different areas of the watershed with the farmers. Flooding resulting from heavy rain, for example, only occurs in the lower lying areas of the watershed (Njabini, Kinamba and Kwaharaka). The intensity of frost is also much higher in those areas as they are not protected by the forest. Yield reductions in milk production that result from the occurrence of frost, for example, were reported to be 85 % and 95 % for Kinamba and Njabini, as compared to 10 % and 0.5 % in Sasumua Churiri and Sasumua Kiamweri, respectively. Similar reasons were also provided for the differences in the impact of gathano on milk production (cf. Table A1 in the Annex) as gathano is more intense in the lower areas, and animals were regarded as better adapted to conditions of coldness in the upper areas. As compared to the other areas, Sasumua Churiri is also not so much affected by drought given their proximity to the forest and their access to water sources (cf. Table 8). The group of Sasumua Churiri speak of dry spells, whereas the other groups speak of drought.

The differences in sensitivity between Sasumua Churiri and the other areas also became evident when looking at the trends in the number of livestock over time. Whereas most other groups showed a clear declining trend in sheep and cattle following the incidence of foot and mouth and drought in the mid-1980s, numbers of both sheep and cattle continued to increase in Sasumua Churiri until the mid-1990s and beginning of 1990s, respectively. The reasons provided for this were again the closeness to the forest, which provided fodder as well as herbal medicine for the animals that were believed to boost the immune system and cushion the effect of drought.

Table 7: Areas within the watershed affected by the various climatic events

	Kwaharaka	Kinamba	Njabini	Sasumua Churiri	Sasumua Kiamweri
Early onset	Everywhere	Everywhere	Everywhere	Everywhere	Everywhere
Delayed onset	Everywhere	Everywhere	Lower part – due to distance to the river, absence of water ponds due to hard soil and low soil fertility	Areas along the forest not so much affected	Everywhere
Drought	Everywhere	Area between Naivasha road and Muniaka road most affected as it is flat and less fertile	Warungana and Karom-boithi due to distance to the river, absence of water ponds due to hard soil and low soil fertility		Upper areas near the forest not so much affected
Dry spell				Areas along the forest are not so much affected	
Flood	Lowland area	Area between Naivasha road and Muniaka road most affected as it is flat and less fertile	Only in flood prone areas (Wa-rungana, Karomboithi, Kiandege)		
Frost	Lower areas	Area between Naivasha road and Muniaka road most affected as it is flat and less fertile	Mostly in the low lying and flat areas of Warun-gana and Karomboithi	Areas along the forest are not so much affected	Areas along the forest are not so much affected

Table 7 (cont.): Areas within the watershed affected by the various climatic events

	Kwaharaka	Kinamba	Njabini	Sasumua Churiri	Sasumua Kiamweri
Heavy rain				Soil area due to steep slopes that are prone to erosion	Low lying and flat areas affected by stagnant water
Gathano	Cold everywhere, frost affecting lower areas	Everywhere	Everywhere	Everywhere	Everywhere
Wind	Black cotton soil areas, Open grassland areas, areas with low tree cover	Most affected as they receive wind both from Sasumua side and the Aberdare mountains	Njabini also affected by wind		Flat areas, along forest areas not so much affected

Source: Author's own compilation

There are also differences in sensitivity for different kinds of livestock. Whereas the early onset of the rainy season, for example, has largely beneficial effects on cattle (increased fodder availability and increased milk production), the effects on sheep, rabbits and chicken are negative; they suffer from diarrhoea, diarrhoea and pneumonia, and coccidiosis, respectively. Delayed onset of the rainy season, which has partly disastrous consequences for cattle, however, does not have substantial impact on sheep and rabbits as they are able to feed on dry grass; the delay even has beneficial impacts for chicken as it increases egg production. Chicken and rabbits, on the other hand, are much more affected during periods of gathano, as they are sensitive to cold. Compared to livestock, the differences in sensitivity are less pronounced for the different crops grown. For delayed onset of the rainy season, frost and drought, farmers reported substantial yield losses of between 50 % to 100 % for most of the major crops grown.

Table 8: Water sources in the different communities

	Kwaharaka	**Kinamba**	**Njabini**	**Sasumua Churiri**	**Sasumua Kiamweri**
Springs				(privately owned)	x (only provides little amount of water)
Piped water	Collapsed in 1970s	In some areas only	In some areas		In some areas only
Water tanks / rainwater harvesting	x	x	x	x	x
Boreholes	4 private	3 private	1 but not functional		1 community but not functional
Water ponds			x		
River			x		x
Communal dam	Silted	Silted	Silted		Silted
Wells	x	x	x	x	x
Sasumua dam				Illegal to fetch water from there	
Water provision throughout the whole year	No	No	River yes, Piped water no, Wells no	Wells dry up, Springs yes Sasumua dam yes	Wells sometimes dry up, Piped water rationed

Source: Author's own compilation

5.3 Coping and adaptation strategies

5.3.1 Coping strategies to deal with climate stresses

Farmers have responded to the impact of these events by employing a number of coping strategies, which were analysed in terms of the agent implementing the strategy (individual, community, or government), the effectiveness of the strategy (is the coping strategy working?) and the timing of the implementation (implemented before (ex-ante), during or after the event (ex-post) occurred). In addition to identifying strategies currently employed, farmers were also asked whether they are aware of any other strategies that could be but currently are not used. Two broad classes of coping strategies are distinguished: those relating to farm management practices and those primarily aimed to minimize livelihood impacts.

Details about the various coping strategies, their effectiveness and their timing of implementation are provided in Table A2–Table A4 in the Annex, while the major points are discussed below.

In Sasumua watershed, most of the coping strategies are employed at the individual level and can be classified as curative (implemented during or shortly after the event occurred) rather than preventive (they would be implemented before the event occurs). In contrast, the majority of coping strategies of which farmers are aware, but which are not yet implemented, fall into the category of preventive strategies.

Of those strategies currently implemented, not all are deemed to be successful (see Table A2 in the Annex). Some of the farm management practices, though they cushion the effect of the impact, are still associated with income losses due to the high expenses involved (buying fodder, etc.) or due to price reductions that result from overproduction (planting alternative crops) or from reductions in the quality of the produce (reducing farm inputs, substituting fertilizer with manure, or reducing the number of livestock). The farm management practices generally regarded as effective include chemicals and veterinary treatment (depending on the physical condition of the livestock) and the plantation of hedges and trees to prevent damages resulting from frost and wind. Sprinkling crops with water to prevent damage from frost, although regarded as being effective, is constrained by limited amounts of water and finances. Different opinions were expressed about the alternation of planting patterns. While delaying the planting pattern in the case of frost was in general regarded as ineffective due to the unpredictability of the onset of the rainy season, planting in a rush in the case of the early onset of the rainy season was in general regarded as effective for those that have seeds or the money to buy seeds, although the period is associated with great stress, overwork and child labour. Different opinions were also voiced regarding the effectiveness of digging trenches and channels to drain water away during periods of heavy rain and flooding. Whereas in Kwaharaka farmers regarded the response as effective, people in Kinamba and Sasumua Churiri reported that this is not the case, especially not in flat areas, where the soil is already waterlogged and water is often directed to neighbouring farms, thus leading to conflicts.

Among the coping strategies employed to minimize livelihood impacts, strategies targeted to minimize health impacts were in general regarded as effective (hospital treatment, heavy clothing and using cream to prevent frostbites), while most related to food shortage (rely on food left in the shamba[9]; buy food, borrow food from neighbours) were regarded as not working or partially working at best (storing food) with the exception being the use of kitchen gardens. A similar picture emerges for strategies targeted at minimizing financial losses, such as searching for alternative employment, borrowing money or cutting expenses by reducing the number of farm inputs and livestock found to be not working or only partially working due to a general lack of jobs, the fact that people do not have bank accounts or lack the necessary security assets to obtain a loan and because the disposal of assets is seen as a short-term solution only (see above). Strategies to deal with water shortage depend to some extent on the type of water sources available, which differ between the various locations in the watershed (see Table 8). Whereas communities in Sasumua Kiamweri and Njabini have rivers nearby with water throughout the year, communities in Kinamba and Kwaharaka lack this type of water source. As a consequence people in Kinamba, Kwaharaka and Sasumua Kiamweri often walk long distances (up to 10 km) to fetch water from Sasumua River. While this type of strategy is found to be effective as there is usually enough water in the river, the distance and physical strain involved poses particular challenges for the poor, the sick and the elderly. Some people have modified the strat-

9 Shamba is the Swahili word for “any field used for growing crops” (Collins English Dictionary).

egy by hiring people or transport facilities to fetch water, which obviously involves extra expenses. Most people rely on their own wells, which, however, dry up during the dry season. The effectiveness of digging ponds deeper also depends on the height of the water table, which, for example, has been reported to be very deep in Kinamba, in contrast to Sasumua Kiamweri and Churiri, for instance, where water is much closer to the surface. Rainwater harvesting is already implemented or planned to be implemented in the future, but at least one group reported that the amount harvested is insufficient due to the small size of water tanks. The strategies to deal with social conflict and stress are to share problems with friends and neighbours and to initiate a process of consultation with the affected parties, which is usually regarded as effective, although divorce and suicide were mentioned as alternative responses, thereby calling their effectiveness into doubt.

Interestingly farmers also identified a number of coping strategies, such as collection of timber and non-timber forest products from the forest and the burning of sawdust and wheat to prevent frost damage; these strategies were employed in the past and regarded as effective but are not implemented widely anymore. The reasons for the abandonment of these strategies include the introduction of forest bans and regulations and unawareness, laziness and high expenses associated with the burning of sawdust to prevent frost (see Table A3 in the Annex).

The preventive strategies not yet implemented (see Table A4 in the Annex) comprise modern farm management practices, including silage making; zero-grazing; improved livestock breeds; drought-resistant crops; the adoption of greenhouse technology; increasing storage of food, seeds and water; irrigation; soil conservation structures, such as gabions, terracing and contour farming; and more mixed farming. The preventive strategies to minimize livelihood impacts of which farmers are aware but which are not yet implemented include electric heaters in homes, off-farm employment (setting up a business), drilling boreholes, storing food, improving personal hygiene, and constructing an additional electric fence at the forest boundary to prevent animals from encroaching farmland.

5.3.2 Adaptation strategies to deal with changing trends in temperature and rainfall

Farmers have also implemented some strategies to deal with changing trends in temperature and rainfall. As revealed during the changing trend analysis concurrent with the decreasing amount of rainfall and reduction in water availability, water conservation activities increased in all areas of the watershed. These activities include roof rain water harvesting in combination with water tanks and the construction of water ponds and small dams. However, farmers acknowledged that the effectiveness of these strategies is limited, given the decrease in rainfall and the great demand for water, with water shortage still perceived to be a major problem. According to agricultural extension officers working in the area the rate of water conservation in the watershed is still comparatively low; the main reasons cited are that there is a lack of funding for water conservation structures and that there used to be plenty of rain.

The changing trend analysis also revealed that, with increasing temperatures, farmers started to engage in the production of new varieties of crops, especially beans, maize and peas. However, according to agricultural extension officers, farmers often introduce new crops by trial and error, not based on expert advice. In addition, the new crops are often affected by fungal diseases, which decrease their productivity and lead to extra expenses for farmers in the form of increased use of agrochemicals, once again demonstrating the limited effectiveness of this strategy.

The effectiveness of current strategies and the implementation of preventive strategies is thus hampered by a number of constraints, particular in the area of finances, knowledge and technology, as is reflected in the rating of adaptive capacity (see section 5.5). In addition, some of the constraints are also linked to the historic development in the watershed. Population pressure and a reduction in land sizes, for example, have led to interference with the drainage system originally developed by the colonialists. This has limited the effectiveness of drainage channels in the case of floods and heavy rain and often caused conflicts between farmers, as the water is often directed to neighbouring farms. Furthermore, the relatively short history of settlement in the area with farmers having migrated from other places with different climatic conditions has also hampered the use of traditional coping strategies. As one participant framed it during discussions *"Kikuyus are not originally from this place; we did not know this area; we were not used to the climate of the area"*.

5.4 Future exposure to climate related stress and adaptation options

The direction in which the climate in East Africa and in Kenya in particular might go is highly uncertain (Boko et al. 2007; SEI 2009), partly due to the limited availability of regional climate models; available models also provide a wide range of different results. In a recent analysis on climate science and impacts in Kenya, a joint report by IGAD Climate Prediction and Applications Centre and the Stockholm Environment Institute concludes that, while model predictions about temperature increases are relatively consistent, there is a wide variation regarding the projections of future rainfall patterns and the occurrence and severity of floods and droughts (ICPAC / SEI 2009; SEI 2009).

Thus, given the uncertainty and partly contrasting information of the various climate models, farmers were asked to envision different possible climate scenarios and discuss their impacts and possible strategies to deal with these changes. In addition, farmers were encouraged to discuss whether current coping strategies are adequate in order to deal with these changes.

