AARHUS UNIVERSITET

Smallholder Farmers' Adaptation to Climate Change in Zenzelima, Ethiopia

A Case Study of Female and Male Farmers Perception of and Ability to Adapt to Climate Change in Zenzelima, Ethiopia.

Supervisors

Univ. Prof. Dr. agr. biol. Bernhard Freyer

Senior Scientist DVM PhD Mette Vaarst

Anne Skambraks

Registration Number: 1341470

Email: anneskam.a.gmail.com

University of Natural Resources and Life Sciences Vienna

Department of Sustainable Agricultural Systems

Division of Organic Agriculture

European Master in Organic Agriculture and Food systems

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Abstract

Zenzelima is a small kebele located in the North-western part of Ethiopia, where future climate change is predicted to challenge the farmers' agricultural systems beyond their coping range. Farmers in Zenzelima will therefore need to adapt to climate change in order to maintain their livelihoods in the future. Adaptation to climate change requires the recognition of the need to adapt and the ability to adapt. This study therefore analyses the farmers' perception of climate change and their ability to adapt to climate changes. For this qualitative interviews have been performed with 10 farmer households in Zenzelima, where both husband and wife have been interviewed, 4 agricultural extension workers, and 1 employee from The Organization for Rehabilitation and Development in Amhara (ORDA). The results show that most of the farmers do not apply agricultural adaptations to climate change, since their awareness of the need to adapt and their adaptive capacity is low. The main factors influencing the farmers' adaptive capacity is their availability and access to water, agricultural land, agricultural inputs, information on agricultural adaptation strategies, and decision power. Furthermore, individual human capital and institutions are influencing the interviewed farmers access to the above listed means and their ability to imply adaptation strategies to climate change. Information on effective agricultural adaptation strategies should be promoted, the farmers access to agricultural inputs should be increased, and institutions that limits the adaptive capacity of farmers should be discarded in order to increase the adaptive capacity of farmers in Zenzelima to climate change.

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The pictures used in this thesis are exclusively taken by myself during May 2014 in Ethiopia.

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1. Introduction

Ethiopia holds the second highest population of Sub-Saharan Africa with an estimated population of about 94 million. At the same time The World Bank (2014) claims that it is one of the poorest and least developed countries in the world. Agriculture is the main source of livelihood and the basis of the national economy, accounting for 41 % of the country's Gross Domestic Product. Approximately 85 % of the population lives in rural areas, relying on subsistence farming with less than 1 ha available for cultivation, while accounting for 95 % of the country's agricultural production (Evangelista, Young, & Burnett, 2013; Di Falco, Yesuf, Kohlin, & Ringler, 2012). The major food crops grown are cereals, which constitute the primary diet for most of the population (Evangelista et al., 2013). Livestock further plays an important role, since Ethiopia holds the largest livestock population in Africa (Berhanu Gebremedhin, Pender, & Tesfay, 2004), and the majority of smallholder farmers depend on animals for cultivation, draught power and transportation of goods (Belay & Abebaw, 2004).

The agricultural sector is dominated by traditional farming practices with only few farmers applying modern techniques, such as irrigation (0.6 %), fertilizer, and improved seeds (Evangelista et al., 2013). Labour is the main input used during land preparation, planting, and post harvest processing and likewise, the agricultural productivity is low (Di Falco, Veronesi, & Yesuf, 2011; Di Falco et al., 2012). Furthermore, declining farm size due to population growth, land degradation due to inappropriate land use, tenure insecurity, insufficient agricultural extension services, lack of agricultural marketing, and an inadequate transport network are limiting the agricultural productivity (Bewket & Conway, 2007; Hassan & Deressa, 2009). Land degradation and declining soil fertility is mainly caused by soil erosion, which is entailed by the cultivation of steep slopes, deforestation and overgrazing, and which has led to other environmental problems including desertification, loss of biodiversity, and water and air pollution (Hassan & Deressa, 2009; Tadege, 2007). Furthermore, the agricultural production is heavily dependent on natural rainfall, particularly on the amount and seasonal distribution, and therefore especially sensitive to fluctuations in precipitation (Conway & Schipper, 2011; Evangelista et al., 2013).

The climate of Ethiopia is characterized by showing high variability annually, seasonally and geographically. Especially the amount and seasonal distribution of precipitation are varying annually and difficult to predict, while the temporal distribution of rainfall during the growing season is an important factor influencing crop yield (Evangelista et al., 2013; Tadege, 2007). Rains can be delayed by several weeks or stop during critical germination periods, leading to short- and long-term droughts with crop failures, food shortages and famines. Furthermore, when occurring during the dry season, rainfall can facilitate the spread of crop diseases (Evangelista et al., 2013). Ethiopia's agriculture is highly influenced by these climatic conditions and has a long history of coping with extreme weather events (Bewket & Conway, 2007). During the last four decades the country has experiences countless localized drought events and several devastating famines, and Ethiopia has been categorized as food-insecure country since the early 1970s (Belay & Abebaw, 2004). Even though drought is not a new phenomenon in Ethiopia, the frequency of occurrence has increased in some areas and likewise the variability in rainfall patterns (Evangelista et al., 2013). The national average annual minimum temperature

between 1951 and 2006 has been increasing by app. 0.37 °C per decade between 1951 and 2006, while annual rainfall has remained more or less constant when averaged over the whole country (Tadege, 2007, p. 1).

Different climate projection models predict different climate scenarios for Ethiopia, but they all predict that the countries climate will change in the future (Hassan & Deressa, 2009; Tadege, 2007). Several climate projection models[1] agree that Ethiopia will experience an increase in mean annual temperature by 2050, while the predicted values range from 1.7 to 3.82 °C. However, these models disagree on the change in precipitation, with some[2] predicting a decrease and others[3] a small increase in national annual precipitation by 2050 (Hassan & Deressa, 2009; Tadege, 2007).

Increasing temperature and higher variability in rainfall will influence Ethiopia's agriculture and is expected to worsen the existing conditions, which could lead to further increase of land degradation, soil erosion, deforestation, loss of biodiversity and desertification (Bewket & Conway, 2007). However, the damage will not be equal throughout the country, but vary across different agro-ecological zones[4] (AEZs). Some AEZs can benefit from a slight increase in temperature during the right time of the season, whereas others will experience detriments. Likewise, change in precipitation will affect different AEZs differently (Hassan & Deressa, 2009).

Zenzelima is a small *kebele*[5] located in Amhara Region in the north-western part of Ethiopia and located in the AEZ of tepid to cool sub-moist mid-highlands. According to Legesse (2013) and Bewket and Conway (2007) the area around Zenzelima has experienced a trend of slight increase in annual mean maximum and minimum temperature and decrease in annual precipitation since 1960. According to Tadege (2007) Amhara Region is predicted to be one of the states with the highest temperature increase in Ethiopia. Ayalew, Tesfaye, Mamo, Yitaferu, and Bayu (2012) likewise state that Amhara Region and in particular the area of and around Zenzelima could further experience an increase in mean maximum temperature and a decrease in annual rainfall. According to Hassan and Deressa (2009) the tepid to cool sub-moist mid-highlands will experience climate changes, that cause agricultural losses by 2100 of measures, to which farmers in Zenzelima will have to adapt in order to avoid a complete failure of their agricultural sector. It is therefore relevant to examine how farmers in Zenzelima respond to climate change and to examine their ability to adapt to future climate changes.

[1] IPCC emissions scenarios, A2, B1, and A1B; PCM, CGM2, HADCM3

[2] CGM2, IPCC mid-range (A1B) emission scenario

[3] HADCM3 and PCM model

[4] Agro-ecological zones are zones defined by climatic characteristics, landform and soils (FAO, n.d.).

[5] *Kebele* in Amharic means neighborhood which functions as a municipality and the lowest administrative unit in Ethiopia.

2. Theoretical Framework

In this chapter I will define and describe the main terms that are fundamental when examining farmers' adaptation to climate change. Furthermore, I will present the theory that will function as framework for analyzing the results.

2.1. Responding to Climate Change – Mitigation and Adaptation

According to the United Nations' Intergovernmental Panel on Climate Change (IPCC) (1994) responses to climate change can be grouped into two categories: *mitigation* and *adaptation*.

Mitigation embraces responses that deal with the *cause* of climate change rather than the impact climate change has on a given area (Carter et al., 1994). For example, raising taxes on kerosene is a mitigation response, since it is perceived as a method to decrease the flight traffic and emissions, which are contributing to the atmospheric greenhouse gas content and causing anthropogenic climate change.

Responses classified as *adaptations* deal with the *impact* of climate change rather than the cause (Carter et al., 1994). For example, cultivating drought resistant crops in areas that experience decreasing rainfall can be classified as *adaptation,* since it is a response to an climate change impact instead of its cause. This does not mean that an adaptation response excludes the influence on climate change, but the influence will only be a secondary and not a primary. This is visualized in Figure 1, where the black arrows symbolize direct effects or feedbacks, whereas grey arrows indicate secondary/indirect effects.

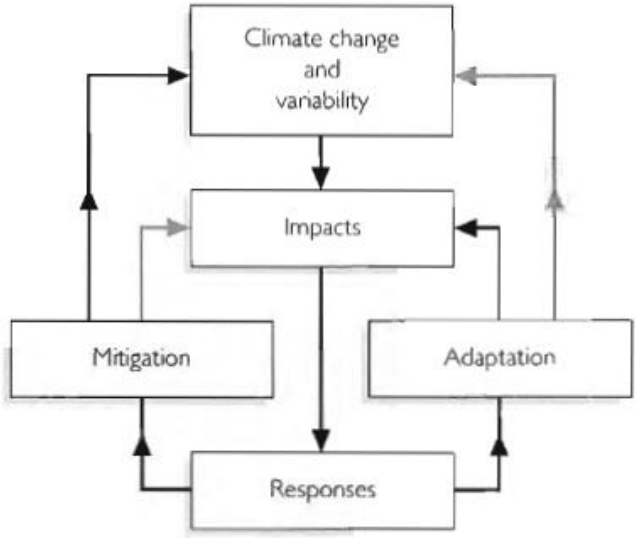

Figure 1: The Relation of Mitigation and Adaption to Climate Change and its Impact. Source: Smith (1993) cited in Carter et al. (1994, p. 32).

In this thesis I focus on adaptation rather than mitigation responses and therefore only first-mentioned will be described in detail.