The scenarios discussed included a further increase in temperatures, a reduction in the amount of rainfall, an increase in the amount of rainfall, a further shift in the timing of the rainy season, an increased incidence in the severity of droughts, and an increased incidence of flooding. As can be seen from Table 9 farmers perceived the impact of these scenarios as quite negative, anticipating an increased incidence of pests and diseases, food shortage and increases in poverty for most of the scenarios. Even for the scenario of increases in rainfall – which, given the current problem of water shortage, one would expect to have at least some positive impact – negative impacts, such as increases in crop and human diseases and increases in soil erosion prevailed.

5.5 Adaptive capacity

After the discussion of coping and adaptation strategies, farmers were asked to identify the assets they deemed important for implementation. These assets were grouped according to livelihood assets in terms of human, social, natural, physical and financial capital. For each of these categories farmers were asked to select five indicators separately for floods, droughts and climate variability and in two different areas of the watershed: 1) the

Table 9: Perceived impacts of various climate scenarios

Scenarios	Perceived impacts by farmers
Further increase in temperature	Land dries very fast Drought More pests and diseases Decreases in rainfall Lack of fish in rivers Shortage of water in dams, rivers and wells Shortage of food, as current varieties will not be suited
Further reductions in rainfall	Desertification More pests Failure of planting Shortage of food, hunger Increase in poverty Increases in market prices (but lack of finances to buy)
Increase in the amount and intensity of rainfall	Increased occurrence of floods More crop diseases (esp. fungal diseases) Increased occurrence of human diseases caused by overflow from pit latrines Increase in soil erosion
Shifts in the timing of the rainy season	Shortage of seedlings and seeds Death of livestock in the case of delayed rains and dry spell Shortage of food, hunger Increase in poverty Poor market prices for food produce
Droughts becoming more severe	Lack of water Death of animals and people Shortage of food, hunger Poor diet Poor hygiene (due to lack of water) Increase in poverty, increase in theft, unemployment

Source: Author's own compilation

more upper lying areas and areas with forest nearby (Sasumua Kiamweri and Sasumua Churiri and upper parts of Njabini, around 2,500 m–2,700 m); and 2) the lower lying areas without forest (Kwaharaka and Kinamba around 2,500 m).

Table 10 shows the indicators selected for drought for the upper lying areas and areas close to the forest. The indicators selected for the other events and for the lower lying areas without forest are provided in Table A5 and Table A7 in the Annex, which only show slight variations to those selected for drought.

Most of the indicators selected by farmers are similar to those typically identified in the literature. The exception might be the indicator positiveness / willingness to solve the problem, which is not usually mentioned under the human capital category. Optimism and enthusiasm were, however, also identified as part of human capital in the self-assessment of adaptive capacity by local resource managers in Australia (Brown et al. 2010), indi-

Table 10: Selected indicators for adaptive capacity for drought (upper lying areas and areas close to the forest)

Human capital	Social capital	Physical capital	Natural capital	Financial capital
Knowledge	Welfare groups	Farm inputs	Tree cover	Funds
Health	Cooperative societies	Water tanks, dams wells, ponds	Soil Quality	Savings
Positiveness/willingness to solve the problem	Friends	Buildings	Livestock	Bank account
Commitment	Church groups	Food store	Forest	Security assets
Skills	Family	Roads	River	Employment in agriculture

Source: Author’s own compilation

cating that local communities see this as an important asset base for implementing adaptation.

For each of the indicators, farmers were asked to rate the current state from a scale of 1 to 5; with 1 indicating a very bad current state and 5 indicating a very good current state[10]. In addition, farmers were asked to provide reasons for their choice. The rating was originally supposed to be done individually on a sheet of paper to differentiate the rating of adaptive capacity between men and women and according to socio-economic status, given the stated disadvantages of conducting rating in a group as highlighted by Roth et al. (2010). However, during a pre-test conducted with six farmers it became evident that the majority of farmers had trouble filling in the sheets correctly and in time, partly because of illiteracy. As such, ratings were conducted in group settings, though separately for men and women in two different areas of the watershed (on the one hand, the lower lying areas without forest nearby and on the other the upper lying areas and, areas with forest nearby). The rating exercise was conducted for climate variability as well as for droughts and floods (in the lower lying areas of the watershed). The results of the rating exercise served as the basis for discussions of strategies to increase the various elements of adaptive capacity.

Ratings of adaptive capacity confirmed earlier results from group discussions showing constraints in adaptive capacity in most capitals and slightly different ratings between 1) the upper areas and areas with forest nearby and 2) the lower areas without nearby forest. Whereas difference at the aggregate level between climate variability, floods and droughts, and between genders are not so pronounced, they become more apparent at the scale of individual indicators.

5.5.1 Aggregate scores of adaptive capacity

At the aggregate level, most indicators receive an average score of between two (bad) and three (average) and do not differ much between climate variability, floods and droughts (see Figure 2 to Figure 9). The exception is the rating of natural capital for drought and climate variability by men in the

10 This differs slightly from the approach outlined in Roth et al. (2010), who did not rate the current state but the transformability of assets for adaptation to climate change and equated low transformation with high priority for action.

upper areas and areas with forest nearby, which received a good rating (four). For most of the capitals, the lower areas without nearby forest receive a slightly lower score than the upper areas and areas close to the forest, although the difference is not very great. The exception is again natural capital, where the upper areas and areas close to the forest receive a much higher score due to the good state of forests and rivers in those areas. The results of the rating exercise thus confirm earlier results from group discussions, where farmers considered the upper areas and areas close to the forest to be less affected by drought and frost due to the proximity to the forest and the presence of permanent rivers.

In general, there is little difference between the ratings of women and men. Women tended to give slightly higher ratings for human capital and a slightly lower rating for social and natural capital. For human capital, differences between men and women are especially pronounced in the rating of commitment and positiveness towards drought and climate variability in

Fig. 2: Rating of adaptive capacity for drought in the upper areas of the watershed and areas close to the forest

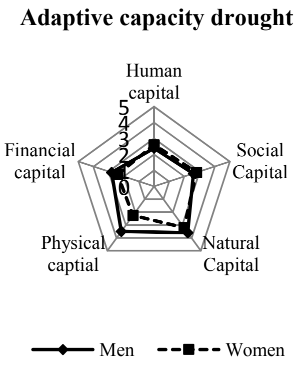


Fig. 3: Rating of adaptive capacity for drought in the lower areas of the watershed without nearby forest

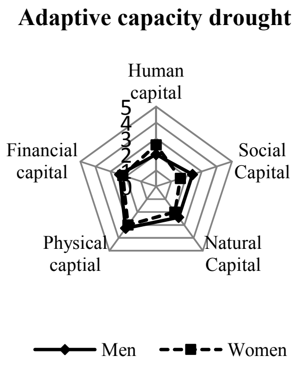


Fig. 4: Rating of adaptive capacity for drought done by the district livestock officer for the whole area

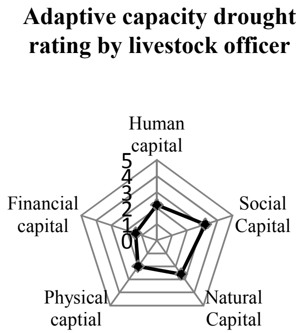
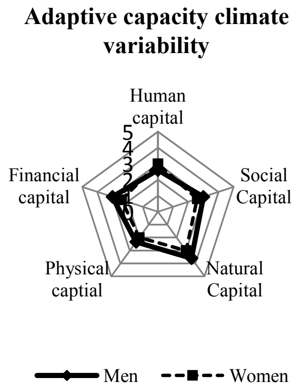


Fig. 5: Rating of adaptive capacity for climate variability in the upper areas of the watershed and areas close to the forest



Source: Author's own calculations

Fig. 6: Rating of adaptive capacity for climate variability in the lower areas of the watershed without nearby forest

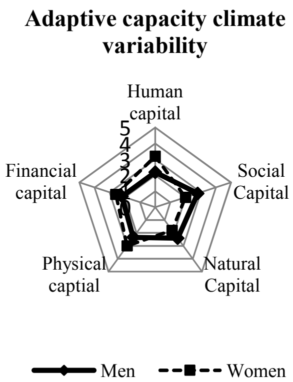


Fig. 7: Rating of adaptive capacity for climate variability by the district livestock officer for the whole area

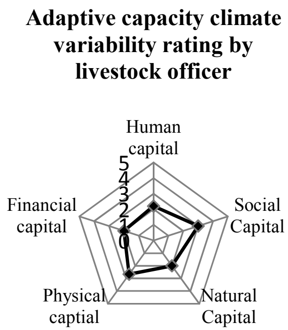


Fig. 8: Rating of adaptive capacity for flood in the lower areas of the watershed without nearby forest

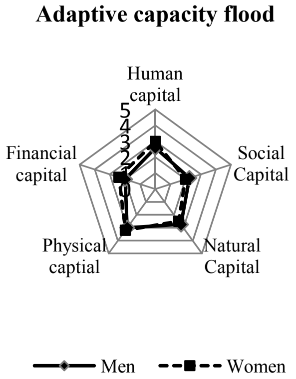
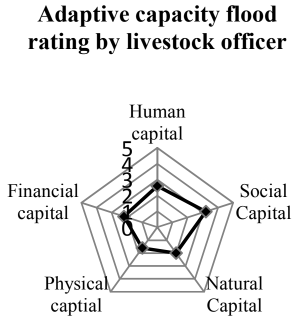


Fig. 9: Rating of adaptive capacity for flood by the district livestock officer for the whole area



Source: Author's own calculations

the lower areas without nearby forest. Women especially complained that men are not committed and not available for work, a fact interestingly reflected in the rating of men, who gave themselves a low score, indicating that men have quite good self-reflection.

For social capital, the most apparent difference is in the rating of church groups for climate drought and climate variability. Whereas men reasoned that church groups *"bring a positive attitude towards life"* and boost moral, women lamented that churches only talk about heaven and do not say anything about climate problems. Both groups, however, saw great potential in using church groups to discuss and learn about climate problems; after all, most members of the community go to church, so there is thus great outreach to the community.

For climate variability, women gave lower ratings to friends than men did. Whereas men said they do discuss strategies on how to deal with climate variability among friends, women complained that friends are far away and that they usually do not talk about climate variability.

For physical capital, the most pronounced difference is in the rating of buildings for drought and floods. Men considered buildings to be very good given that everybody *"had shelter and no one had to sleep outside"*, whereas women reflected more on practical things – not having enough storage (with farm chemicals, food and farm equipment all stored in the same place) and having inadequate shelter for animals during floods.

In the lower areas, the difference in ratings for natural capital is largely due to the difference in ratings of forest. Whereas women reflected on the fact that there is no forest in their specific area and thus gave a rating of one, men considered the forest in the upper areas, where they go in the case of adverse climatic events in search of fodder and water. The difference in ratings between men and women thus suggests that the spatial proximity of forests is much more important for women than for men.

In the upper areas and areas with forest nearby, similar differences occur in the rating of human capital, with women rating willingness higher than men for climate variability. For natural capital, interesting differences occurred in the rating of soil quality. Whereas women considered the soil quality to be bad, with soil erosion having contributed to the loss of top soil and reduced fertility, men perceived the texture and quality of the soil as good, although they also mentioned that fertility has been decreasing. As in the case for the lower areas without forest, differences in physical capital for the upper areas and areas close to the forest also relate to the different ratings for buildings for the same reasons.

5.5.2 Scores of individual indicators

The indicators receiving the lowest scores within each category were largely consistent across the different climatic events. In some instances, however, differences occurred (see Table A5 – Table A7).

Within the category of human capital, skills, commitment (apart from floods) and positiveness (except for climate variability for women) tended to get quite low scores. The low level of skills is to some extent astonishing because the area has an agricultural training centre that offers seminars for farmers for free. During discussions with farmers and district government officials several factors emerged that explain this discrepancy. First, there is ignorance among farmers, which was acknowledged both by farmers themselves and district government officials. Farmers do not see the value of attending those courses either because they lack knowledge about the importance of the courses or they do not perceive them to be useful. The farmers added that they do not attend courses because they are not paid to do so, indicating that they do not value the knowledge gained during seminars but only see the opportunity costs of attending the seminar: time spent and transport expenses. Second, the advancement of practical skills by farmers seems to be hampered by a disconnect between farmers and agricultural extension officers. There is a gap between the demand-oriented approach by agricultural extension officers and the supply-oriented expectations by farmers. Farmers, for example, complained that agricultural officers are always in their office but never come to their field. The farmers also stated that they would not call the officers for fear of having to pay transport and subsistence allowance.

Among social capital, cooperative societies gained the lowest score because they collapsed. Different opinions were voiced about the need to revive them. While some of the participants regarded them as very important due to their ability to influence the prices of their farm products, others seemed to be too discouraged by bad experience, mistrust and bad management in the past. Welfare groups also gained bad to average scores in most instances. In both areas, people complained that not many people joined welfare groups, partly due to low levels of trust that might be linked to bad experience with the running of existing welfare groups; people in both areas complained about mismanagement and badly organized groups that lack a vision and focus on the collection of money rather than the implementation of activities. Women also complained that most groups are for women only and do not talk about climate issues. In the lower areas without nearby forest, church groups received particularly low ratings from women. As noted above, the reasons provided were that churches do not talk about climate issues. The lower areas without nearby forest also gave friends lower ratings than the upper areas and areas close to the forest, with friends perceived to be too far away, not helping out in times of hardship and not being open for the problem of others.

Within the category of natural capital, soil quality tended to get the lowest score, as soil was perceived to be exhausted and of bad quality, a fact that had already become visible during the changing trend analysis. The exception is the ratings of men in the upper areas and areas close to the forest, which rated the soil texture to be good. As noted above, rivers and forest received low scores in the lower areas due to the absence of forests and permanent rivers in the area. In the upper areas and areas close to the forest, men rated livestock as bad due to limited diversification in the type of livestock kept, poor quality breeds and the limited amount of livestock that can be kept on small plots.

Food store and greenhouses were among the indicators that received the lowest scores under physical capital. The low score of greenhouses is due to the high expenses and lack of knowledge in setting up and running greenhouses. As a result, not many people have invested in greenhouses. The lack of knowledge about the construction of food stores was also regarded as one reason for the low ratings for food stores, in addition to the perishable nature of foods.

Within the category of financial capital, savings and bank accounts received the lowest scores. While funds received average scores, farmers complained that they have no money to save due to the high expenses of farm inputs compared to the low price for their farm products. Most farmers grow potatoes and cabbages as the main crops, which leads to overproduction, and hence low prices. However, the discussion revealed that low levels of financial capital are not only related to the limited availability of funds but also to deficits in financial management, as comments made during discussions (such as *"when people have money in their pocket it is like running water"*) clearly show. In addition, most farmers do not have bank accounts, partly because they have no money to save but also because *"bank accounts are for the rich"*. Security assets tended to get low to average scores. Farmers noted that not all people have security assets, like title deeds or logbooks, and even if they do they are too risk-averse and afraid to use them to get a loan.

In some instances, individual indicators received different ratings for climate variability, floods and droughts. As farmers were always asked to provide reasons for their choice of rating, some insights were gained on whether these differences reflect real differences in adaptive capacity or are results of the repeated rating process. The ratings sometimes seem to reflect real differences. Both men and women rated the commitment in the case of floods as much higher (difference of 1–2) than in the case of drought because there are *"no other ways to deal with floods once they are there"*. Men also rated the welfare groups lower than in the case of droughts, as flooded areas make it difficult for groups to meet and because the uncoordinated channelling away of water from the individual farms leads to animosities between neighbouring farmers thus breaking the morale of welfare groups. For water tanks, wells, dams and ponds, women rated water tanks, which they considered to be too small, during drought, whereas they rated water ponds for floods, as reflected in the lower ratings for drought. For climate variability women rated positiveness higher than for droughts and floods, which seems to suggest that they find extreme events harder to deal with.

In other cases (tree cover, land, friends, church groups, family, funds, savings, bank account, employment in agriculture, etc.), ratings were slightly different (difference of 1) between floods, drought, and climate variability although the reasons provided were fairly similar, so that differences do not seem to be real. Another explanation for the different ratings of climate variability by women in the lower areas without nearby forest could be that one elderly woman who was not present during previous ratings joined the group. The woman was quite dominant and although the facilitator noted the problem and tried to react on it, the presence of the woman could have unduly influenced the results.

5.6 Implementation of adaptation

As mentioned above, the implementation of adaptation is influenced by a number of factors, including recognition of the need for adaptation, the belief that adaptation is possible and desirable, and willingness to undertake adaptation.

5.6.1 Recognition of the need for adaptation

The recognition of the need for adaptation is closely linked to the problem perception of climate variability and change. If the impact of certain climate events and trends is not perceived to be problematic or ranks low as compared to other problems, the willingness to implement adaptation options is likely to be low.

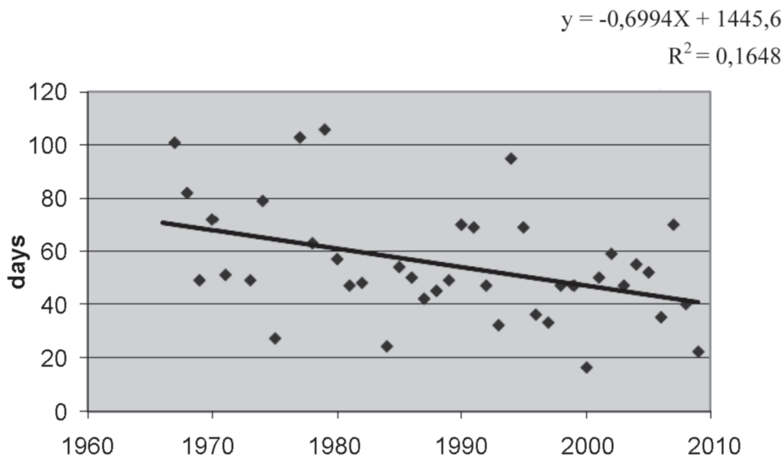
In order to examine the perceived importance of climate problems as compared to a host of other problems, problems were ranked. Farmers were encouraged to discuss and list a wide range of problems and select the eight most important ones. Pair-wise ranking was then done to identify the most important problems. Interestingly, climate problems (including both climate change and unreliable rainfall) were mentioned in three out of the five areas in the watershed, where it ranked among the top four problems (see Table A8 – Table A12 in the Annex). Climate problems are thus ranked highly in the problem perception of communities in Sasumua watershed.

For the purpose of triangulation, the perception among farmers of climatic and non-climatic trends were compared with those of district government officers, hydrological experts, and available meteorological data. The district government officers and hydrological experts confirmed the trends depicted by farmers during group discussions, indicating that farmers show a high level of awareness about past changes in the watershed.

Statistical analysis of available meteorological data using the non-parametric Mann-Kendall test revealed that, although the overall amount of rainfall over time has not changed, the amount of rainfall in the long rainy season and the number of rainy days per rainy season has reduced significantly over time, as can be seen in Figure 10 and Figure 11. In addition, the Mann-Kendall test revealed significant decreases in the number of rainy days at the monthly (April, May, June, August, October), seasonal (March–April–May) and annual level (see Table A14). The Mann-Kendall test also showed significant changes regarding the seasonality of long rains, with cessation dates occurring earlier and the duration reducing (see Table A15). No apparent trend, however, was discernible for the amount of rainfall and the number of rainy days for the short rains, although there is a weak significant increase for the duration of this season. In terms of extreme events, the Mann-Kendall test revealed significant increases in the maximum length of dry spell for the months of April, May, June and August, while no significant trends was discernible for heavy precipitation. Rainfall intensity, on the other hand, shows an increase at the annual level and for the months of June and October (see Table A16 – Table A18). The meteorological evidence thus confirms farmers' claims in terms of changes in the amount of rainfall and the number of rainy days for the long rains, a shift in the timing of the rainy seasons and the increased occurrence of dry spells. Claims that heavy precipitation events had reduced over time, could, however, not be confirmed by the meteorological data. The farmers' perception that temperature had increased over time could not be confirmed due to lack of available temperature data for the area.

The recognition of the need for adaptation can also be inferred from the fact that many of the current coping strategies to deal with current climate related stresses are perceived to be inadequate, either because they are not

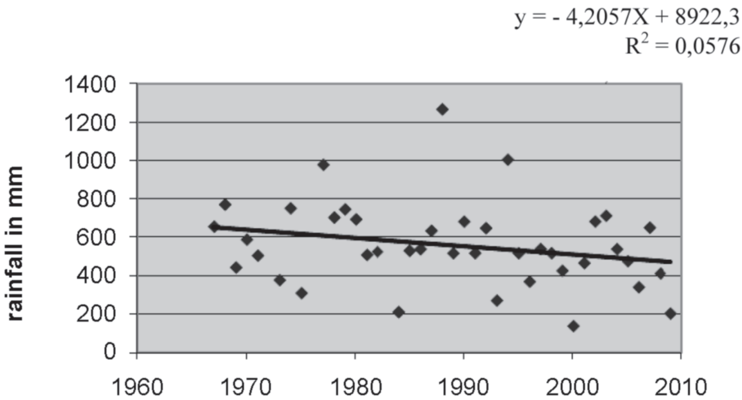
Figure 10: Changes in the number of rainy days for the long rains over time[1]



[1] The onset and cessation dates and thus the duration of the rainy season was calculated according to Ovuka and Lindquist (2000) and Diop (1996) cited in Camberlin and Diop (Camberlin / Diop 2003) , which define the onset as the "first period, after 10 March (long rain period) and 1 October (short rain period), of five days with at least 25 mm of rainfall, the start and at least two other days in this period are wet (i.e. more than 0.1 mm rainfall received) and no dry period of seven or more days occurs in the following 30 days" and "at least 7 consecutive dry days", respectively. However, the condition of "no dry period of seven or more days occurring in 30 days following the onset of the rainy season was relaxed to 10 days, as it was found that the more stringent criteria produced too many failed onsets of the rainy season. In addition, the time restriction was moved forward to 1st of February and 1st of September in order to include the possibility of early starts.

Source: Author's calculations

Figure 11: Changes in the total amount of rainfall during the long rains over time



Source: Author's calculations

working or because they are not yet implemented due to various constraints (see section 5.3 and Table A2–A4 in the Annex). Interesting differences were found in the perceived adequacy of current coping strategies to deal with future changes in climate. Whereas strategies to deal with droughts becoming more severe were perceived to be inadequate, strategies to deal with increased shifts in the timing of the rainy season were perceived to be adequate in the upper parts of the watershed only, again due to the better availability of water sources and the proximity of the forest. Current strategies to deal with floods were perceived to be adequate *"provided that they are implemented,"* which again reflects farmers' current lack of involvement in preventive strategies until flooding occurs. The differences in the adequacy of current coping strategies between floods and droughts could also reflect the fact that farmers are relatively used to the incidence of flooding, given that the watershed has traditionally been a wet place with waterlogged soil, whereas droughts are experienced more rarely. Many of the strategies identified to deal with possible future changes in climate coincide with the preventive coping strategies that are not yet implemented (see section 5.6.4.3), again highlighting the need for adaptation.

Low to average ratings in many indicators of adaptive capacity combined with high ratings given towards the importance of improving the current situation also reveal the recognition about the need for adaptation. The ratings made by farmers were compared with the ratings made by agricultural officers, who were asked to rate according to their perception of the adaptive capacity of farmers. Unfortunately, ratings could only be obtained from one district livestock production officer. The results were, however, broadly similar to those of the farmers, suggesting that there is a shared problem perception among farmers and district government officers. In some indicators of adaptive capacity for floods, however, the district livestock production officer tended to give higher ratings for social capital for all indicators except friends and much lower ratings for physical capital, with all indicators except water tanks, dams, wells and ponds receiving a lower score.

5.6.2 The belief that adaptation is possible and desirable

During discussions about adaptation options to deal with future climate change, farmers regarded the implementation of these strategies as feasible provided that awareness, knowledge and education are increased. The importance and desirability of increasing levels of knowledge is also reflected in the high ratings the indicator received in terms of priority for actions, as shown below.

To examine the desirability of facilitating adaptation (i. e., increasing the determinants of adaptive capacity) farmers were asked to rate the priority of action to improve the current state of the indicators of adaptive capacity on a scale from 1 (very low priority of action) to 5 (very high priority of action). Farmers were told that a low current state of an indicator does not necessarily translate into a high priority of action and vice versa. In addition, farmers were asked to provide reasons for their choice.

Most of the indicators received high ratings for the priority of action to increase their current state (see Table A5 – Table A7). Overall indicators receiving the highest scores were broadly similar between women and men, climate variability, floods and droughts and between the upper areas and areas with forests nearby and the lower areas without nearby forest. In some instances indicators receiving the highest priority of action coincided with those receiving a low score for the current state (skills, cooperative societies, soil quality, forest and tree cover in the lower areas, food store, greenhouse, savings, etc.). Farmers thus see a great need to improve the current state of these indicators. In addition, high priority was also given to indicators receiving an average or good score (forest, river, funds, health, knowledge, farm inputs, family, church groups, roads, etc.), indicating the great importance farmers gave to those indicators in dealing with flood, drought or climate variability.

Many of the indicators under natural capital had high priority of action despite a good or average score, indicating that farmers are aware of their dependence on natural capital and place great store on maintaining and enhancing the current state. Forests were, for example, regarded as an important source of wood, timber and fodder during drought and valued for their properties to act as windbreaks and modify the impact of frost. Funds and health were regarded as the backbone for implementing many of the strategies, as some of the reasons provided for the ratings show, such as *"health is everything", "money is everything"*, and *"without funds there are no savings"*. Similar reasons were provided for increasing the level of knowledge about strategies to deal with drought, floods and climate variability. Farm inputs were seen as one of the main ways for increasing produce, and hence funds. The family is seen as the basis on which to solve problems, as opposed to friends who *"come and go"*; church groups are seen as an important way to reduce stress levels during crises and valued for their outreach function (*"where you can get the community together is at the church"*). Farmers, however, said this function could be substantially improved if they also talked about climate problems.