2.2. Adaptation to Climate Change

In the IPCC's Third Assessment Report from 2001 adaptation to climate change is defined as *"[…]* ***adjustments*** *in ecological, social, or economic systems* ***in response to*** *actual or expected* ***climatic stimuli*** *and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change."* (Smit & Pilifosova, 2001, p. 879)

A s*timulus* is here defined as a change in meteorological variables associated with climate change. It is important to enhance that these variables are different from weather events and refer to changed values of statistical parameters such as average intensity, frequency, or variance of for example temperature and precipitation patterns (Eisenack & Stecker, 2012). This includes both long term global climate change and current variability in climatic conditions, but in agricultural systems the climatic stimuli with the heaviest impact are variability and extremes rather than average conditions (IPCC, 2001; Smithers & Smit, 1997). The climatic stimulus is only of importance if it has an impact on an *exposure unit*, which refers to all actors and systems that are exposed to a stimulus, because they depend on climatic conditions (Eisenack & Stecker, 2012).

In the definition by Smit and Pilifosova (2001) adaptation refers to *ecological*, *social* and *economic* adjustments made to a climatic stimuli and the impact of this stimuli. In this thesis I use the term *adaptation* to only include adjustments made by humans and always in context to climate change. I understand human adaptation as "*a process, action or outcome in a system (household, community, group, region, country) in order for the system to better manage or adjust to a changing condition, stress, hazards, risk or opportunity"* (Barry Smit & Wandel, 2006, p. 282). It furthermore includes *cultural adaptation,* which refers to the process in which groups of people develop or adopt new and improved methods and technologies to their cultural repertoire in order to cope with the environment (Barry Smit & Wandel, 2006; Tompkins & Eakin, 2012). When projected to climate change I therefore understand human adaptation as adjustments to changing conditions, stresses, hazards, risks and opportunities triggered by climate change stimuli, by developing or adopting new and improved methods, skills and technologies.

2.2.1. Types of Adaptation

Adaptation is important since it can be used to assess the impact on and the vulnerability of a system, and to develop and evaluate the response options. Various types of adaptations have been distinguished with different types of classifications (Eisenack & Stecker, 2012; IPCC, 2001; Smithers & Smit, 1997). In the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) adaptations are categorized according to their purposefulness, timing, temporal scope and to their spatial scope (IPCC, 2001). According to their purposefulness the IPCC group adaptations as either *autonomous* or *planned* (see Figure 2).

Autonomous adaptation is defined as a response triggered by market or welfare changes and as a non-conscious response to a climatic stimulus (IPCC, 2007a). Furthermore, autonomous adaptation refers to responses initiated by private actors rather than by governments and tends to respond to multiple stimuli rather than a climatic stimulus alone. These other stimuli are

mainly triggered by economic, social, technological, institutional, and political changes (IPCC, 2001).

Planned adaptation is the result of a conscious policy decision, based on climate change awareness and that action is needed to return to, maintain, or achieve a desired state (IPCC, 2007a).

Autonomous and planned adaptation is thus broadly interpreted as private and public adaption, respectively, where private decision makers include individuals, households, businesses, and corporations, whereas public decisions always are performed by governments at all levels. Furthermore, consciousness is used as distinguishing parameter between autonomous and planned adaptations. The definition of the IPCC imply that the farmer does not act out of an conscious respond to climate change at the time of the decision, but that his response is stimulated rather by market and welfare change (IPCC, 2001). For example if a farmer changes his crop type because the crop is better suited to the new climatic conditions, the response can be defined as autonomous adaptation, since the response is initiated by the farmer himself (private actor) and triggered by what the farmer incrementally perceives as climate variability or changes in growing season, and it does not necessary imply the farmers understanding of climate change on a global scale (Jamieson, 2005). A planned adaptation could be the government producing and distributing seeds of drought resistant varieties to the farmer, which is classified as a public act, triggered from a conscious awareness of climate change.

The relationship of autonomous and planned adaptation to a climatic stimulus is shown in Figure 2.

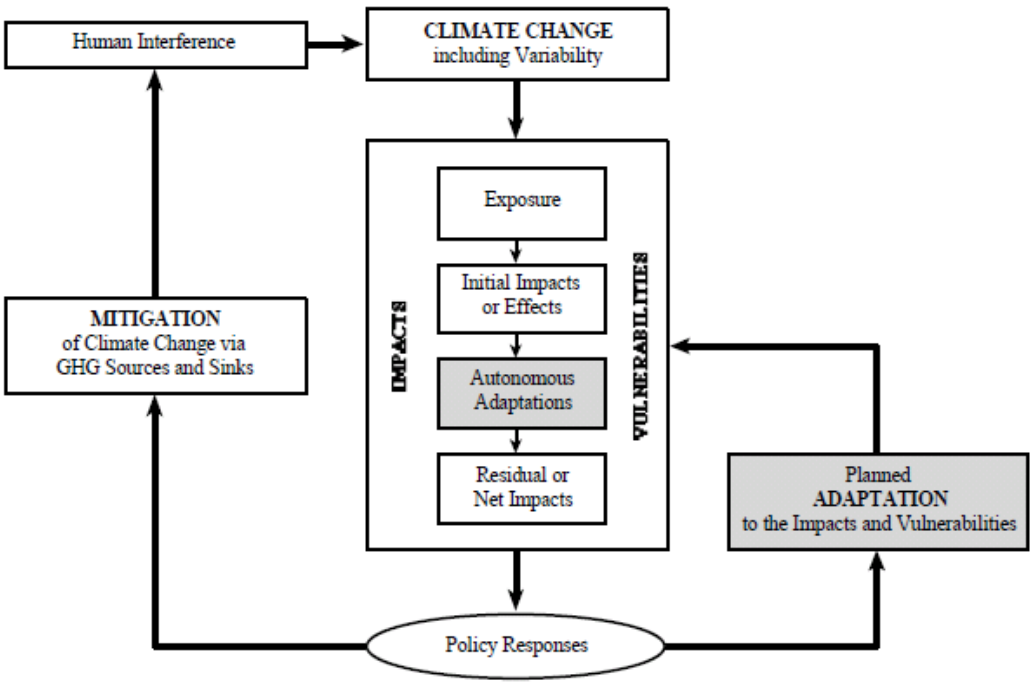

Figure 2: The Relation of Autonomous and Planned Adaption to a Climate Change Stimulus. Source: Smit & Pilifosova (2003, p. 9).

According to Smithers and Smit (1997) autonomous adaptations can both imply *conscious* and *unconscious* adjustments to climate change. They (ibid.) define *conscious adaptations* as adjustments where the actor responds out of an understanding of the climatic stimulus and with the goal to reduce the negative impact or benefit from the impact of the climatic stimulus. On the contrary, they define *unconscious adaptations* as incidentally adjustments made after the impact of a climatic stimulus without an understanding of the cause and therefore a passive action (Smithers & Smit, 1997). In this thesis I focus on adaptations performed by farmers rather than by governments and therefore on autonomous adaptation rather than on planned adaptations. Furthermore, I focus on adaptations that are applied consciously since analysing unconsciously applied adaptations are methodologically difficult to achieve.

Another distinction of types of adaptations is, depending on their timing, into *reactive* and *anticipatory*. *Anticipatory* or also called *proactive* adaption takes place *before* impacts of climate change are observed, whereas *reactive* adaption refers to the responses *after* a climate change impact. Anticipatory adaptation requires a well-founded understanding of climate change and knowledge on possible adaptation strategies. Autonomous adaptations are therefore mainly reactive, while planned adaptations can be either reactive or anticipatory. Furthermore adaptations can be grouped into short-term and long-term, and localized and widespread (IPCC, 2001). An interesting alternative grouping is according to the motivation of an adaption. An adaptation can here be classified as a *facilitating adaptation*, if the operator acts with the purpose to change something for other operators or a biophysical system, whereas adaptations made out of the purpose to change something for herself is classified as a *reflexive adaptation (Eisenack & Stecker, 2012)*. However, an exact distinction between whether an adaptation is applied for the individual itself or for other is not always easily identified.

More important than categorizing the type of adaptation is to analyse which factors are important in order for an individual or system to adapt to climate change.

2.3. Factors for Successful Adaptation

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

1) Timely recognition of the need to adapt

2) The ability to adapt

2.3.1. Recognition of the Need to Adapt

Even though the IPCC (2001) state that adaptations can be performed unconsciously, being aware of the necessity to adapt is important for timely and successful adaptation to climate change (Frankhauser and Tol, 1997). According to Maddison (2007) farmers unaware of climate change are less likely to apply agricultural measures that are effective in adapting to climate change than farmers who are aware of climate change. He (ibid.) therefore states that successful adaptation to climate change involves a two-stage process in which it is first necessary to perceive that climate change has occurred before deciding whether or not to apply an adaptive measure.

When using the term *perceiving* I understand it as becoming aware of something directly through any of the senses. The perception of climate change is an important pre-requirement in becoming aware of climate change, especially in areas where information on climate change is limited. However, perceiving climate change does not necessarily imply recognition of the need to adapt (Maddison, 2007).

Similarly, Eisenack and Stecker (2012) note that adaptations to climate change are not applied if there is no operator to perform the adaptation. They (ibid.) define an operator as an individual or collective actor (i.e. individual, a private household, a group, a government) that performs the respond and is part of a social entity. An operator will be missing if none of potential operators are aware of climate change or recognize the problem and thus the necessity to adapt. Unawareness of climate change or its impact can occur if social habits and normative standards prohibit an understanding of the climatic stimulus. Furthermore a situation of a missing operator will occur if potential operators ignore the impact of the climatic stimulus on the exposed unit. Ignoring the problem can occur if potential operators prioritize other issues (Eisenack & Stecker, 2012).

2.3.2. The Ability to Adapt – *Adaptive Capacity*

The second requirement to successful adaptation is the ability to adapt, also referred to as *adaptive capacity*. *Adaptive capacity* can be defined as the potential or ability of an individual or a social system to cope with a wide range of environmental conditions by developing genetic or behavioural characteristics (Fullan & Loubser, 1972; Smit & Pilifosova, 2003; Barry Smit & Wandel, 2006).

The concept of adaptive capacity has its source in evolutionary biology, and in an anthropological context the term genetic characteristics can be replaced by cultural practices. Likewise to evolutionary biology, the adaptive capacity of a society or culture determines its survival. Cultures or societies who are able to respond to and adjust to changes quickly and easily are considered to have a high adaptive capacity (Barry Smit & Wandel, 2006).