The district livestock production officer also gave a high priority to most of the indicators that farmers rated highly, again indicating a shared perception about the desire to improve the current state of indicators.

5.6.3 Willingness to implement coping and adaptation strategies

The willingness to implement adaptation is to some extent reflected in indicators for positiveness/willingness to solve the problem and commitment, which were selected by farmers as important indicators of adaptive capacity. The low current rating that these indicators received, especially in the ratings by men and for droughts and climate variability, indicate a low willingness to implement coping and adaptation strategies.

This low willingness was also evident when discussing the reasons why known preventive strategies are not being implemented. In addition to financial constraints, the limited availability of land, the size of land and a lack of knowledge, farmers cited cultural reasons and ignorance as some of the main reasons why preventive measures are not more widely adopted. With reference to their tribal culture, typical responses were *"Kikuyus run at the last minute", "Kikuyus tend to act in the 11th hour", "a Kikuyu rushes when it is already dark", "we are used to learning from mistakes", "there is no hurry in Africa"* and *"people will only work when the problem strikes"*. Farmers also admitted that they have a *"don't care"* attitude and are ignorant, citing the example of not taking an umbrella with them as a preventive measure despite knowing of the high probability of rain in the rainy season – *"we know that it is raining nowadays, but no one in this room is carrying an umbrella with them"*. On the other hand, both commitment and low willingness to solve the problem also received high ratings in terms of priority of action, suggesting that farmers are aware of this problem and willing to change attitudes.

5.6.4 Adaptation options

5.6.4.1 Options identified by farmers to increase the determinants of adaptive capacity

The fact that willingness and commitment to solve the problem are a real bottleneck in implementing adaptation options also became visible during discussions about which actions need to be taken to improve the current state of the indicators. For the two indicators with the highest score in each category, farmers identified a number of actions to improve the indicator's current state (see Table A19).

In almost all indicator categories, some actions that actually relate to increasing the level of commitment were mentioned. In many cases, they pertain to: seeking, following and implementing the advice given, say, by agricultural extension workers and health officers; attending seminars and meetings; obeying rules and regulations laid down in welfare groups and families; and changing attitudes from *"just saying to saying and doing"*. Interestingly, the options suggested for an increase in the level of commitment and positiveness relate to improving the level and flow of information; i.e., an information deficit might be the underlying reason for the low level of commitment and positiveness. Increasing the level of awareness is in fact also explicitly expressed as an option to increase the levels of indicators in most of the categories – mainly in terms of increasing awareness about the importance of certain assets, i.e. the importance of knowledge and skills, welfare groups, good family relationships, dams, water and soil conservation and greenhouses.

In addition to awareness-raising, there is an expressed need in most categories to increase levels of knowledge and skills through training and seminars. The expressed needs for knowledge provision and trainings are thus not limited to improving farming methods, soil conservation and tree planting, but also include welfare groups, hygiene and health issues (including diets), and financial management.

Apart from these *"soft"* adaptation measures, farmers also identified a number of *"hard"* adaptation measures: increasing the level of tree planting; implementing new and/or improved methods of farming, such as zero-grazing and crop rotation; high-quality breeds; certified, drought-resistant seeds; organic farming; soil conservation (bench terracing, planting of Napier grass, and agroforestry); desilting old dams and constructing new ones; and repairing roads.

While some of the options can be done by individuals, for others there is a clear need for external assistance. Most of the actions in which individuals are the sole actor implementing the action are those related to increasing commitment levels. However, as noted above, even here external assistance from agricultural extension officers and community development officers is required through awareness-building. For the other options, outside assistance is mainly required in terms of capacity building, i. e. information and training about new farming techniques, soil conservation, setting up and running welfare groups and financial management.

5.6.4.2 Options identified by district government officials to increase determinants of adaptive capacity

In addition to farmers, district government officials were also asked to identify adaptation options to increase the determinants of adaptive capacity.

As shown in Table A20 in the Annex, most of the actions identified closely correspond to those identified by the farmers. District government officials also clearly see a need to help farmers enhance the skill and knowledge levels. Unlike farmers, who mainly identified local agricultural extension officers or *"experts"* as external actors providing assistance, district government officials included a wider range of actors, including NGOs, research institutions, financial institutions and government institutions at the higher levels as important actors.

In the discussion on some of the constraints faced in implementing these options, district government officials also complained of low levels of commitment and high levels of ignorance on the part of farmers, which supports the finding made earlier that willingness to implement adaptation options is low. Additional constraints identified are limited financial resources on the part of farmers and government to implement adaptation options.

5.6.4.3 Implementing adaptation options

During the envisioning exercise for possible future climate change, farmers were also asked to identify adaptation options to deal with these changes. As Table 11 shows, many of the adaptation options identified closely correspond to the preventive measures known to farmers but not yet implemented, along with measures identified to enhance certain elements of adaptive capacity, including such soil conservation practices, as building terraces and gabions, increasing the level of tree planting, introducing new crop varieties, investing in added value, switching to mixed farming, adopting greenhouses, increasing levels of water harvesting, and raising awareness about possible future climate change.

Table 11: Adaptation options identified by farmers to deal with future changes in climate

Identified adaptation options	Scenarios					
	Further increase in temperature	Further reductions in rainfall	Increase in the amount of rainfall	Shifts in the timing of the rainy season	Droughts becoming more severe	Increased risk of flooding that results from increased intensity of rainfall
Tree planting	x	x				
Introducing new varieties of crops		x			x	x
Using indigenous crops that can withstand heavy rain			x			x
Silage making				x		
Increase levels of water harvesting	x	x	x			
Rehabilitate boreholes		x				
Construction of gabions and terraces to control soil erosion			x			
Greenhouses	x		x			x
Preservation of food and food storage				x	x	
Increase education and awareness about possible changes	x				x	
Change farming practices towards mixed farming	x			x		
Invest in value addition				x		
Reduce food intake / use stinging nettles instead of kales					x	
Ask for relief food					x	

Source: Author's own compilation

6 Discussion and conclusions

The purpose of this study was to use a participatory vulnerability assessment to identify practical measures that would enhance the Sasumua watershed community's ability to deal with current climate extremes and variability along with future climate change. In conducting the analysis, considerable emphasis was put on developing a better understanding of the factors that shape adaptive capacity as a basis for identifying practical adaptation measures.

Farmers in Sasumua watershed remain exposed to a wide range of climatic events, including floods, drought, frost and gathano, and have identified a changing trend in temperature and rainfall over the past decades, as was partly confirmed by meteorological records. Although farmers have employed a number of coping and adaptation strategies to deal with these events and trends, there is a great need for the implementation of further adaptation strategies for current and future climate extremes and variability.

The need for adaptation arises from the limited effectiveness of current coping strategies, the insufficient use of preventive strategies and the low levels in several categories of adaptive capacity. Constraints in adaptive capacity are especially evident for the indicators of skills, commitment, positiveness, welfare groups, cooperative societies, soil quality, food stores, greenhouses, savings, and bank accounts.

Farmers have identified a number of options to increase the various indicators of adaptive capacity and implement strategies to deal with future changes. Most elements of adaptive capacity can only be enhanced with the help of external actors, such as agricultural extension officers, especially for the enhancement of skills and knowledge needed to implement farm management strategies to deal with climate variability and change. In this regard, the current disconnect between the supply-oriented expectations of farmers and the demand-oriented approach (offering advice) of by agricultural officers (as evident in the low attendance of trainings and seminars by farmers) seems to pose difficulties for fostering greater levels of cooperation. On the other hand, both farmers and district government officials see the problem the same way and have identified a similar set of possibilities for increasing the various elements of adaptive capacities, which is encouraging. In fact, some of the actions identified – such as inviting experts to welfare and self-help groups to raise awareness and using them to foster training in other areas seem to be a promising start for fostering greater levels of cooperation.

While farmers in general regarded the implementation of these strategies as feasible and desirable, current low levels of commitment and willingness to implement these strategies might turn out to be a real hurdle that can only be overcome through increased awareness and capacity building, again demonstrating the need for a greater cooperation between farmers and extension officers. Farmers have decided to follow up on the PRA workshops conducted by forming a self-help group to increase the use of preventive strategies, indicating that increasing the awareness of farmers through careful explanations and engaging them in a process of self-reflection might indeed go a long way to change behaviour.

In general, the application of participatory approaches allowed key constraints in adaptive capacity and adaptation options to be identified. The workshops were very well attended, and discussions were lively and active, with both men and women contributing during group discussions. A former local chief mobilized farmers and distributed written invitations, which certainly helped produce the high attendance rates, as did the tea and lunch served during the workshops. In addition, farmers also valued the knowledge and insights gained during the workshops. In particular, the realization that most farmers engage in curative rather than preventive strategies proved to be a real eye-opener and prompted action; farmers decided to form a self-help group to advance the implementation of preventive strategies. The farmers also valued the participatory nature of the workshops, as opposed to the normal kind of seminar/workshop where *"we just sit and listen"*. The advantage of using participatory approaches noted in the literature – the process leads to empowerment of participants and prompts action to implement change (cf. e. g. Brown et al. 2010; Chambers 1994a) – was thus also exploited in this study.

One possible disadvantage of using participatory approaches to vulnerability analysis is that much of the information provided by the local community is based on their perception, which does not necessarily reflect reality. Van de Steeg et al. (2009), for example, have shown that farmers' perceptions of the frequency of good, average and poor seasons in Kenya can differ markedly from long-term climate data. As far as possible, much of the information generated through the PRA was thus triangulated using meteorological records, literature sources on the area, and discussions with district government officials and experts working in the area. In general, these other sources confirmed the perceptions of farmers, indicating that farmers show a great level of awareness both with regards to current problems affecting the watershed and to changes in climate trends over time.

The farmers were also able to identify and rate the different indicators of adaptive capacity. After careful explanations, participants were able to understand the concept of adaptive capacity, allowing them to conduct the rating exercise at ease. Although ratings of adaptive capacity between floods, droughts and climate variability did not differ much at the aggregate level, there were some differences at the level of individual indicators, both with regards to the selection of indicators and their ratings. Clearly, adaptive capacity is specific for different events and justified the separate rating of adaptive capacity for droughts, floods and climate variability.

Roth et al. (2010) identified several problematic issues that occurred during rating exercise of adaptive capacity in Bangladesh and India, including group dominance, audience (participation and disruption by outsiders), and time effects (participants not being able to stay for the whole duration of the workshops due to other commitments). These problems also partly arose during this study, although several steps were taken to minimize their effects. Given the problem of group dominance influencing the rating process, the rating exercise for this study was originally to be done individually on a sheet of paper. However, following the pre-test, this approach was abandoned due to time constraints and participant illiteracy. Time effects arose as the duration of the workshops were quite long, stretching over the whole day for the rating of adaptive capacity and for multiple days for the first series of workshops and for the rating of adaptive capacity for the lower areas. Although the rate of participation was in general quite high, some farmers could not make it on the following days and then sent other family members (i. e., new participants) as proxies, which proved to be a problem in the rating exercise for adaptive capacity for women in the lower areas. In that group, one woman who had not been there on the previous day tended to be quite dominant, which influenced the rating process and might explain the difference in ratings for individual indicators of climate variability as compared to drought and floods. In hindsight more careful steps should have been taken to prevent new participants from entering multi-day workshops. Apart from family members being sent as representatives, other disruptions by curious audiences as in Bangladesh did not occur because meetings were held in closed buildings (schools, churches, and offices), which minimized attraction by non-participants. To minimize problems of fatigue associated with the long duration of the workshops, adequate breaks for lunch and tea were included. In addition, a couple of energizing games were conducted during the workshops, which proved to be effective as ice-breakers and in keeping discussions lively and engaged. To minimize travel time and expenses for participants, the workshops were centrally located, and farmers received small compensation for transport costs incurred.

Further disadvantages in the methodology of self-assessing adaptive capacity mentioned by Roth et al. (2010) concern the limited comparability between different regions due to the selection of different sub-indicators and the subjectivity involved in the rating process. According to Roth et al. (2010), differences in indicator ratings do not necessarily have to reflect real differences and might also be influenced by the use of different facilitators. As ratings for men and women were run in parallel due to time constraints, this study also had to make use of different facilitators. To minimize the effect of the facilitators influencing the rating due to different modes of questioning, careful training was conducted with both facilitators at the same time, which also included mock ratings. Subjectivity in ratings could also be controlled as participants were always asked to provide reasons for their ratings to reveal whether differences in ratings were real. Furthermore, ratings were conducted for multiple events (floods, drought and climate variability) to check for consistency in ratings for those indicators that were the same across events. In most cases, ratings of indicators for which similar reasons were provided did not differ by more than one point, which lends some credibility to the results.