Adaptive capacity has also been termed "*coping capacity", "coping ability"* or "*capacity of response"* (Gallopín, 2006), but I choose to use the term adaptive capacity, since the term *adaptive* refers to adjusting while *capacity* refers to a measure of ability. Combined, the two terms therefore create a function that presents a measurement of the ability to adjust to climate change.

The adaptive capacity of a system is often confused with the term *resilience*. Resilience is different in the sense that it refers to "*a systems ability to absorb change and disturbance while undergoing change so as to still* ***retain*** *essentially the same function, structure and identity"* (Walker et. Al. (2004) cited in (Gallopín, 2006)). The adaptive capacity of a system can thus be seen as a component of resilience since adaptations can be performed to maintain a current state, but adaptive capacity can also determine adaptations to achieve a new function, structure and identity (Gallopín, 2006).

Marshall, Park, Howden, Dowd, and Jakku (2013, p. 13) define adaptive capacity as the human potential to convert existing resources into successful adaptation strategies. These resources or factors that determine ones adaptive capacity are among others: natural and man-made

resources, information, social networks, technology, infrastructure, human capital, institutions, governance, and an equal access to these (Adger & Tompkins, 2004; IPCC, 2007b; Smit & Pilifosova, 2001).

Especially the availability and access to means will increase an individuals' adaptive capacity, but likewise the lack of these can cause barriers to his/her coping range. According to Eisenack and Stecker (2012) means can be of three notions: *available*, *employed* and *necessary*. *Available means* refers to means that are disposable by the operator, e*mployed means* refer to the part that is actually used for a specific adaptation, and *necessary means* are those who are necessary in order to make an implementation effective. A barrier to implying adaptations occurs if the *necessary means* are not available. Furthermore, they (ibid) group means into:

1) Resources
2) Knowledge/Information
3) Power

Resources are here defined as natural or man-made resources, and while knowledge and power sometimes are categorized as resources as well, when speaking of resources in this context it only refers to material values (Eisenack & Stecker, 2012). Both natural and man-made resources are often essential to apply an adaptation measure and their lack therefore highly reduced ones adaptive capacity. Likewise the broader an individuals' access is to different resources, the greater his/hers adaptive capacity will be (IPCC, 2007b).

Knowledge/information on beneficial adaptation strategies is needed in order to adapt to climate change successfully (Frankhauser and Tol, 1997). When used in the context of farmers the term refers mainly to knowledge/information on agricultural adaptation strategies.

Power as mean refers here to the power to decide also termed *decision power*. Decision power can already be necessary from the beginning in order to be able to invent an adaptation idea and finally to be able to apply the strategy. For example an adaptation can be restricted if a motivated operator does not have the legal power to act. In another case an operator can have the legal power to act, but does not use the power due to cultural norms that oppress the operator. This can occur in societies where women are taught to oppress their ideas and opinions due to cultural norms. Even though the legislative framework gives them the legal power to act, they might not feel empowered or know about their power because of cultural constraints.

In order to adapt successfully to climate change all three factors are required, namely the access to natural and man-made resources, access to information and the power to decide and take action (Eisenack & Stecker, 2012). For example, if the farmer has been exposed to more heavy rains and therefore an increase in soil erosion, he would need knowledge on what he could do to prevent the new negative impact on his land. However, not only the knowledge that building terraces can reduce soil erosion is required, but also the knowledge on how to construct the terrace is needed. Furthermore, the farmer needs resources to build the terraces in the form of basic digging tools or construction materials. In this example these resources are rather simple, but in other cases the required resources can be unavailable either because they are too expensive, not present, or because social structures and roles keep them inaccessible

to certain groups or gender. Finally, the farmer needs power to decide that economic resources are spend, in order to buy the construction materials, and the legal power to implement the adaptation measure.

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

2.3.3. Human Capital

According to Verhoglyadova (2006, p. 250) human capital is defined as *"incarnated fund of human abilities, knowledge, skills and motivations to encourage human productivity".* Fullan and Loubser (1972) state that individual adaptive capacity is highly influenced by personality factors associated with mental strength (such as self-esteem, self-competence, etc.) and skills, which are influenced by an individuals' capacity for *variation* and *retention.*

Variation capacity is an individual's ability *to generate* new ideas and alternative solutions to problems. The *retentive capacity* refers to the ability of an individual *to evaluate* and therefore be able *to select and apply* new ideas to solve the problem. *Variation* and *selective retention* are complementary processes, and selective retention can only occur after an amount of ideas have been generated. Further, the two functions can differ in their range and therefore having the ability to generate various possible solutions does not imply the ability to order and select the most effective one out of the generated ideas (Fullan & Loubser, 1972).

The *variation capacity* of an individual, hence the ability to generate new ideas and solutions to problems, is based on intuitive thinking and formed by three critical functions according to Guilford (1963) (cited in (Fullan & Loubser, 1972)):

1. The ability to retrieve or recall information from the memory storage
2. Flexibility
3. Openness to new experiences

The ability to retrieve or recall information from the memory storage is fundamental to generate ideas and alternative solutions. Theoretically, the magnitude of memories increases with time and age of an individual. Similarly, the more educated a person is, the broader range of knowledge and information for retrieval would be available (Fullan & Loubser, 1972). However, the ability to recall these memories and retrieve information from them differ among individuals and might depend on age and other individual factors. It can be argued that the individual's ability to retrieve memories increases until a certain age, after which it declines naturally.

The second function contributing to the *variation capacity* is flexibility, which refers to the ability continually to modify or redefine information in order to view them in new situations. With other words, flexible thinking is the ability to shift reflectively from imagining one situation to another. Fullan and Loubser (1972) suggest that flexible thinking can be trained and increased especially through education.

The third function critical for an individual's variation capacity is openness to new experiences. Fullan and Loubser (1972) state that underlying to this quality trait is the believe in one's own judgment and the perception that the environment is manipulable and controllable. A person open to new experiences will therefore be more likely to question traditional practices and develop new or alternative ways instead of passively accepting traditional ones.

Retention capacity involves the ability to order different experiences and ideas, relate them systematically on the basis of logical reasoning and select from these in order to solve a problem. It is based on analytical thinking and depends on the individual's ability to analyze, abstract and combine new elements and their logical interrelations (Fullan & Loubser, 1972).

Variation and *retention capacity* is equally important in order to achieve a high individual adaptive capacity. A high variation capacity will not create a high adaptive capacity if the individual has a low retention capacity and therefore is unable to sort his generated ideas to achieve the optimum solution. Likewise, having the ability analytically to sort out the best solution will not result in a high adaptive capacity if the individual cannot generate a variation of ideas to solve the problem. A high individual adaptive capacity therefore requires a high variation capacity and retention capacity, where the individual is able to generate many alternative solutions to a problem and is able to order and range these according to their effectiveness.

2.4. Levels of Adaptive Capacity

According to Barry Smit and Wandel (2006) the adaptive capacity is context-specific and varies among countries, communities, social groups and individuals, and over time. The scales of adaptive capacity are interdependent and therefore the capacity of a household to cope with climatic stress depends to some extend on the adaptive capacity of the community, which further might be formed by the adaptive capacity of the region (Smit & Pilifosova, 2003). Similarly, Fullan and Loubser (1972) state that the adaptive capacity of individuals and social systems are interdependent and show a reciprocal relationship in which individuals with a high adaptive capacity will influence the character and adaptive functioning of a social systems and vice versa. They (ibid.) further state that education and adaptive capacity are interwoven at both individual and therefore also on social levels.

The factors determining and influencing the adaptive capacity of an individual on different levels are visualized in Figure 3.

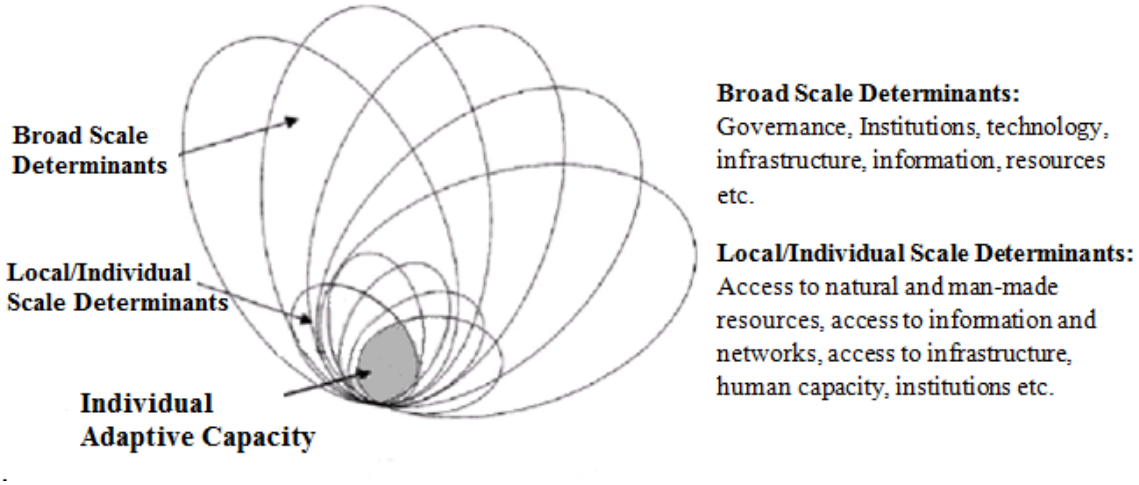

Figure 3: Factors Determining Individual Adaptive Capacity at Different Scales. Adapted from Barry Smit and Wandel (2006, p. 286).

2.5. Coping Range

Most individuals and societies can cope with conditions that deviate from the average, but only to some extend and in a certain range. The adaptive capacity of an individual or system determines his/hers *coping range*, where the boundaries of this range are of gradual nature and referred to as "coping or adaptation threshold" (B. Smit & Pilifosova, 2003). An individual or household becomes vulnerable to conditions positioned beyond the coping threshold and thus outside of the coping range. An increased frequency of events near the coping threshold or a catastrophic event beyond the threshold of a coping range may decrease the threshold beyond which the system cannot adapt (Barry Smit & Wandel, 2006). For example, in a year of drought a farmer can adapt to this stress by drawing on stored resources. However, if he continues to use the stored resources as adaptation to the climatic stress and thus decreases his adaptive capacity, his coping range will narrow. If he in the following years likewise is affected by drought, hence close to the threshold of his coping range, he will not be able to build up his storage and at some point the coping range will be too narrow to survive.

The coping range of a system is not static and it responds to changes in economic, social, political and institutional conditions over time. For example, population pressure and resource depletion may reduce an individual's adaptive capacity gradually and thus narrow his/hers coping range. Likewise, increasing infrastructure and technology might increase the adaptive capacity of an individual and therefore his/hers coping range (Barry Smit & Wandel, 2006). This is visualized in Figure 4.

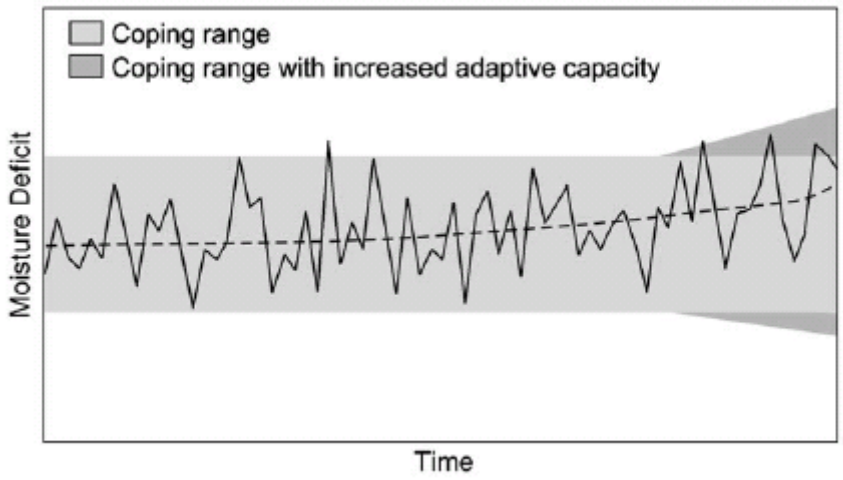

Figure 4: Coping Range and Adaptive Capacity of a System. Source: Smit & Pilifosova (2003, p. 287)

2.6. Adapting to Climate Change at Farm Level

In the previous sections I have described the theoretical foundation of adaptation. In this section I will describe adaptation strategies that are focused on the given practical context, namely small-holder farmers in Ethiopia. The adaptation strategies listed are mainly agricultural practices that can be performed at farm level in order to moderate negative impacts of climate change stimuli and/or to benefit from the opportunities such impacts bring. Several adaptation options on farm level exists i.e. diversifying the farming system, the use of new crop types and varieties, the use of new livestock species and breeds, the adjustment of planting dates, altering cropping location, improved land management, expanded rainwater harvesting, and improved water use efficiency. However, implementation of these individually will only have limited effect and therefore a combination of several of the options should be applied. Furthermore, it is important to highlight that not all adaptations may be beneficial to an agricultural system in the long-term.

2.6.1. Crop Adaptation Option

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

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

2.6.2. Livestock Adaptation Options

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

2.6.3. Agro-ecological Practices

Agro-ecology is a sustainable farming approach that combines the two disciplines agronomy and ecology. It is defined as a way of farming that protects natural resources by using new, modified, or adapted practices or techniques that contribute to a more environmentally friendly, ecological, organic or alternative agriculture (Wezel et al., 2009). An important strategy to manage negative impacts of climate change on farm level is to focus on diversifying the farming system so it decreases its vulnerability to stresses from outside (Nelson, 2010). These practices and techniques are rooted in traditional small-scale agriculture (Altieri, 2009) and form a very suitable farming strategy for smallholder farmers in Ethiopia. Agro-ecology focuses especially on soil fertility and organic matter management, on the conservation of natural resources, and on creating a divers farming system by using practices such as poly-culture, raised fields, terraces, and agro-forestry (Altieri, 2009; Wezel et al., 2009). Therefore traditional agro-ecosystems are less vulnerable to climatic stresses since they grow a wide range of different crops in various spatial and temporal arrangements (Altieri, 2009, p. 108).

Using agro-ecological practices similarly focuses on the conservation of natural resources, which is another option to decrease the vulnerability and thus adapt to climatic changes. Especially soil and water have an important function in agricultural systems and therefore soil and water management and conservation are crucial to improve resilience. Soil conservation methods include vegetative soil coverage and control of soil erosion through i.e. planting trees, building terraces and optimizing drainage channels. Water management and conservation is similarly important and closely linked to soil conservation. It involves optimizing the current use of water and creating new water sources (Gebrehiwot & van der Veen, 2013).

To diversify the farming system the farmer can choose to grow different crops on different fields or on the same field and/or by mixing crop and livestock systems. The practice of cultivating different crops in the same field is referred to as poly-culture (Altieri, 2009), whereas the cultivation of wooden perennials combined with crops and/or animals is defined as agro-forestry (Atangana, Khasa, & Chang, 2014, p. 35). According to Altieri (2009) the cultivation of poly-

cultures can increase the yield of harvestable products per unit area by 20 to 60 percent compared to mono-cultures, since poly-cultures reduce losses by weeds, insects, and diseases, and are more efficient in using the available natural resources. The production of each commodity will be less compared to a monoculture production, but the farmer gets a higher total and more divers output per field unit (Altieri, 2009, p. 105).

Agro-forestry is defined as a land-use system where woody perennials are integrated with agricultural crops and/or livestock in the same land unit, in a spatial arrangement or temporal sequence (Atangana et al., 2014, p. 35). In both systems the growing of different crop types reduces the farmer's risk of complete failure, since different crop types in general are affected differently by climatic events. Furthermore, mixed holding of several livestock species and plant based systems will increase the resilience of the farming system, since likewise animals and plants are affected differently by climatic stresses. The more divers the cropping system is, the less vulnerable the farming system will be to climatic impact and stresses (Gebrehiwot & van der Veen, 2013). Furthermore, in agro-forestry systems the farmer can influence the microclimate, since trees can reduce temperature, wind velocity, evaporation, and direct exposure to sunlight and hail (Altieri, 2009, p. 108).

2.6.4. Other Options to Adapt to Climate Change

In addition to diversifying the farming system, the farmer can increase his adaptive capacity by including non-farming activities into his livelihood (Howden et al., 2007). Households, in which one or more members contribute to the economy of the household, by working with non-farming activities, will be less dependent on the farming output and therefore less vulnerable to harvest failure due to climatic stresses.

Migration is another adaptation option to climate change, since mobility can function as method to escape environmental threats. Migration can be temporally or permanent, and occur within the country or between countries. It can bring opportunities, but also challenges. Migration can enable people to diversify their income and migration of some individuals can benefit a whole community if money is sent back to the village. However, migration to other climate change vulnerable areas or to areas that already face population pressure entail challenges rather than opportunities (Black, Bennett, Thomas, & Beddington, 2011).

After this theoretical introduction of adaptation to climate change I would like to present my objectives and aims of this thesis.

2.7. Objectives

My aim is to analyze how female and male smallholder farmers living in Zenzelima adapt to climate change and which factors are influencing their adaptations and lack of adaptations. When I use the term female farmers I refer to women who perform daily or occasionally agricultural tasks and/or are married to a male farmer.

Since adapting to climate change is influenced by the awareness of climate change and the awareness of the necessity to adapt to these changes, I will first analyze the farmers' perception of climate change. The aim is here to find which changes farmers in Zenzelima have perceived

in temperature, precipitation, and/or environmental over the last 10 to 20 years that vary from the normal annual variability, if any.

Furthermore, adapting to climate change is dependent on the ability to adapt and I will therefore analyze the adaptive capacity of the farmers by examining how farmers in Zenzelima have responded to climate changes so far and by examining which factors are potentially influencing their adaptive capacity.

I focus on the differences and similarities of female and male farmers in Zenzelima in order to discover how gender relations influence the adaptive capacity.

2.8. Research Question

How do female and male farmers in Zenzelima, Ethiopia, adapt to climate change and which factors are influencing their adaptations?

To answer the research questions, the following sub-questions will be treated:

- *Which climate and environmental changes have smallholder farmers in Zenzelima perceived, if any?*
- *How have they responded to these changes?*
- *Which factors are influencing the adaptive capacity of smallholder farmers in Zenzelima?*
- *How are these factors influencing the farmers' adaptive capacity?*

Before answering these questions I will present the case area Zenzelima and the methods I have used to achieve the empirical data.

3. Case-study Zenzelima

The survey was conducted in the *kebele* Zenzelima located in Amhara Region in the north-western part of Ethiopia (see Map 1).