In this study both areas within the watershed selected similar sets of sub-indicators for the different elements of adaptive capacity, which facilitated comparison between the areas at the sub-indicator level in addition to the aggregate level. In order to allow for comparison between the ratings of men and women, the indicators were selected within one group before splitting up for the rating exercise.

While the methods employed provided a relatively quick overview of the main constraints in adaptive capacity and actions to improve the current state, the analysis remains at a rather broad level. The method could thus be complemented by an in-depth assessment of adaptive capacity at the household level, using the indicators selected during the group ratings. This approach would combine some of the advantages of participatory approaches of vulnerability analysis (identification of indicators is by locals rather than outsiders) with the more formal quantitative approaches of vulnerability assessments and would provide further quantitative evidence of differences in adaptive capacity between the different areas of the watershed. In addition, the rating of priority of action resulted in little differentiation in terms of the importance of increasing individual indicators of adaptive capacity, as most indicators received high to very high scores. In order to prioritize between the various options for implementing adaptation measures, multi-criteria analysis could thus be used.

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Annexes

Table A 1: Impact of climate variability and extremes

Climate variability and extremes	Impact							
	Food	**Crop yield**	**Livestock**	**Ecosystem**	**Social context**	**Health**	**Income**	**Others**
Early onset of the rainy season	Food shortage in all areas except Sasumua Churiri	Reduced, as land has not been pre-pared in time and seedlings for planting are not yet ready Increased occurrence of weeds in the farm	Increase in milk production due to abundance of fodder Feet rot and outbreak of diseases due to wet sheds Sheep are affected by diarrhoea Chicken are affected (die of coccidiosis) Rabbits are affected by diarrhoea and pneumonia	Some worms are killed	Huge work-load, but few labourers available Changes in lifestyle (eating habits) Theft in-creases (seedlings from other farms are uprooted) Houses are wet	Hunger Diseases (pneumonia, cold, flu)	Income increases for those that have been prepared Reduced income/lack of finances due to reduced crop yield and because alternative crops are planted Milk is sold at low prices	Distorts farming calendar ("farmers are confused") Transport system is affected (impassable roads) Drainage channels are not cleared, increases risk of flooding

Table A 1 (cont.): Impact of climate variability and extremes

Climate variability and extremes	Impact							
	Food	**Crop yield**	**Livestock**	**Ecosystem**	**Social context**	**Health**	**Income**	**Others**
Delayed onset of the rainy season	Shortage of water and food	Low crop yield as planting is delayed and crops that have been planted too early are destroyed Cabbages and potatoes affected by cutworm Potatoes affected by blight Maize, peas and beans do not survive	Cattle suffer from lack of enough water, shortage of fodder and effects of dis-eases (rinder-pest, east coast fever, foot and mouth) Reduced milk production Sheep are not so much affected as they eat dry grass, but at-tacked by Hyenas Increased egg production for chicken	Increased human wildlife conflict as wild animals come out of the forest in search for food Bees and birds migrate leading to increases in pests (worms and flies) Trees whither Flowering reduced Animals die	Idleness (no work in the farm) High rates of crime, theft Increase in conflicts Business go down "Madness due to too much thinking", insanity Lack of employment Begging increases Praying in church increases People travel for long distances in search for water and fodder Some people sell land and migrate	Dust affects health Hunger	Reduced or no income	Increased availability of firewood Those with enough income take advantage of low input prices Business people gain as people forced to buy food High cost of input as seeds are not available Distorts farming calendar

Table A 1 (cont.): Impact of climate variability and extremes

Climate variability and extremes	**Impact**							
	Food	**Crop yield**	**Livestock**	**Ecosystem**	**Social context**	**Health**	**Income**	**Others**
Drought	Lack of food Lack of water	Reduced/no harvest Aphids, cutworms and flies destroy crops	Starvation and death of animals Reduced milk production Livestock affected by diseases (weakened bones, rinderpest and foot and mouth) Reduced heat in animals	Animals die Trees whither Grass dries up and burns easily	Hard time School drop outs, as school fees cannot be covered Crime rates and insecurity increases Domestic conflicts and conflicts within the community increase Begging increases Increased risk of fire in homesteads Migration, especially among the young	Starvation and death of people Dietary changes (poor diet, reduction in the amount of meals) Foot injuries as people have to walk long distances in search for fodder and water Increased rates of communicable diseases Wounds take long to heal	Reduced income (low prices for livestock, high prices for food and farm inputs)	

Table A 1 (cont.): Impact of climate variability and extremes

Climate variability and extremes	Impact							
	Food	**Crop yield**	**Livestock**	**Ecosystem**	**Social context**	**Health**	**Income**	**Others**
Floods	Food shortage	Reduced harvest, as root rot Shortage of seedlings Potato blight Erosion and mineral leaching	Animals unable to feed well Increased milk production as increased availability of fodder Pneumonia as cattle sleep on wet areas Worms in livestock	Pollution / foul smell Erosion	Working in the farm becomes difficult Houses are flooded Migration	Malaria Colds (children) Athletes foot Typhoid Cholera	Reduced income (food is sold at lower prices) Increased expenditure (digging of channels)	Pit latrines overflow Impassable roads (some children are unable to go to school)
Gathano	Food shortage	Reduced yield and of lower quality Diseases (Black spot and blight) Crops take longer to mature	Slight reduction in milk production in lower areas Milk production is better in upper areas as increased fodder availability and animals are better adapted to cold Pneumonia Calves do not survive Reduced egg production Young rabbits die		Heavy clothing People unable to work People eat a lot Idleness	Cold Flu Rheumatism People that have asthma suffer Women conceive during that time Elderly and children of poor people die because of cold	Reduced income due to high expenses	Education is affected, students are unable to concentrate in class due to cold Increased number of road accidents due to mist

Table A 1 (cont.): Impact of climate variability and extremes

Climate variability and extremes	Impact							
	Food	**Crop yield**	**Livestock**	**Ecosystem**	**Social context**	**Health**	**Income**	**Others**
Frost	Food and water shortage	Reduction in/no crop yield Seed and crop rot	Low milk production due to lack of fodder Starvation and death of livestock Pneumonia and foot and mouth disease	Grass is dried	Idleness Increases in theft (especially in areas not affected by frost) People unable to meet daily needs Food cannot be stored	Frost bites Cold, flu, whopping cough People are cold (especially the children and at night) Hunger	Low income (prices for commodities are high)	Education affected as parents unable to pay for school fees
Wind	Lack of food Lack of water	Destruction of crops Cross pollination	Amount of fodder decreases	Trees are uprooted	Destruction of houses	Injuries “People get sick by inhaling germs” Allergies	Low income	Increased availability of firewood

Table A 1 (cont.): Impact of climate variability and extremes

Climate variability and extremes	Impact							
	Food	**Crop yield**	**Livestock**	**Ecosystem**	**Social context**	**Health**	**Income**	**Others**
Heavy rain	Less food in Kiam-weri Increase in food production in Sasu-mua Churiri	Destruction of crops (washed away, rot) No germination of seedlings Blight Land is damaged Crops are prema-ture Increased needs for chemicals	Affected by diseases (diarrhoea, foot rot) Low yield in milk production Increased availability of fodder, but low quality (causing diarrhoea)	Soil erosion Trees that are not securely anchored in the soil are washed away	Houses get wet (not cemented) Transportation is affected (causes crops to rot)	Pneumonia *Homa* Cholera Deaths due to lightning Elderly most affected	Low income due to high costs of chemicals and charcoal and low prices for products	Children fail to go to school Lack of firewood (especially for those without storage facilities)
Dry spell	Food and water shortage	Low crop yields Loss of seeds Plants wither	Starvation and death of cattle due to lack of fodder Sheep are attacked by wild dogs	Erosion caused by wind Decline in natural vegetation	Reduction in num-ber of livestock, which is sold at a loss Begging increases Idleness Unemployment	Lack of balanced diet/ Malnutrition	Shortage of money Prices for commodities are high (business selling commodities benefit)	Children drop out of school due to lack of money to pay school fees (collect wild fruit s and beg)

					Increased conflicts between forest department, Sasumua dam management and the community Corruption increases Crime rate increases Increase in hatred and suspicion Temporary migrations in search for food Divorce rates increase (wives run away from home) More time spent gathering food and water			

Source: Author's own compilation

Table A 2: Coping strategies currently implemented

Strategy	Timing of implementation	Effectiveness	Constraints	Climatic event
Farm management practices				
Application of chemicals to deal with crop diseases	Ex-ante During	Yes	Not used according to manufac-turer's guidelines Expensive	Gathano Flood Delayed onset
Planting hedges/trees/windbreaks	Ex-ante	Yes	Lack of knowledge about suitable trees	Wind Frost
Sprinkling crops with water	Ex-ante/Ex-post	Yes	Availability of water Finances	Frost
Digging wells deeper	During	Yes		Dry Spell
Veterinary treatment	During	Partially Yes	Depends on the physical condition of the animal	Delayed onset Heavy rain
Buying fodder for live-stock	During	Partially Yes	Limited amount of fodder available Distance to the forest Expenses in buying fodder and paying levies to forest and traffic officers	Frost Flood Drought Delayed onset

Table A 2 (cont.): Coping strategies currently implemented

Strategy	Timing of implementation	Effectiveness	Constraints	Climatic event
Farm management practices (cont.)				
Move livestock to other/less flooded areas (e.g. school grounds/forest)	During	Partially	Not all have the option Lack of money to pay traffic levies	Frost Flood
Restock livestock	Ex-post	Yes		Frost
Digging channels, trenches and dams	Ex-ante During	Partially/no	Conflicts arising as water is directed to neighbouring farms Not effective in flat areas and in case where soil is waterlogged Reductions in land size forced modification, water is now directed to roads and water courses as opposed to large open areas	Flood
Contour farming	Ex-ante		Lack of skill Lack of manure Small land sizes	Heavy rain
Borrow seeds	During	Yes	Market price	Heavy rain

Table A 2 (cont.): Coping strategies currently implemented

Strategy	Timing of implementation	Effectiveness	Constraints	Climatic event
Farm management practices (cont.)				
Reducing number of livestock	During	Stop-gap measure No	Animals are sold at low prices/at loss Expensive to restock the herd	Drought Delayed onset Dry Spell
Reduce levels of farm inputs	During	Partially/no	Cuts expenses, but reduces crop yield	Drought
Substitute fertilizer with manure and compost manure	Ex ante and during	Partially	Reduces crop yield Lack of knowledge Availability of manure	Drought
Rainwater harvesting	Ex-ante	Yes / partially	Water tanks are too small	Drought
Call game officers to return animals back to the forest	Ex-post	Partially		Delayed onset
Improved hygiene / mosquito nets / boiling water	Ex-ante	Yes	Lack of awareness Negligence	Heavy rain

Table A 2 (cont.): Coping strategies currently implemented

Strategy	Timing of implementation	Effectiveness	Constraints	Climatic event
Minimizing livelihood impacts				
Treatment in hospitals	During	Yes	Difficult for the poor Certain groups refuse treatment for religious reasons State hospitals are affordable, private hospitals are expensive	Early onset of the rainy season
Buy heavy clothing	Ex-ante During	Yes	Difficult for the poor, disabled, orphaned and the old due to lack of finances	Gathano Frost
Buy cream to protect skin from coldness	Ex-ante During	Yes	Difficult for the poor, disabled, orphaned and the old due to lack of finances	Gathano Frost
Grow kitchen gardens	During	Yes	Decreasing land sizes	Delayed onset
Borrow food from neighbours/relatives	During	No	Neighbours and relatives also only have limited amount of food, some relatives are far away	Gathano Delayed onset

Table A 2 (cont.): Coping strategies currently implemented

Strategy	Timing of implementation	Effectiveness	Constraints	Climatic event
Minimizing livelihood impacts (cont.)				
Buy food on credit	During	Yes	Finances	Gathano Drought Delayed onset
Buy food	During	No/partially	Finances Food bought just enough to sustain life, food intake is reduced	Delayed onset Dry spell
Rely on food left in the shamba	During	No/Yes	Not enough left in shamba	Drought
Modify dietary habits	During	Partially		Frost
Store food	Ex-ante	Partially	Perishable nature of the food No excess to store Lack of storage structures/facilities Lack of new technologies to store potatoes	Delayed onset

Table A 2 (cont.): Coping strategies currently implemented

Strategy	Timing of implementation	Effectiveness	Constraints	Climatic event
Minimizing livelihood impacts (cont.)				
Government relief food	During	No	Corruption Not accessible to all Relief food is not enough	Drought Delayed onset
Borrow money from friends	During	No	Difficult for the poor as they do not have friends Friends also do not have enough money to lend	Early onset of the rainy season
Borrow money from banks	During	No	People do not have bank accounts and it takes too long to get a loan	Early onset of the rainy season
Borrow money from social groups	During	Partially	Lack of information of "what to do with the loan" Only accessible for members Limited awareness about existence of groups	Drought
Search for alternative employment	During	No Partially	No jobs available Not an alternative for elderly and sick people	Early onset of the rainy season Frost Drought