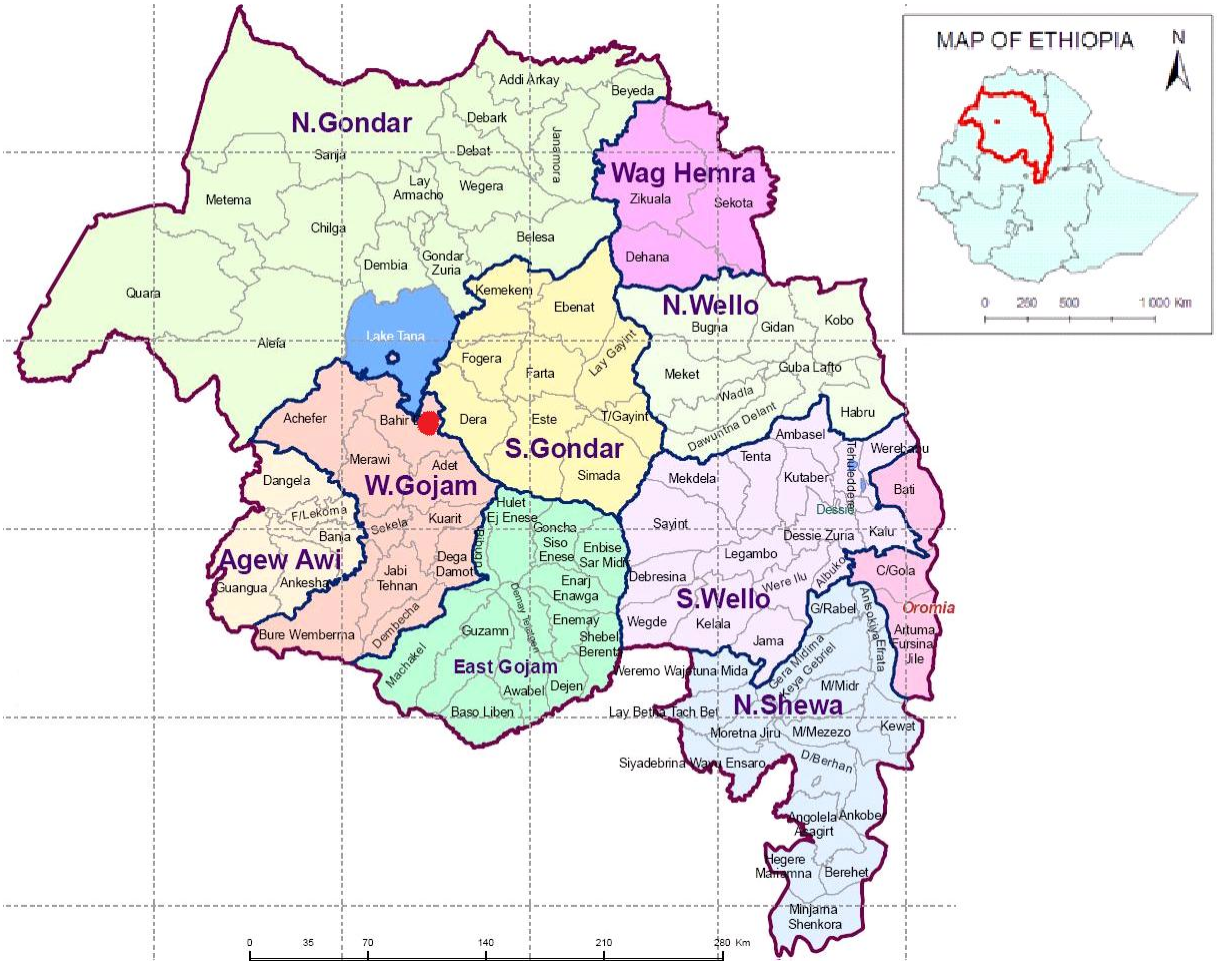

Table 1: Map of Amhara Region and Ethiopia. Amhara Region and the regions' administrative zones and woredas are viewed to the left and Ethiopia with regions is viewed to the right. The red point marks the location of the study area Zenzelima. Source: Adugna (n.d.).

Amhara Region is divided into 11 administrative zones and 105 *woredas*[6]. Elevations range from 700 m in the east to 4600 m in the northwest, with about 69 % of the region consisting of highlands (≥ 1500). Approximately 30 % of the total area is being used for cultivation, 30 % for grazing, 17 % is covered by forest, woodlands and shrublands, 4 % by water bodies, 3 % by settlements, and 16 % is classified as wasteland (Bewket & Conway, 2007).

Zenzelima belongs to the *woreda* of Bahir Dar Zuria, which is part of the West Gojam administrative zone. The *kebele* is situated about 7 km from Bahir Dar city, which is the capital

[6] *Woreda* is the administrative level above *kebeles* equivalent to a district (Di Falco et al., 2011)

of Amhara National Regional State. It boarders to the country's biggest lake, Lake Tana, which is the source of the Blue Nile (Haregeweyn, Fikadu, Tsunekawa, Tsubo, & Meshesha, 2012). Zenzelima consists of the three villages Sesaberet, Gedro and Skt. Michael and has a total population of 11,030 people with a distribution of 5,643 females to 5,487 males (Agricultural Extension Worker, personal communication, May 5, 2014). The *kebele* is divided by a major road that connects the capital city of Ethiopia, Addis Abeba, with Gondar City by going through Bahir Dar. Agriculture is the main source of livelihood, but the opening of a new campus of Bahir Dar University in 2011 (ECO-opia, 2013) has led to an increase of small shops and restaurants.

Picture 1: Main road from Bahir Dar to Gonder leading through Zenzelima.

Picture 2: The new university campus of Bahir Dar University next to farmers' fields in Zenzelima.

3.1. Agriculture

The farming practices in Zenzelima are very typical for Ethiopia, where agriculture is characterized by being highly dependent on rainfall and by using traditional tools and practices. The major crops cultivated are wheat (*Triticum* spp.), barley (*Hordeum vulgare*), finger millet (*Eleusine coracana*), teff (*Eragrostis tef*), sorghum (*Sorghum Bicolour*) and maize (*Zea mays*). Teff is indigenous and the most preferred grain in Ethiopia and primarily used in the making of traditional fermented bread called *injira.* Sorghum and millet are the least preferred cereals, but relatively drought and pest tolerant (Evangelista et al., 2013). The majority of farmers rely on both crop production and livestock, with cattle being predominant, since it is used for milk and meat production, as draft power and as commodity to generate income. Furthermore, sheep, goats and chickens are commonly hold (Solomon, Snyman, & Smit, 2007).

Farmers in Zenzelima have the opportunity to achieve free advice and trainings on agricultural practices by contacting the agricultural extension office located in Zenzelima (Agricultural Extension Worker, personal communication, May 5, 2014). The agricultural extension service in Ethiopia is believed to have started in the early 1950's with the establishment of Alemaya University, who started training and advising farmers on improved poultry production, horticulture, tree seedlings production and distribution, improved wheat varieties, and apiculture. Since 1963 the Ministry of Agriculture (MoA) regulates the agricultural extension service on national level and has implemented several development plans with the aim to modernize agriculture in Ethiopia. These programs were all funded and assisted by foreign aid and the first extension program developed without foreign assistance and fully funded by the Ethiopian

government was the Participatory Demonstration and Training Extension System (PADETS) in 1995. The main aim of the program was to increase productivity and production of smallholder farmers, increase food self-sufficiency, increase the supply of raw materials for export and domestic use, enhancing the rehabilitation and conservation of natural resources, and empowering and encouraging farmer organizations. The methods used and which are still used today are demonstration plots and the provision of information on agricultural technology, agricultural inputs and credits. At the state of 2002 about 4.2 million farmers and 15.000 extension workers were participating in the extension program. Currently, extension service is mainly funded and provided by the government through its *woreda* level Offices of Agriculture and Rural Development (OoARD). In Amhara Region the agricultural extension service has a different structure of the woreda level and here the woreda is classified into two extension areas. The extension activities in each extension area is regulated by a team consisting of an extension team leader, an extension and training expert, and of experts in crop production, animal production, and natural resource management (B. Gebremedhin, Hoekstra, & Tegegne, 2006).
In Zenzelima the agricultural extension office consists of four agricultural extension workers specialized in crop production, livestock production, natural resource management, and land administration. At the time when the field study was conducted the office was advising 289 female and 1494 male farmers living in Zenzelima (Agricultural Extension Worker, personal communication, May 5, 2014).

3.2. Climate and Climate Change Bahir Dar Zuria

As mentioned earlier, Zenzilima belongs to the woreda Bahir Dar Zuria which is located in the Agro-ecological zone 2 classified as being tepid to cool sub-moist mid-highlands (FAO, 1996 cited in (Hassan & Deressa, 2009, p. 533)). Bahir Dar Zuria is situated at an altitude ranging from 1,700 to 2,300 m with minimum and maximum temperatures of 10 °C and 32 °C, respectively, and average annual rainfall ranges from 820 to 1,250 mm (Legesse, 2013). Significant intra-regional differences in rainfall amount, variability, and trend occur in Amhara Region (Bewket & Conway, 2007) with about 84 % of the annual rainfall occurring in *Kiremt*, the main wet season, lasting from June to September. The rest of precipitation occurs equally divided in *Belg*, the minor wet season lasting from March to May, and in *Bega*, which is the dry season from October to February (Bewket & Conway, 2007).

When comparing maximum and minimum temperature for Bahir Dar Zuria district from 1960 to 2006, high annual variability can be seen with maximum temperatures ranging from 25 to 28 °C and minimum temperatures ranging from and 7.9 to 13.4 °C. However, a trend of increasing annual maximum temperature of app. 1 °C and minimum temperature of app. 3 °C, respectively, can be seen. When comparing the annual amount of rainfall between 1961 and 2009 a trend of decrease in precipitation of approximately 163 mm has occurred (See figure 5). Likewise to the max and min temperature, high variability per annum is characterizing the area (Legesse, 2013).

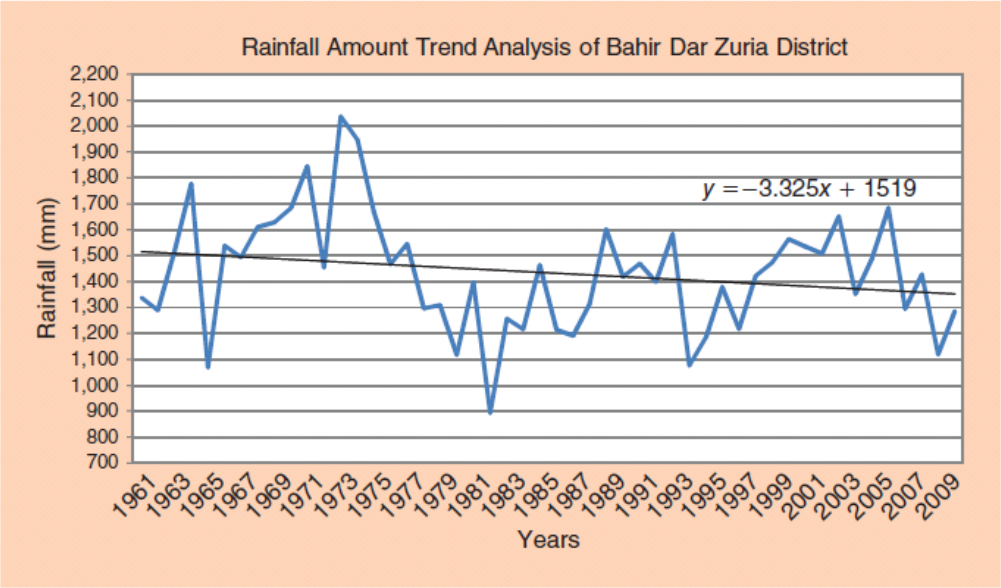

Figure 5: Annual Average Rainfall Amounts (mm) between 1961 and 2009 for Bahir Dar Zuria District. Source: Legesse (2013, p. 32).

Bewket and Conway (2007) similarly found a trend of declining annual rainfall from 1961 to 2003 comparing rainfall data of a weather station located in Bahir Dar, but classified these values as not statistically significant. When comparing the rainfall data of the different years, high variability can be seen with a cluster of negative anomaly from 1978 to 1988 and from 1994 to 1998. Positive anomaly occurred between 1966 and 1977 and from 1988 to 2003 (see Figure 6). Generally, higher inter-annual variability occurs in *belg* and *bega* than in the main rainy season *Kiremt*.

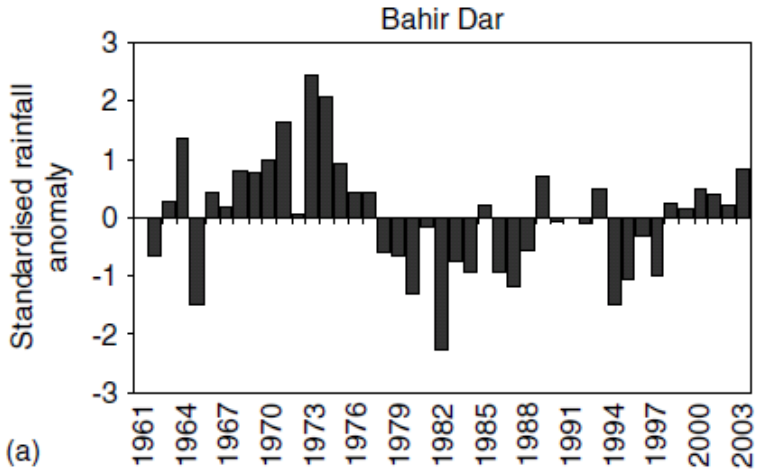

Figure 6: Standardized Rainfall Anomaly of Weather Station in Bahir Dar from 1961 to 2003. The y-axis shows the standard deviation of the average annual. Source: Bewket & Conway (2007, p. 1474).

According to Bewket and Conway (2007) the average amount of rain on a wet day (mean wet-day amount) has decreased significantly, while the probability of dry days per year likewise has decreased significantly. This means that the weather in Bahir Dar has developed into containing more days with rain per year, but with a lower amount of precipitation daily and annually.

3.2.1. Climate Change Predictions

For the IPCC mid-range (A1B) emission scenario Amhara Region is predicted to be one of the Ethiopian regions with the highest temperature increase with mean annual temperature increasing with 1.1 °C by 2030, 2.1 °C by 2050 and 3.4 °C by 2080 compared to the 1961-1990 average (Tadege, 2007). When projecting the SDSM scenario Amhara Region and in particular the area of and around Zenzelima could experience an increase in mean maximum temperature of 0.4° C, 1.0° C, and 1.8° C by 2020, 2050 and 2080, respectively. Annual rainfall could decrease by 4.2%, 3.3 %, and 12.2 % by 2020, 2050 and 2080, respectively (Ayalew et al., 2012).

According to Hassan and Deressa (2009) the tepid to cool sub-moist mid-highlands (to witch Zenzelima belongs) will experience increasing temperature and decreasing precipitation and therefore a reduction in crop yield by the year 2050 when projected to the CGM2 scenario. Under the HADCM3 and PCM scenario the tepid to cool moist mid-highlands are expected to receive increasing temperature and increasing precipitation, and thus benefit from climate change by 2050, but experience negative impacts by 2100. In all three scenarios the tepid to cool sub-moist mid-highlands will experience fundamental agricultural losses by 2100 which makes agricultural adaptations a necessity in order for the smallholder farmers to maintain their agricultural subsistence (Hassan & Deressa, 2009).

3.3. Methodology

The data in this study were collected through qualitative semi-structured interviews with 10 female and 10 male small-holder farmers in Zenzelima, 4 agricultural extension workers, and 1 employee from The Organization for Rehabilitation and Development in Amhara (ORDA) during May 2014 in Ethiopia. The interview guides were inspired by theory on qualitative interviews by Boyce and Neale (2006); Jacob and Furgerson (2012); Turner (2010). Two test-interviews were performed to optimize the interview guide further.

3.3.1. Selection of Interviewees

20 small-holder farmers in Zenzelima were chosen *ad hoc* by asking for their willingness to participate in the project on-site. The interviews were performed immediately afterwards or in single cases on an agreed date in the same week. Criteria for the selection of the farmers were that the interviewees were farmers, above 18 years old, living in Zenzelima and that both wife and husband were willing to participate in the interview. The 20 interviewees therefore represent 10 households. This criterion was of importance since one of the focus areas in this survey was to analyze for differences in perception and action related to the role and nature of gender and thus similar living conditions were required. Furthermore, I was aware of including old, middle-aged and very young farmers in the study in order to get a divers age spectrum. The average age of the interviewed farmers is 40 years, with the youngest being 18 years old and the oldest 75 being years old.

The four agricultural extension workers were interviewed, because I considered them as being an important potential source of information for the farmers in Zenzelima and as having a potential influence on the farmers, due to their function as advisors on agricultural practices. All interviewed extension workers were graduate university students specialized in plant production, animal science, land administration and natural resource management, respectively, and none of them had worked longer than one year as advisor in Zenzelima. Three of the advisors were male and one was female, with the youngest being 21 and the oldest 31 years old.

Finally, one interview was performed with a female worker from The Organization for Rehabilitation and Development in Amhara (ORDA), who was responsible for women relations in the organization. She was chosen as respondent because of her indebt knowledge on the situation of female farmers and women in rural areas of Amhara, because of her many years of work experience in this field.

To ensure the anonymity of the interviewees no real names are provided and all respondents have therefore been given a reference number instead.

3.3.2. Conduction of the Interviews

I structured the interviews with the farmers in such way that it would start with an open question about her/his everyday tasks and life situation in Zenzelima, followed by some more general questions on the life as farmer in Zenzelima. Afterwards I asked questions related to climate and other changes in the natural environment, questions about women relations, and finally questions about the community. Since I used a qualitative approach some interviews further contained individual questions and questions were not raised in the same order.

All interviews were taped, in order to give the interviewee maximum attention, and assisted with short handwritten notes or drawings and afterwards transcribed verbatim. The interviews with the farmers were mostly held in their homes or on their fields, whereas the interviews with the extension workers and the worker from ORDA were held in or outside their offices in Zenzelima and Bahir Dar, respectively. The interviews lasted in average about 30 minutes with the shortest interview lasting 15 minutes and the longest one hour.

The majority of the farmers did not speak English and therefore a female interpreter was interpreting the English questions from English to Amharic for the farmers and the answers reverse to me. The term *translator* and *interpreter* are often used synonymous, but they imply different skills. Jones & Boyle (2011, p. 110) define a translator as a person changing written text into another language, whereas an interpreter changes spoken languages into spoken form of another language. I chose a female interpreter since I wanted the female farmers to feel unrestricted to speak about women relations and I considered the presence of a male as potentially restricting their answers. Likewise, the absence of the husbands and other male adults was required during the interviews with the female farmers, in order to make the women feel free to speak about their relation to their husband and without feeling limited or hushed by them. Through to cultural norms the interviews were often held in the presence of other village members, since it showed to be impolite to ask them to leave. Therefore, during interviews with women especially children and elder women were present (see Picture 3 & 4) and during interviews with men especially other men and children were present (see Picture 5). The

presence of other villagers might have influenced the answers of the respondents, since it could have encouraged a farmer to say certain things and/or hindered him/her in expressing other things. For example the presence of people who the interviewee values as confidential and has a close relationship to might have made the interviewee feel more comfortable and relaxed and therefore more open to the interview. The presence of people who the interviewee perceives as untrustworthy or fears social judgement from might have kept the interviewee from expressing her true opinion and thoughts.

Picture 3: Female farmer being interviewed in front of her house in the presence of curious children and other women.

Picture 4: Female farmer interviewee and her children.

Picture 5: Interview with male farmer in his garden next to the interpreter.

Furthermore, the women were very busy and thus often had to do housework such as preparing food or taking care of their children during the interview. This might have influenced the quality of the interview negatively, since the interview was not given full attention.

During the interviews with the extension workers and the employee from ORDA, all respondents where alone during the whole interview and were therefore not affected by the presence of their colleges or other village members.

3.3.3. Coding and Analyzing the Interviews

I used the computer program AtlasTI to code the interviews and I used a combination of initial coding and a structural approach to code the data. When I use the term structural approach I refer to the process of using my theoretical framework in order to create main categories and sub-categories and afterwards to sort the statements of the interviewees into these categories by giving them codes. For example one main category was climate change, while a subcategory was temperature. Another example is adaptive capacity as main category and access to economic resources as subcategory. Furthermore, I included codes that were not directly linked to my theoretical framework, but of importance in understanding the farmers livelihood situation and this process I refer to as initial coding.

3.4. Experiences and Field Work Realities

According to Mikėnė, Valavičienė, and Gaižauskaitė (2013) qualitative interviewing is a process of constant interaction between pre-constructed methodology (the researcher) and the field (the participant), which is build upon the perspectives and behaviours of participants while at the same time the researcher becomes an active instrument of collecting information and of validation. Qualitative field-work can often be unexpected and challenging, and it therefore requires a high level of preparation and flexibility (Mikėnė et al., 2013). Even though I had prepared myself theoretically before conducting the interviews, the real conditions and unexpected situations have both influenced the outcome of the interviews positively and negatively.

3.4.1. Finding Access to the Field

Flick (2007) (cited in (Mikėnė et al., 2013)) notes that *finding access* to the field is fundamental to compose a qualitative study.

Finding access to the field was partly difficult, since it was hard to find farmers in Zenzelima who were willing to be interviewed, mainly because I set the precondition that both wife and husband of a household had to be interviewed. The husbands however were often not at home, whereas the wives often were too busy working in the household to have time for a qualitative interview. Arranging appointments further showed to be very difficult since the farmer often would not show up on the agreed date. In some cases the male farmers were anxious to help me with my research, while their wives were rather sceptical and seemed to participate in the interview only due to their husbands wish. In other cases it was the opposite and the female farmers convinced their husbands to participate. In both cases the quality of the interviews with the sceptical respondents was influenced negatively and resulted in lower quality of the interview. Furthermore, some farmers were not willing to participate in an interview because they had no

interest in the topic and perceived it as a waste of time. Another factor complicating the access to the field was geographical distance. All of the farmers I interviewed were located in Skt. Micheal and Sesaberet and in relatively near distance to the main road. Gedro however, the third village constituting the kebele Zenzelima, was situated farther away and difficult to access without any transportation option. Therefore, I did not conduct any interviews with farmers from Gedro, which may have influenced the interview data and results of this study.

3.4.2. Situation of the Interview

The optimal situation is to conduct a qualitative interview in an environment which is comfortable and non-disturbing for both researcher and participants and without outsiders intervening during the interview process (Mikėnė et al., 2013). This turned out to be challenging in some cases, where it was difficult and sometimes impossible to convince the female or male farmer to move to a place, where we could be alone. Mainly because women always would have to take care of their children or felt uncomfortable being alone with us, and therefore either children or other women would be present while conducting the interviews. The presence of other women can have influenced the responses of the interviewees both positively and negatively, since the female farmer might feel more comfortable or restricted around other women. However, especially the presence of the young children often took the focus of the female respondents, which may have reduced the quality of the interview. The male farmers were more often interviewed alone, simply because they often were alone when I approached them. However, when other people where present some similarly refused to move to another place or to ask the other villagers to leave. Thus often other farmers or family relatives were present during the interview, which might have influenced the outcome. Furthermore, especially the female farmers but also some male farmers only agreed to participate in the interview if they could continue working while responding to the questions. This entailed that they were less concentrated on the interview and responded shorter than the average.