Table A 2 (cont.): Coping strategies currently implemented

Strategy	Timing of implementation	Effectiveness	Constraints	Climatic event
Minimizing livelihood impacts (cont.)				
Sit and wait for god to intervene/Pray	During			Early onset of the rainy season
Repair roads (community)	During	Yes	Lack of cooperation among people	Early onset of the rainy season
Child labour	During	No		Early onset of the rainy season
Walk long distances to fetch water	During	Yes	Expenses for hiring persons to fetch water Time consuming	Drought Delayed onset
Roofing the house	Ex-post	Yes		Wind
Pour saw dust and soil in sheds and houses	During	Partially		Heavy rain

Source: Author's own compilation

Table A 3: Coping strategies used in the past that are not used anymore

Strategy	Timing of implementation	Effectiveness	Constraints	Climatic event
Trapping of wild animals in the forest	During	Yes	Introduction of forest bans and regulation	Delayed onset
Collection of honey in the forest	During	Yes	Introduction of forest bans and regulation	Delayed onset
Collection of firewood and charcoal in the forest	During	Yes	Introduction of forest bans and regulation	Delayed onset
Burning sawdust/wheat on the fields	During	Yes	Used to be applied during colonial times Lack of burning materials High cost of paraffin Laziness Lack of knowledge	Frost

Source: Author’s own compilation

Table A 4: Coping strategies not yet implemented

Strategy	Timing of implementation	Constraints	Climatic event
Farm management practices			
Buy seeds in advance and store	Ex-ante	Lack of enough funds	Early onset of the rainy season
Use of machinery (tractors)	Ex-ante	Tractors are too expensive Land sizes too small	Early onset of the rainy season
Irrigation	Ex-ante	Lack of water Lack of finances Lack of technology Lack of knowledge Agricultural officers are few and are not exploring areas and giving people the skills required	Early onset of the rainy season Drought Dry Spell
Self-made organic solution to cure diseases	During	Lack of information and knowledge Time consuming BUT Wider application of "organic solution" perceived to be cheaper than using chemicals	Gathano
Zero grazing	Ex-ante	Lack of knowledge Lack of finances (also due to low quality breeds) Lack of labour	Gathano Frost

Table A 4 (cont.): Coping strategies not yet implemented

Strategy	Timing of implementation	Constraints	Climatic event
Farm management practices (cont.)			
Greenhouses	Ex-ante	Lack of finances Lack of skills Lack of knowledge Lack of water Lack of technology	Gathano Wind Frost Flood
Plant different varieties of crops/mixed farming	Ex-ante	Lack of finance and technology	Early onset of the rainy season
Agroforestry	Ex-ante	Lack of knowledge Lack of skills Small land sizes	Gathano Heavy rain
Sprinkling crops with water	Ex-ante/Ex-post	Availability of water Lack of finances Tanks are expensive	Frost
Digging ponds and wells	Ex-ante	Lack of finances Soil structure Laziness /"Work at the 11th hour" Shortage/small pieces of land Lack of knowledge	Flood Dry Spell Drought

Table A 4 (cont.): Coping strategies not yet implemented

Strategy	Timing of implementation	Constraints	Climatic event
Farm management practices (cont.)			
Digging ponds and wells	Ex-ante	Lack of finances Soil structure Laziness /"Work at the 11th hour" Shortage/small pieces of land Lack of knowledge	Flood Dry Spell Drought
Join community water projects that provide piped water	Ex-ante	Not all are capable of joining Poor leadership/Corruption within management Previous failure of other projects Lack of water Ignorance	Drought
Storing fodder/silage making	Ex-ante	Lack of knowledge Lack of capital Lack of storage facilities Lack of materials to store fodder (polythene bags)	Frost Drought
Buying water tanks/tapped water	Ex-ante	Lack of finances	Dry Spell
Drilling boreholes	Ex-ante	Lack of finances	Dry Spell

Table A 4 (cont.): Coping strategies not yet implemented

Strategy	Timing of implementation	Constraints	Climatic event
Farm management practices (cont.)			
Contour farming		Lack of knowledge Lack of skills Small land sizes	Heavy rain
Gabions	Ex-ante	Lack of knowledge Lack of capital	Heavy rain
Terracing	Ex-ante	Small land sizes (most farmers even cover the terraces to increase the area of production) Lack of knowledge Soil is waterlogged Lack of finances (otherwise could hire labour) Difficulties in implementation Lack of willingness	Heavy rain
Invest in better breeds/drought resistant breeds	Ex-ante	Lack of finances Lack of knowledge	Drought
Plant drought resistant crops	Ex-ante	Lack of finances Ignorance Lack of technology	Drought

Table A 4 (cont.): Coping strategies not yet implemented

Strategy	Timing of implementation	Constraints	Climatic event
Farm management practices (cont.)			
Expand area of agricultural production	Ex-ante	Shortage of land	Drought
Plant different varieties of crops	Ex-ante	Lack of water, finance and technology Ignorance	Dry Spell
Minimizing livelihood impacts			
Private hospital treatment	During	Lack of finances	Early onset of the rainy season
Herbal medicine	During	Limited availability	Early onset of the rainy season
Borrow money from banks and Saccos	During	People do not have bank accounts Lack of sufficient security assets Perceived to be risky Lack of information on how to apply and what to do with the loan	Gathano Frost Dry Spell
Electric heaters	Ex-ante	Lack of finances Lack of electricity Lack of technology	Gathano
Build stronger houses	Ex-ante	Lack of finances	
Improved hygiene/mosquito nets/boiling water	Ex-ante	Lack of awareness Negligence	

Table A 4 (cont.): Coping strategies not yet implemented

Strategy	Timing of implementation	Constraints	Climatic event
Minimizing livelihood impacts (cont.)			
Store food	Ex-ante	Perishable nature of the food No excess food to store Lack of finance Lack of technology	Dry Spell
Start a business	Ex-ante	Lack of finance Lack of knowledge	Dry Spell
Construction of electric fence to keep animals from encroaching into the farmland	Ex-ante		Dry Spell

Source: Author's own compilation

Table A 5: Rating of adaptive capacity for climate variability

	Upper areas and areas close to the forest				Lower areas without nearby forest				Rating by district livestock officer	
	Men		Women		Men		Women			
	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action
Human capital										
Knowledge	3	4	3	4	3	5	3	5	2	5
Health	3	5	3	5	3	5	3	5	3	5
Positiveness/willingness to solve the problem	2	4	4	4	2	5	4	3	2	5
Commitment	2	4	3	4	2	4	4	4	2	5
Skills	3	5	2	5	1	5	2	4	2	5
Average	**2.6**	**4.4**	**3**	**4.4**	**2.2**	**4.8**	**3.2**	**4.2**	**2.2**	**5**
Social Capital										
Welfare groups	3	4	2	4	3	5	3	4	4	4
Cooperative societies	1	2	1	3	1	4	2	5	1	5
Friends	3	4	3	4	3	4	1	2	3	4
Church groups	4	5	3	4	4	5	1	2	4	5
Family	4	5	4	5	3	5	3	4	3	5
Average	**3**	**4**	**2.6**	**4**	**2.8**	**4.6**	**2**	**3.4**	**3**	**4.6**

Table A 5 (cont.): Rating of adaptive capacity for climate variability

	Upper areas and areas close to the forest				Lower areas without nearby forest				Rating by district livestock officer	
	Men		Women		Men		Women			
	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action
Natural Capital										
Tree cover	3	4	3	4	3	5	2	5	2	5
Land	4	5	2	5	2	5	2	3	2	5
Livestock	2	4	3	4	3	5	3	3	3	5
Forest	4	5	4	5	3	5	1	5	2	4
River	5	5	3	4	1	2	1	3	1	4
Average	**3.6**	**4.6**	**3**	**4.4**	**2.4**	**4.4**	**1.8**	**3.8**	**2**	**4.6**
Physical captial										
Farm inputs	3	5	3	5	3	5	3	4	4	4
Water tanks, dams, wells, ponds	3	4	2	4	3	5	4	4	3	4
Buildings					5	4	3	5	2	4
Food store	2	5	1	5					1	5
Greenhouse	1	4	1	3	1	5	2	5	1	5
Borehole	1	3	1	2					1	4

Table A 5 (cont.): Rating of adaptive capacity for climate variability

	Upper areas and areas close to the forest				Lower areas without nearby forest				Rating by district livestock officer	
	Men		Women		Men		Women			
	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action
Physical captial (cont.)										
Roads					2	5	3	5	2	5
Average	**2**	**4.2**	**1.6**	**3.8**	**2.8**	**4.8**	**3**	**4.6**	**2**[1] **2.4**[2]	**4.4**[1] **4.4**[2]
Average (only farm input, greenhouse, water tanks)	**2.3**	**4.3**	**2.0**	**4**	**2.3**	**5.0**	**3.0**	**4.3**	**2.6**	**4.3**
Financial capital										
Funds	3	5	3	5	3	5	3	5	2	5
Savings	2	5	2	4	2	5	2	5	2	5
Bank account	3	4	2	4	2	4	1	5	2	5
Security assets	3	4	2	3	1	3	3	4	2	5
Employment in agriculture	4	5	3	5	3	5	4	4	1	5
Average	**3**	**4.6**	**2.4**	**4.2**	**2.2**	**4.4**	**2.6**	**4.6**	**2**	**5**

Notes: [1] Using the same indicators as in the upper areas
[2] Using the same indicators as in the lower areas

Source: Author's own compilation

Table A 6: Rating of adaptive capacity for drought

	Upper areas and areas close to the forest				Lower areas without nearby forest				Rating by district livestock officer	
	Men		Women		Men		Women			
	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action
Human capital										
Knowledge	3	4	3	5	3	4	3	5	2	5
Health	3	5	3	5	3	5	3	4	2	4
Positiveness/willingness to solve the problem	2	4	2	4	2	5	2	2	2	5
Commitment	2	4	3	4	1	4	3	5	3	4
Skills	2	5	2	5	1	5	2	4	2	5
Average	**2.4**	**4.4**	**2.6**	**4.6**	**2**	**4.6**	**2.6**	**4**	**2.2**	**4.6**
Social Capital										
Welfare groups	2	5	3	4	3	5	2	4	3	4
Cooperative societies	1	2	1	2	1	4	1	5	2	5
Friends	3	4	3	4	2	4	2	3	3	3
Church groups	3	5	3	4	4	5	1	4	4	4
Family	4	5	4	5	2	5	2	4	4	4
Average	**2.6**	**4.2**	**2.8**	**3.8**	**2.4**	**4.6**	**1.6**	**4**	**3.2**	**4**

Table A 6 (cont.): Rating of adaptive capacity for drought

	Upper areas and areas close to the forest				Lower areas without nearby forest				Rating by district livestock officer	
	Men		Women		Men		Women			
	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action
Physical Capital										
Farm inputs	3	5	2	5	3	5	3	5	3	5
Water tanks, dams wells, ponds	3	5	2	4	3	5	3	4	2	5
Buildings	5	4	2	3	5	4	3	4	2	4
Food store	2	4	1	4					1	5
Roads	3	5	3	5	2	5	3	5	1	5
Greenhouse					1	5	2	4	1	5
Average	**3.2**	**4.6**	**2**	**4.2**	**2.8**	**4.8**	**2.8**	**4.4**	**1.8**[1] **1.8**[2]	**4.8**[1] **4.8**[2]
Average (excl greenhouse and food store)	**3.5**	**4.8**	**2.3**	**4.3**	**3.3**	**4.8**	**3**	**4.5**	**2**	**4.8**
Financial capital										
Funds	3	5	3	5	3	5	2	4	1	5
Savings	2	5	2	4	2	5	1	5	1	5
Bank account	2	4	2	4	2	4	2	4	1	5

Table A 6 (cont.): Rating of adaptive capacity for drought

	Upper areas and areas close to the forest				Lower areas without nearby forest				Rating by district livestock officer	
	Men		Women		Men		Women			
	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action
Financial capital (cont.)										
Security assets	3	4	2	3	2	4	3	5	2	5
Employment in agriculture	4	4	3	5	3	5	3	4	2	5
Average	**2.8**	**4.4**	**2.4**	**4.2**	**2.4**	**4.6**	**2.2**	**4.4**	**1.4**	**5**

Notes: [1] Using the same indicators as in the upper areas
[2] Using the same indicators as in the lower areas

Source: Author's own compilation

Table A 7: Rating of adaptive capacity for floods

	Lower areas without nearby forest				Rating by district livestock officer	
	Men		Women			
	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action
Human capital						
Knowledge	3	5	2	4	2	4
Health	2	5	3	4	3	4
Positiveness/willingness to solve the problem	2	4	3	5	3	4
Commitment	4	3	4	5	3	4
Skills	2	5	3	4	2	4
Average	**2.6**	**4.4**	**3**	**4.4**	**2.6**	**4**
Social Capital						
Welfare groups	2	5	2	5	4	5
Cooperative societies						
Friends	2	5	2	2	2	4