3.4.3. Working with an Interpreter

Werner and Campbell (1970) describes the optimal function of an interpreter in field work as:

"An interpreter is not an adjunct to a cross-cultural-cross language project, he is central to its success. It takes time and patience to learn to work with an interpreter . . . ideally he should be a bilingual, linguistic-cultural expert and colleague, in every sense of the word a confidant of the project. Such a person is more important than any of the "rules"." (Werner and Campbell (1970, p. 408) cited in (Jones & Boyle, 2011)

However, this was not the case in my research. The interpreter helping me with my field work interviews was no native English speaker and her level of English was not sufficient to perform a literal interpretation. Therefore she would give me a resume of the respondents' answers and leave out parts that she found unimportant for my study. To increase the quality of the interviews I therefore got several parts of the recorded interviews reinterpreted by another person, who delivered a literal interpretation. In these reinterpretations I found that my field interpreter had left out many responses which I valuated as important and would have liked to follow up on and sometimes even added information, which the respondent had not mentioned:

Field work interpreter:

> *"Before there is different indigenous trees and it covered the land and the river was throughout the year, but now there is only eucalyptus. And now there is drought. And before they used grass as roof for the house, but now they use iron." (Male farmer 1)*

Re-interpreter:

> *"When I was a young kid there used to be all trees, everything was green and there used to be plenty of rivers and the rivers used to be wet all year around. Now there is drought on the rivers, we are facing many problems due to the drought. When I was a kid there used to be endemic/local trees. Now they are all gone and replaced by eucalyptus and mango trees. Some of the local trees are dokma, eshe. It used to be much better when these trees where around." (Male farmer 1)*

The example shows that my field work interpreter delivered resumes of information she evaluated as important to my study. The farmer is not mentioning that he had grass roof and changed it to iron roof, but my field work interpreter observed this and evaluated it as important information. Furthermore, the literal interpretation shows personal values of the respondent, which are very important in order to understand the answer and situation of the respondents.

The low quality of the field work interpreter has a big influence on the outcome of the interviews since it hindered the interaction between me and the respondent. Mainly because I could not follow up on statements that my field work interpreter had left out in her interpretation and secondly because I asked the respondents questions to statements that my field work interpreter stated, but which the respondents had not mentioned. However, since a high share of the responses has been reinterpreted, the quality of the output is rather influenced by the lack of follow up questions than by incorrect results.

4. Results

In this chapter I present the results acquired through the performed interviews. The chapter starts with a short description of the settings under which female and male farmers in Zenzelima live, in order to give the reader a better understanding of the following results. This description is followed by a part concerning female and male farmers' perception of climate change in Zenzelima and their observations of other changes in their natural environment. The second part of the analysis concerns the farmers' responses to these changes and analyses their adaptive capacity by examining their access to natural and man-made resources, information, and decision power, and by examining the influence of individual characteristics and socio-cultural characteristics on these.

4.1. The Life of Female and Male Farmers in Zenzelima

The life of female and male farmers in Zenzelima is highly influenced by their work tasks and responsibilities. According to the interviewees there exists a clear division in both, with women mainly being responsible for the household and caretaking of the livestock, while men are responsible for the income of the household and fieldwork.

4.1.1. Female Farmers' Work Tasks in Zenzelima

Female farmers in Zenzelima thus spend most of their day in or close to their house, occupied with household related work tasks such as cleaning, washing, cooking, making local beer, caretaking of their children, and feeding their livestock. They are further responsible for fetching water and for bringing lunch to their husbands while they are ploughing the land. Apart from their responsibilities in the household they help their husbands with field work during the time of seeding, weeding, and harvesting. Their work load is very high, since they are working from the early morning to the late evening, mostly without any help from their husbands with household tasks. Some of the younger females in Zenzelima have started to work in small shops or as retailer on the local market at Wednesdays and Saturdays, but the share of females engaging in income creating activities is rather low.

> *"After I wake up I will prepare breakfast for my husband and children and start cleaning the house. And sometimes I help my husband on the field with weeding or harvesting. [...] In our culture the woman does everything in the home and helps her husband on the farm, but men are only outside of the house." (Female farmer 1)*
>
> *"On the farm women and men work together. Female mostly do not plough the land, but they help with the row planting, putting fertilizer and seeds. Before going to the field I work at home. And I go and help my husband. I come back and also I cannot sit, my husband can sit, but I need to make the dinner and other things, so the workload for woman is very high." (Female Farmer 3)*

Picture 6: Female farmer making traditional Ethiopian bread called *injera*.

4.1.2. Male Farmers' Work Tasks in Zenzelima

According to the interviewed male farmers their primary responsibility is assuring an income for their household. Their main tasks are related to field work in the form of ploughing, weeding, harvesting, and taking care of livestock. The men are further responsible for selling the livestock and some are engaged in other non-agricultural income creating activities. Their work tasks are mainly located outside of their house and it is common to leave the household tasks solely to the female members of the household.

> *"On a normal day I spend the day plowing and spreading seeds and this kind of farming stuff." (Male Farmer 8)*
>
> "[I am responsible for] *everything outside of the house." (Male farmer 2)*
> *"It is my responsibility to create a happy family and to teach my children." (Male Farmer 3)*
>
> *"I advise my children to learn, buy clothes, and to create happiness." (Male Farmer 6)*
>
> *"I am fulfilling the home. If there is something missing I make sure it is assured." (Male Farmer 4)*

Picture 7: Male Farmer ploughing his field with traditional plough and oxen.

4.1.3. Community Life in Zenzilima

According to the interviewees most of the farmers living in Zenzelima have a very close relationship to their nearest neighbours and interact with them daily, mainly by drinking coffee together. Furthermore, it is traditionally practiced that the neighbours and other village members help each other at the time of weeding and harvesting. However, this tradition is decreasing, since farmers employ extra workers for weeding and harvesting if they have the necessary resources:

> *"We drink coffee together, we celebrate together, every time happy we are together. With the neighbors to our fields we do weeding together. When they ask one day for help we do and then another day they help us" (Female Farmer 1)*
>
> *"Around the house we drink coffee together, we celebrate together, everything of extra things we do together. For example if someone is not healthy we carry him to the hospital and if there are good things we celebrate together. And on the fields before there was a deep relationship between the farmers, but now it decreased the relationship, because if some farmers have money they pay for the worker and in this way have not much relationship." (Male Farmer 1)*

4.2. Perception and Awareness of Climate Change

As mentioned in section 2.3. successful adaption to climate change requires the awareness of the necessity to adapt, which further requires the awareness of climate change. Therefore the following section concerns the female farmers' (FFs) perception of climate change, followed by the male farmers' (MFs) and the agricultural extension workers' (AEWs) perception of climate change.

4.2.1. Climate Change Perceptions of Female Farmers

Four of the 10 female farmers replied that they had perceived changes in the climate during the last 10 to 20 years (FF1, 2, 4, 10). Three expressed that they had not observed any weather changes which they perceived as climate change (FF3, 5, 9) and three did not answer the question properly (FF6, 7, 8), also after explaining and changing the formulation several times. Out of the four who had perceived climate changes all referred to an increase in temperature, but only one replied that she had experienced a decrease in rainfall (FF2):

> *"Since I am mostly inside the house I don't know about changes in rain. But it has become warmer in the house." (Female farmer 1)*
>
> "*"Everything has decreased, the rainfall the river, the forest*. [...] *because of the temperature increase I sweat more." (Female farmer 2)*
>
> *"[…] I don't understand about that* (climate change) *since I am responsible for the home, but I hear from my husband about the rain, but not much. But I have experienced increase of temperature because the food goes bad faster." (Female farmer 4)*
>
> *"The temperature has increased steadily. […] When there is high temperature the injera is spoiled faster and goes bad after 2 or 3 days." (Female farmer 10)*

The statements of female farmer 1, 4 and 10 shows that their perception of climate change is linked to temperature increase inside the house, and connected to their awareness of faster spoilage of food. Since cooking and storing the food belongs to the responsibilities of women, it can be argued that the female farmers noticed the increase in temperature since the change affected their field of responsibility. Female farmer 2 however had perceived an increase in temperature because she had observed that she sweated more. She further mentioned that she had perceived a decrease in precipitation, while the three other respondents either mentioned that they had not perceived any changes in precipitation or stated that they did not know about rainfall, since it was something taking place outside the house and thus not belonging to their field of responsibility. This could indicate that the ability to perceive changes in rainfall might be linked to being outside. Since most of the female farmers' working responsibilities are inside or close to their house, their time outside and especially on the field is limited. Only three of the female interviewees (FF7, 8, 9) mentioned that they left their house regularly in order to sell vegetable or other products and the other respondents stated that their work primarily was

related to their household and that they only worked on the field during seeding, weeding and harvesting time.

Female farmer 3, 5 and 9 responded that they had not perceived any changes in the climate during the last 10 to 20 years. However, female farmer 9 had only lived in Zenzelima since 9 years. Female farmer 3 was well aware of variability in weather events during the last 20 years, but did not perceive these as climate changes since she had not seen any climate trends or patterns:

> *"The weather is not continuous. Sometimes the rain is high. If the rain is high there is flood which remove houses, not mine, but others houses and they need to build again. And also the soil is eroded. But that is not happening every year. Sometimes at the winter the temperature is very high, even we cannot sit inside the house, we need air. Not only in the day also during the night it is so warm that we cannot sleep, we have to put on light close. The winters can be very hot here and the summer cold, but it is not continuous. The weather differs from year to year." (Female farmer 3)*

Female farmer 5 stated that she had not observed any climate changes, but later in the interview she mentioned that she predicted that the temperature would increase because she expected the land unit per household to decrease.

Female farmer 6, 7, and 8 did simply not answer the question, if they had seen any changes in the climate during the last 20 years, properly, also after explaining and changing the formulation several times. This might be due to their lack of understand of the difference between climate and weather or due to lack of interest in the topic. They referred to weather changes within a year, stated their satisfaction with the weather this year, or kept on talking about other changes related to her livelihood.