Table A 7 (cont.): Rating of adaptive capacity for floods

	Lower areas without nearby forest				Rating by district livestock officer	
	Men		Women			
	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action
Social Capital (cont.)						
Family	3	3	3	3	4	4
Guarantor	1	2	1	1	2	4
Average	2.2	3.8	2	2.6	3.2	4.2
Natural Capital						
Tree cover	4	5	3	4	3	5
Land	3	5	2	5	1	5
Livestock	3	5	2	4	3	5
Community dam	1	5	3	5	1	5
Average	**2.75**	**5**	**2.5**	**4.5**	**2**	**5**

Table A 7 (cont.): Rating of adaptive capacity for floods

	Lower areas without nearby forest				Rating by district livestock officer	
	Men		Women			
	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action
Physical captial						
Farm inputs	3	5	3	4	1	5
Water tanks, dams wells, ponds	3	5	4	5	3	5
Buildings	5	4	3	2	2	5
Food store	2	5	3	4	1	5
Roads	2	5	3	5	1	5
Average	**3**	**4.8**	**3.2**	**4**	**1.6**	**5**
Financial capital						
Funds	2	5	2	2	2	4
Savings	1	5	1	2	2	5

Table A 7 (cont.): Rating of adaptive capacity for floods

	Lower areas without nearby forest				Rating by district livestock officer	
	Men		Women			
	Current state	Priority of action	Current state	Priority of action	Current state	Priority of action
Financial capital (cont.)						
Bank account	3	5	2	3	2	5
Security assets	1	1	3	4	2	5
Employment in agriculture	3	5	4	5	3	5
Average	**2**	**4.2**	**2.4**	**3.2**	**2.2**	**4.8**

Source: Author's own compilation

Table A 8: Results of pair-wise problem ranking Kwaharaka

Problem	**Score**	**Rank**
Lack of knowledge (information know how, skills)	7	1
Water shortage	5	2
Lack of capital	5	2
Low income	4	3
Poor shelter (poor housing)	3	4
Unreliable rainfall (includes both too much and not enough rain)	3	4
Uncertainty in price fluctuations, exploitative middlemen	1	5
Poor means of transport and roads	0	6

Source: Author's own compilation

Table A 9: Results of pair-wise problem ranking Kinamba

Problem	**Score**	**Rank**
Inadequate knowledge	7	1
Exploitative middlemen	6	2
Climatic changes	4	3
Water shortage	4	3
Impassable roads	3	4
Diseases	2	5
High cost of inputs	2	5
Poverty	0	6

Source: Author's own compilation

Table A 10: Results of pair-wise problem ranking Njabini

Problem	**Score**	**Rank**
Lack of adequate knowledge	7	1
Water shortage	6	2
Diseases	5	3
Unemployment	4	4
Landlessness	3	5
High cost of farm inputs	2	6
Drug abuse	1	7
Fluctuating prices	0	8

Source: Author's own compilation

Table A 11: Results of pair-wise problem ranking Sasumua Churiri

Problem	**Score**	**Rank**
Lack of knowledge	7	1
Climate change	6	2
Water shortage	5	3
HIV/AIDS	4	4
Lack of enough money	3	5
Poor market	2	6
High prices of farm inputs	1	7
Storage	0	8

Source: Author's own compilation

Table A 12: Results of pair-wise problem ranking Sasumua Kiamweri

Problem	**Score**	**Rank**
Lack of employment	7	1
Water shortage	6	2
Lack of health facilities	4	3
High cost of food stuffs	4	3
Poor transport	3	4
Drug abuse	2	5
Lack of electricity	2	5
Negligence by parents	0	6

Source: Author's own compilation

Table A 13: Results of Mann-Kendall test for monthly, seasonal and annual rainfall

Time series	First year	Last year	n	Test Z	Significance	Sen´s slope estimate Q
January	1966	2009	43	-0.042		-0.007
February	1966	2009	43	-0.733		-0.477
March	1966	2009	43	-0.167		-0.208
April	1966	2009	42	-0.585		-0.569
May	1966	2009	43	**-1.381**	**x**	**-1.239**
June	1966	2009	43	-0.659		-0.387
July	1966	2009	43	**-1.737**	+	**-0.854**
August	1966	2009	44	-0.111		-0.047
September	1966	2009	44	0.192		0.050
October	1966	2009	44	0.030		0.036
November	1966	2009	44	-0.455		-0.280
December	1966	2009	44	0.779		0.337
Total	1966	2009	42	-0.694		-2.538
MAM	1966	2009	42	**-1.300**	**x**	**-2.859**
OND	1966	2009	44	-0.010		-0.096

Notes: Symbols denote: *** significant at $\alpha = 0.001$ ** significant at $\alpha = 0.01$ * significant at $\alpha = 0.05$ + significant at $\alpha = 0.1$ x significant at $\alpha = 0.2$ MAM = March, April, May OND = October, November, December

Source: Author's own calculation using the MAKESENS program developed by the Finnish Meteorological Institute (Salmi et al. 2002)

Table A 14: Results of Mann-Kendall test for number of rain days (>0.1mm) per month

Time series	First year	Last year	n	Test Z	Significance	Sen´s slope estimate Q
NoraindayJanuary	1966	2009	40	0.000		0.000
NoraindayFebruary	1966	2009	41	0.237		0.000
NoraindayMarch	1966	2009	41	-1.026		-0.077
NoraindayApril	1966	2009	41	**-1.849**	+	**-0.125**
NoraindayMay	1966	2009	41	**-1.705**	+	**-0.118**
NoraindayJune	1966	2009	40	**-2.608**	**	**-0.153**
NoraindayJuly	1966	2009	41	-0.746		-0.034
NoraindayAugust	1966	2009	42	**-2.135**	*	**-0.120**
NoraindaySeptember	1966	2009	42	-0.535		0.000
NoraindayOctober	1966	2009	42	**-1.394**	x	**-0.094**
NoraindayNovember	1966	2009	42	0.620		0.033
NoraindayDecember	1966	2009	41	1.048		0.083
Noraindaytotal	1966	2009	38	**-1.536**	x	**-0.450**
NoraindayMAM	1966	2009	41	**-2.744**	**	**-0.396**
NoraindayOND	1966	2009	41	-0.135		0.000

Notes: Symbols denote: *** significant at α = 0.001 ** significant at α = 0.01 * significant at α = 0.05 + significant at α = 0.1 x significant at α = 0.2 MAM = March, April, May OND = October, November, December

Source: Author's own calculation using the MAKESENS program developed by the Finnish Meteorological Institute (Salmi et al. 2002)

Table A 15: Results of Mann-Kendall test for onset- duration- cessation- total amount- number of rain days and mean rain per rain day for the calculated long rainy (lr) and short rainy (sr) seasons

Time series	First year	Last year	n	Test Z	Significance	Sen´s slope estimate Q
lronset	1966	2009	40	-0.128		-0.017
lrtotal (mm)	1966	2009	39	**-1.694**	+	**-3.994**
lrcess	1966	2009	39	**-1.843**	+	**-0.571**
lrduration	1966	2009	39	**-1.453**	x	**-0.757**
lrnoraindays	1966	2009	39	**-2.327**	*	**-0.545**
lrrainperday	1966	2009	39	0.823		0.021
sronset	1966	2009	39	-0.278		-0.111
srtotal	1966	2009	38	0.905		2.167
srcessation	1966	2009	37	**1.322**	x	**0.411**
srduration	1966	2009	37	**1.452**	x	**0.607**
srnoraindays	1966	2009	37	0.916		0.200
srrainperday	1966	2009	37	0.013		0.001

Notes: Symbols denote: *** significant at $\alpha = 0.001$ ** significant at $\alpha = 0.01$ * significant at $\alpha = 0.05$ + significant at $\alpha = 0.1$ x significant at $\alpha = 0.2$ MAM = March, April, May OND = October, November, December

Source: Author's own calculation using the MAKESENS program developed by the Finnish Meteorological Institute (Salmi et al. 2002)

Table A 16: Results of Mann-Kendall test for rainfall intensity (mean rain per rain day)

Time series	First year	Last year	n	Test Z	Significance	Sen´s slope estimate Q
MRPRDJanuary	1966	2009	40	-0.140		-0.004
MRPRDFebruary	1966	2009	41	-0.573		-0.030
MRPRDMarch	1966	2009	41	1.247		0.053
MRPRDApril	1966	2009	41	0.865		0.036
MRPRDMay	1966	2009	41	-0.842		-0.033
MRPRDJune	1966	2009	40	**2.109**	*	**0.112**
MRPRDJuly	1966	2009	41	-1.112		-0.042
MRPRDAugust	1966	2009	42	1.268		0.046
MRPRDSeptember	1966	2009	42	0.564		0.015
MRPRDOctober	1966	2009	42	**1.517**	x	**0.060**
MRPRDNovember	1966	2009	42	-0.607		-0.020
MRPRDDecember	1966	2009	41	0.539		0.020
MRPRDtotal	1966	2009	38	**1.408**	x	**0.375**
MRPRDMAM	1966	2009	41	0.708		0.063
MRPRDOND	1966	2009	41	0.977		0.097

Notes: Symbols denote: *** significant at α = 0.001 ** significant at α = 0.01 * significant at α = 0.05 + significant at α = 0.1
x significant at α = 0.2 MAM = March, April, May OND = October, November, December

Source: Author's own calculation using the MAKESENS program developed by the Finnish Meteorological Institute (Salmi et al. 2002)

Table A 17: Results of Mann-Kendall test for number of heavy precipitation days (>10mm)

Time series	First year	Last year	n	Test Z	Significance	Sen´s slope estimate Q
Januaryhp	1966	2009	40	0.012		0.000
Februaryhp	1966	2009	41	-0.483		0.000
Marchhp	1966	2009	41	1.034		0.030
Aprilhp	1966	2009	41	-0.203		0.000
Mayhp	1966	2009	41	-0.895		-0.031
Junehp	1966	2009	40	1.167		0.000
Julyhp	1966	2009	41	-1.016		0.000
Augusthp	1966	2009	42	0.390		0.000
Septemberhp	1966	2009	42	0.122		0.000
Octoberhp	1966	2009	42	1.195		0.029
Novemberhp	1966	2009	42	-0.209		0.000
Decemberhp	1966	2009	41	0.891		0.000
TOTALhp	1966	2009	38	0.378		0.061
MAMhp	1966	2009	41	-0.507		-0.035
ONDhp	1966	2009	41	0.892		0.053

Notes: Symbols denote: *** significant at $\alpha = 0.001$ ** significant at $\alpha = 0.01$ * significant at $\alpha = 0.05$ + significant at $\alpha = 0.1$ x significant at $\alpha = 0.2$ MAM = March, April, May OND = October, November, December

Source: Author's own calculation using the MAKESENS program developed by the Finnish Meteorological Institute (Salmi et al. 2002)

Table A 18: Results of Mann-Kendall test for maximum number of consecutive dry days (with rainfall <0.1mm)

Time series	First year	Last year	n	Test Z	Significance	Sen´s slope estimate Q
Januarydry	1966	2009	40	-0.631		-0.040
Februarydry	1966	2009	41	-0.735		-0.033
Marchdry	1966	2009	41	0.113		0.000
Aprildry	1966	2009	41	**1.401**	x	**0.045**
Maydry	1966	2009	41	**1.745**	+	**0.066**
Junedry	1966	2009	40	**2.204**	*	**0.125**
Julydry	1966	2009	41	0.666		0.036
Augustdry	1966	2009	42	**2.329**	*	**0.167**
Septemberdry	1966	2009	42	0.534		0.000
Octoberdry	1966	2009	42	0.381		0.000
Novemberdry	1966	2009	42	-0.805		0.000
Decemberdry	1966	2009	41	-1.060		-0.071
TOTALdry	1966	2009	38	0.555		0.053
MAMdry	1966	2009	41	1.065		0.053
ONDdry	1966	2009	41	-0.914		-0.056

Notes: Symbols denote: *** significant at α = 0.001 ** significant at α = 0.01 * significant at α = 0.05 + significant at α = 0.1 x significant at α = 0.2 MAM = March, April, May OND = October, November, December

Source: Author's own calculation using the MAKESENS program developed by the Finnish Meteorological Institute (Salmi et al. 2002)

Table A 19: Actions identified by farmers to improve the current state of indicators

	Actions	Who needs to take the action
Human capital		
Health	Clean the environment	Individual Community
	Drink clean water	Individual
	Improve diet (rich and balanced)	Individual
	Improve the conditions of latrines	Community health workers Individual Community
	Maintain cleanliness in homes	Individual
	Increase education on good hygienic standards and health related issues	Community health workers Ministry of health and education Community Groups Family
	Follow the advice given by health workers	Individual
	Seek advice from medical centers immediately when falling sick	Individual
	Spray stagnant water to kill mosquitoes and tse tse flies	Health officers
	Use mosquito nets	Health officers Individual

Table A 19 (cont.): Actions identified by farmers to improve the current state of indicators

	Actions	Who needs to take the action
Human capital (cont.)		
Skills	Educate the children	Individual Professionals (agricultural extension officers, community health workers)
	Ensure that children go to school	Government enforcing school attendance Individual
	Attend trainings and field days (increase commitment)	Individual
	Increase awareness about the importance of acquiring knowledge and skills	Community Leaders Experts (agricultural extension officers)
	Follow and implement advise given	Individual
Knowledge	Increase education and information provided by agricultural extension officers	Agricultural officers
	Attend seminars, be willing to change attitude	Individual
	Form welfare groups to share ideas	Individual
	Visit other places	Individual
Commitment	Organize groups to share information	Individual/community
	Increase the flow of information	Government ministries
	Be willing to sacrifice	Individual

Table A 19 (cont.): Actions identified by farmers to improve the current state of indicators

	Actions	**Who needs to take the action**
Human capital (cont.)		
Positiveness	Increase education on preventive flood measures	Agricultural officers Individuals Friends
Social capital		
Welfare groups	Increase awareness about the importance of welfare groups and on the role they can play in coping with drought, climate variability and floods e.g. by inviting experts	Agricultural extension officers. Health officers
	Increase the level of trust within welfare groups	Agricultural extension officer Community Development Assistant Group members
	Establish a clear goal for welfare groups	Agricultural extension officer Community Development Assistant Group members
	Improve on the management of welfare groups (non-corrupt leaders)	Agricultural extension officer Community Development Assistant Group members
	Increase commitment by improving on attendance of meetings	Individuals
	Obey the rules and regulations that have been laid down	Group members Community Development Assistant (CDA) for monitoring

Table A 19 (cont.): Actions identified by farmers to improve the current state of indicators

	Actions	Who needs to take the action
Human capital (cont.)		
Family	Hold family gatherings to share problems and minimize disputes, increase awareness about weather changes, also in the wider family	Individuals
	Increase awareness about the importance of good family relationships	Church leaders
	Obey and respect leaders	Individuals
Church groups	Organize seminars and trainings	Church leaders Pastors Community
	Collect food and clothes for emergency situations	Church leaders, individuals
	Reduce the level of fanaticism in church beliefs	Church leaders
	Attend church services	Individual
	Formulate goals and visions for church groups	Church ministers and members
	Implement the advice from church groups	Individual
Friends	Increase level of trust and readiness to help	Individual

Table A 19 (cont.): Actions identified by farmers to improve the current state of indicators

	Actions	**Who needs to take the action**
Human capital (cont.)		
Cooperative societies	People should unite and form a cooperative society instead of involving the government	Social group Individual
	Increase willingness to unite and sell produce at high prices	Social group Individual
Natural capital		
Forest	Report illegal loggers	Community
	Increase the level of tree planting by establishing tree nurseries	Community Forest department
	Increase the level of tree planting in agricultural farms to prevent illegal logging in the forest	Individual
	Stop taking cattle for grazing in the forest	Individual
	Improve on guarding the forest	Forest department
Soil quality	Employ new methods of farming (e.g. zero-grazing or semi zero grazing to prepare manure and improve soil texture)	Farmers Agricultural extension officers to provide advice
	Improve conservation of soil in sloped areas by increasing the level of contour farming, bench terracing, planting napier grass and engaging in agroforestry	Farmers Agricultural extension officers to provide advice
	Crop rotation to improve soil conditions	Farmers Agricultural extension officers to provide advice

Table A 19 (cont.): Actions identified by farmers to improve the current state of indicators

	Actions	**Who needs to take the action**
Natural capital (cont.)		
River	Hold seminars and barazas to educate people in order to stop cultivation along the rivers, reduce the level of deforestation and avoid the plantation of eucalyptus	Agricultural extension officers
	Increase soil conservation to reduce levels of siltation and pollution through fertilizers and pesticides	Farmers Agricultural extension officers to provide advice
Tree cover	Increase the level of tree planting by establishing tree nurseries	Rural forester officers Welfare groups Individuals
	Attend seminars and increase the level of education about the importance of tree planting and the type of species to be planted	Rural forester officers Welfare groups Individuals
	Protect young trees from destruction by animals and people	Individuals
	Increase education on when to harvest trees to prevent them being harvested premature	Rural forester officers

Table A 19 (cont.): Actions identified by farmers to improve the current state of indicators

	Actions	**Who needs to take the action**
Natural capital (cont.)		
Livestock	Increasing the variety of livestock kept	Individuals
	Invest in better breeds	Individuals Welfare groups
	Attend seminars	Individuals Agricultural officers Veterinary officers
	Stop free grazing and implement zero grazing	Individuals
Community dam	Improve awareness about importance of dams	Government
	Identify sites for new dams	Government Community Donors
	Increase knowledge on how to build community dams	Agricultural officer
Physical capital		
Farm inputs	Increase the use of certified and drought resistant seeds	Individuals Agricultural extension officers Groups to facilitate buying of certified seeds
	Increase the practice of semi or zero grazing in order to get own manure	Individuals Agricultural extension officers

Table A 19 (cont.): Actions identified by farmers to improve the current state of indicators

	Actions	Who needs to take the action
Physical capital (cont.)		
Farm inputs (cont.)	Increase advise on genuine farm equipment and machinery and proper application of manure	Agricultural extension officers
	Introduce organic farming	Individuals Agricultural extension officers
	Improve education on better farming practices by agricultural extension officers	Agricultural extension officers
	Government should subsidize farm inputs to reduce the cost	Ministry of Agriculture and livestock
Roads	Inform counselors and government about the state of roads	Community chairman Ministry of roads
	Community action to repair roads (form welfare groups)	Community
	Dig terraces and plant napier grass along the roads	Community Individual
Water tanks, dams	Increase awareness about the need to conserve water and on water harvesting practices	Community groups Water experts Agricultural experts
	Improve on financial management in order to finance bigger tanks	Individual Social groups

Table A 19 (cont.): Actions identified by farmers to improve the current state of indicators

	Actions	**Who needs to take the action**
Physical capital (cont.)		
Water tanks, dams (cont.)	Improve ponds by using polythene bags	Individual
	Improve and increase guttering system on buildings	Individual
	Desilt dams	Individual Community
Greenhouses	Form welfare groups to raise funds for establishing greenhouses	Individuals
	Increase practical advice in the field on how to construct and maintain greenhouses	Agricultural extension officers
	Increase awareness on greenhouse farming	Ministry of Agriculture
Food stores	Increase building of food stores	Individual Extension officers
	Improve education on the importance of stores and the type of stores to be constructed	Individuals Extension officers
	Crop diversification so that non-perishable food can be stored	Individuals Extension officers
Buildings	Increase stores for food and farm inputs	Individuals
	Improve education on financial management in order to enable savings for building stores	Extension officers
	Increase education on how to construct stores	Extension officers

Table A 19 (cont.): Actions identified by farmers to improve the current state of indicators

	Actions	**Who needs to take the action**
Financial capital		
Savings	Join social groups that encourage savings	Individuals
	Increase education on financial management Improve on budgeting (avoiding unnecessary expenses)	Individuals Financial managers
	Build trust among family members to avoid money being stolen	Individuals
Funds	Increase education on financial management	Individuals Financial managers
	Improve application of manure and correct farm inputs	
	Increase knowledge on improved farming practices (e.g. greenhouse farming, certified seeds, improved breeds) by attending agricultural shows and seminars, forming welfare groups and visiting other farms	Individual Agricultural extension officers
	Improve commitment (change from saying to doing and saying)	
	Engage in agriculture as a business	Individuals Experts
	Crop and livestock diversification	Individuals Experts
Employment in agriculture	Adopt good farming practices	Individuals Agricultural extension officers Welfare groups

Table A 19 (cont.): Actions identified by farmers to improve the current state of indicators

	Actions	**Who needs to take the action**
Financial capital (cont.)		
Employment in agriculture (cont.)	Attend seminars	Individuals
	Invest in greenhouses	Individuals Agricultural extension officers
	Crop and livestock diversification	Individuals Agricultural extension officers
	Increase commitment	Individuals
	Dig more terraces and dams	Individual Community
	Improve on drainage	Individuals Community
	Plant napier grass along edges	Individuals
Security assets	Buy quality furniture	Individuals
	Get off farm employment	Individuals
	Adopt a culture of saving to enable investment in security assets	Individuals

Source: Author's own compilation

Table A 20: Actions identified by district government officials to improve the current state of indicators

	Action	**Who needs to take action**	**Difficulties**
Human capital **(e.g. knowledge, skills, health, positiveness, commitment)**	Provide information about the impacts of climate change and measures on how to deal with these through trainings and barazas	Government officers (divisions) NGOs (e.g. greenbelt movement)	Ignorance on the part of the farmers
	Increase skills (e.g. for implementation of greenhouses and silage making) and confidence of farmers by carrying out demonstration activities in addition to providing training in class Use CBOs as visionary groups to train others	Government institutions NGOs Gommunity based organization (CBO)	Lack of resources for demonstration materials
	Increase cohesiveness among farmers by providing group trainings	Community Development Assistant (CDA)	Low cohesiveness among farmers
	Increase commitment by increasing awareness of farmers through trainings	Agricultural training colleges (ATC's) such as the one at Njabini	Low commitment by farmers

Table A 20 (cont.): Actions identified by district government officials to improve the current state of indicators

	Action	Who needs to take action	Difficulties
Natural capital **(e.g. soil quality, tree cover, livestock, river, forest)**	Increase the use of soil analysis Soil fertility improvement	Agricultural research institutes Universities and research institutions Ministry of agriculture	Low funding to the research institutes by the local government Low awareness on the part of farmers about the need for soil analysis
	Improved breeds to increase livestock production	Ministry of agriculture, NALEP (National agricultural and livestock extension program)	Lack of financial capital
	Invest in value addition of farmed products	GOK (Government of Kenya) and SIDA (Swedish International Development Cooperation Agency)	Ignorance on the part of farmers Poor cooling facilities Poor roads
	Train farmers in record keeping in order to improve their ability to deal with price fluctuations	Njaa marufuku Kenya and Kenya agricultural productivity project	Illiteracy and low levels of commitment among the farmers
	Increase agroforestry practices in farms by providing training and advising on the type of tree species to be planted	Forest ministry Greenbelt movement Development organisations that provide tree seedlings to farmers	Small land sizes Limited financial resources of farmers to buy tree seedlings Ignorance on the part of farmers
	Exploit incentives (e.g. carbon credits) to increase tree planting	Ministry of mineral resources and forestry	Inadequate funding by the government

Table A 20 (cont.): Actions identified by district government officials to improve the current state of indicators

	Action	Who needs to take action	Difficulties
Financial capital **(e.g. funds, savings, security assets, bank account, employment in agriculture)**	Increase tree planting in farms as they provide source of income and can be used to acquire loans	Rural forestry department, agroforestry and KAPP (Kenya agricultural productivity project)	Inadequate rainfall, destruction of young tree seedlings by animals
	Increase access to reliable credit facilities	Micro finance institutions, farmers, the government	Lack of collateral
	Revive cooperative societies	Government of Kenya	Bad past experiences with cooperative societies due to corruption
	Educate and train farmers in financial management and project appraisal	Financial institutions Cooperative societies Local government	Poor attendance of trainings by farmers (farmers claim they are busy or expect payments for attending trainings)
Social capital **(e.g. welfare groups, cooperative societies, friends, family, church groups)**	Strengthen welfare groups by encouraging income generating activities Enhance cohesiveness Provide advice to groups Make exchange visits to facilitate learning between groups Target youths to train about new technologies and alternative methods of farming (e.g. poultry and rabbit keeping, improved livestock breeds, greenhouse technology)	Water, Agriculture and Forestry officers	Poor attendance of trainings by farmers (farmers claim they are busy or expect payments for attending trainings) Low levels of education

Table A 20 (cont.): Actions identified by district government officials to improve the current state of indicators

	Action	Who needs to take action	Difficulties
Physical capital (e.g. farm inputs, food store, water tanks, dams wells, ponds, roads, buildings)	Increase adoption of greenhouse technology	Farmers training centres, Kenya Agricultural Research Institute, and Kenya Farmers Association	Lack of financial capital for establishing greenhouses
	Sensitize farmers about the importance of stores	National Cereals and Produce board, Njaa marufuku Kenya, GOK	Ignorance on the part of farmers. Farmers want to practise gate marketing (receive money quickly for their produce)
	Advance cottage industry in the area	Agricultural Training College, (Smallholder Horticulture Marketing Programme), SHOMAP	Lack of commitment on the part of farmers, lack of financial capital
	Improve the state of the roads	Government, county council, SHOMAP (Smallholder Horticulture Marketing Programme),CDF (Constituency Development Fund, KERRA (Kenya Rural Roads Authority)	Inadequate funding

Source: Author's own compilation

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