> *"Mostly at summer the temperature is low. At winter the temperature is very high." (Female farmer 8)*
>
> *"Now the weather is good." (Female farmer 6)*
>
> *"All I know is for now I am happy and we are having good rain." (Female farmer 7)*

Common for these females were that they were elder (35, 45 and 60), and therefore their lack of understanding of the question could be influenced by their level of education, which is expected to be lower than the younger females' level.

4.2.2. Climate Change Perceptions of Male Farmers

Out of the 10 interviewed male farmers only two answered that they had not perceived any climate changes during the last 10 to 20 years (MF5, 6). Six of the interviewed farmers had noticed changes in temperature (MF1, 2, 4, 8, 9, 10) and seven had perceived changes in precipitation (MF 2, 3, 4, 7, 8, 9, 10). Only one of the farmers who had observed climate changes stated that he had not perceived a change in temperature (MF3), whereas all the others had perceived a steady increase in temperature compared to the past:

> *"The temperature and the climate got hotter over the years." (Male farmer 1)*
> *"The outside temperature has increased. Until we come inside our home it is very unfavourable." (Male farmer 8)*
> *"[…] It used to be very cool and comfortable in the past, it is totally incomparable with now." (Male farmer 9)*
> *"Now there is high temperature. The temperature has increased and the rain is rare on this time." (Male farmer 10)*

Whereas the female farmers mainly had perceived increasing temperature inside the house, the interviewed male farmers mainly referred to increasing temperature outside. The farmers perceived the increasing temperature as uncomfortable to their livelihood, but they also understood the impact of high temperature on their yields and mentioned that it composed a physical stress to their crops and animals:

> *"The temperature is not only a problem for people but also for the animals. The animals have to live in the house as well because they cannot control the temperature change. And there is not enough grass, so they need to live in the home where there is shade." (Male farmer 2)*

One farmer even mentioned that the increasing temperature had lead to attacks of corn borers on his stored maize (MF10).

The farmers who had perceived changes in precipitation mentioned that they had observed shifts in the beginning and ending of the raining season rather than directly saying that the rainfall had decreased. Several of the farmers highlighted that they had not observed a continuous pattern in the shift of the rainy season, but that it started earlier and ended earlier in some years or started late and stopped earlier in other years compared to 10 to 20 years ago:

> *"Before the rain started early and the rain is until December. At that time the product of finger millet is high, but now sometimes it starts early and also stops early. But sometimes it starts later and stops at the time of September.[…]" (Male farmer 2)*
>
> *"Before there was much rain, good rain, but now it is not so much anymore. But not so big difference." (Male farmer 3)*

Since the male farmers are responsible for choosing the right time of ploughing, seeding, weeding and harvesting, their awareness of changes in precipitation might be closely linked to their responsibility of choosing the right time for the different procedures. Especially, choosing the right time of seeding and harvesting is crucial, which both mainly are determined by the start and end of the rainy season. The mail farmers natural attention on the start and end of the rainy season could therefore explain why most of the interviewed male farmers had noticed a change in precipitation. Furthermore, when mentioning the climate changes they mainly referred to agriculture and several of the male farmers thus mentioned that the change in precipitation affected their yield (MF1, 3, 9). In years where the rain had started late the yield would be less due to water stress in the early stages of the crop. In years where the rainy season had stopped early the crops would not grow fully and therefore similarly result in a lower yield:

> *"If the rain comes late it is very dangerous and it exposes us to poverty and also drought […]. If the rain season comes on time all the farmers will plant on time, harvest on time and do all the things on time. So it is very good for the rain to come in time." (Male farmer 9)*

Interestingly, many of the farmers explained that this year was special compared to the recent years, since the rain had started very early this year. They therefore hoped that this meant a shift back to the precipitation pattern they knew from the old days:

> *"In the old days the climate used to be very farmable and comfortable. The wet season used to be very long. This year we are getting a good start of the wet season, the same like in old days, but in the previous years the weather and climate was very bad." (Male farmer 7)*
>
> *"Compared to the last three or five years this year is better and the wet season is coming earlier, that is good for the crops. In the past three or five years there hasn't been this kind of weather." (Male farmer 8)*
>
> *"Now the rainfall it is very low compared to the past, so this year is special (because the rain started earlier). By May 15 many of the farmers have already planted maize, when in the recent past years we used to wait until June 15 to plant maize, because the rain would start then. The rain has started early this year, like in the old days. People are surprised because the wet season has started early this year. It has not been the case in the short past." (Male farmer 9)*

Since many of the farmers compared this years' rain to the last 3 to 5 years, it is however questionable if they truly understood the definition of climate changes or if they referred to natural weather variability. The two farmers who had not perceived any changes in the climate (MF 5, 6) seemed to understand the question well and highlighted that shifts in weather were normal and that they had not seen any trends or patterns that indicated climate change.

4.2.3. Climate Changes from the Perspectives of Female and Male lives'

When comparing the female farmers who had perceived climate changes with their husbands perception, it showed that in all cases both had perceived climate change. With other words, out of ten households there were four households were both the wife and the husband had perceived climate change (Household 1, 2, 4, 10). The respondents from these households ranged from 18 to 75 years, which indicates that the perception of climate change is not related to age.

Common for all interviewed female and male farmers were that none of the interviewees mentioned that they had perceived changes in the intensity of rainfall such as heavy rainfall or storms. The interviewed women who had perceived climate change stated that they mainly had noticed these changes since they were directly affected in their everyday tasks (i.e. sweating more, food would go bad faster), while the male farmer often linked the changes they had perceived to farming and especially to yield. This could indicate that perceiving climate change is linked to work tasks and responsibilities. Since the interviewed female farmers held their responsibilities inside the house and therefore spend most of their time inside and around the house, they might have been more aware of changes related to their everyday work in the household, compared to changes related to agriculture. The interviewed male farmers on the contrary stated that they spend most of their time outside the house and on the fields and therefore the changes they had perceived were closely linked to agriculture. However, it is not clear if the respondents mentioning climate changes understood the definition of climate change and instead referred to natural weather variability.

4.2.4. AEWs Perception of Climate Change

Since several of the farmers in Zenzelima are advised by the agricultural extension workers (AEWs) I found it equally relevant to ask the AEWs about their awareness of climate change, because they have a potential high influence on the farmers.

However, it is relevant to mention that none of the four agricultural extension workers advising the farmers in Zenzelima had worked in Zenzelima for more than 1 year and AEW1 had just finished university. They all had an education specialized in one field, but they advised on several things non-specific to their educational background. Only AEW1 answered that he had not observed any climate change in Zenzelima, since he was very new to the area and therefore could not say if climate change was a current challenge for the farmers in Zenzelima or not. However, he seemed to be well-informed about the topic through to his educational background. AEW2 mentioned that he was aware of climate changes related to precipitation. He especially referred to the shift in the beginning and end of the rainy season and mentioned that climate change was a great problem to the farmers in Zenzelima. AEW3 and AEW4 explained that they both had perceived changes in temperature and in precipitation:

> *"I observed that because of deforestation the temperature increased. The cause for deforestation is that the number of people has increased. Before the proper rain started in May, but more often it is late. Then it starts in June/July and stops quickly." (AEW3)*

Furthermore, AEW3 explained that the government provided trainings to the AEWs in order to inform them about the challenges and to raise their awareness of climate change. He was well informed about the definition of climate change and highlighted that it was difficult to distinguish between climate change and variables in weather events. He explained that if the weather trend would continue it would cause many problems for the farmers in Zenzelima. AEW4 already perceived that climate change was challenging the farmers in Zenzelima and had observed that new pests had occurred because of increase in temperature:

> *"Because of the climate change there is new diseases […] Teff is a small seed and before this time it is not affected by borer, but now the Teff is also affected by different borers which is a new thing, because I think it comes from the increase of temperature. […] And another crop is finger millet. Before it was not affected by borer, but now it is affected, which is a new thing." (AEW4)*

Likewise to the interviewed farmers, the AEWs who had perceived climate changes also explained that climate changes especially affected the farmers' yields.

4.3. Awareness of Other Changes Linked to Climate Change

Since perceiving changes in weather as climate change might be difficult, I further asked the farmers about which other changes they had observed related to the landscape and the community in and around Zenzelima. Many of the observations the farmers mentioned, were mentioned by both female and male farmers, but there was still a noticeable difference. Some of the changes the farmers had observed are closely linked to climate change and therefore important to mention, whereas others are not directly linked to climate change, but likewise important since they may influence the ability to perceive climate changes and/or are factors influencing the farmers' adaptive capacity.

4.3.1. Female Farmers Perception of Other Changes

Even though only four of the interviewed female farmers had observed climate changes, most of them were aware of changes in the landscape and changes within the community. They were aware of several challenges, but they did not link these to climate change. They especially mentioned changes in water availability during the dry season, followed by changes in their natural environment which indicated an urbanization process.

4.3.1.1. Change in Water Availability

Several of the female respondents mentioned that it was difficult to get water in Zenzelima, while female farmer 1, 2, and 3 stated that they had observed a decrease in water availability and mentioned that 10 to 20 years ago there used to be water in the rivers throughout the year, but now many of the rivers would only have water during the rainy season. However, only one of the female farmers linked the decrease of water in the river to the decrease in rainfall (FF2), while another explained it by the increase in population (FF3):

"Before there was a river throughout the year, but now not anymore. It is harder to get water now." (Female farmer 1)

"Everything has decreased; the rainfall, the river, the forest. Before the farm was covered by different local crops and trees and the river was used throughout the year, but now the river is not used." (Female farmer 2)

"Before this river was full, but now especially in winter there is no water because there are more and more people and everyone takes water from the river."(Female farmer 3)

The interviewees mentioned that water scarcity mainly affected their everyday tasks in the household and that it had become more difficult to perform tasks in the household with the perfection they wished. For example, the lack of water meant they had to use less water and therefore they could not wash themselves or their children as thoroughly or prepare the food as before:

"Because of the shortage of water I cannot do everything in my home perfectly. For example for washing close, for the cattle, for preparing food." (Female Farmer 2)

Since the task of fetching water mainly is the responsibility of women, the female farmers were more affected by the increasing water scarcity than the male farmers since the increasing difficulties of getting water meant that they would have to spend more energy and time on the process.

4.3.1.2. Change in the Natural Environment and Urbanization

Several of the female respondents said that they had observed further changes in the landscape in and around their village such as the decrease in forest and native plants, a decrease in land size, and/or a decrease in soil fertility. According to Female Farmer 8 the village St. Michael had been covered by forest 50 to 60 years ago and had developed from a rural settlement into a village:

"When I came here at the time of my marriage this village was covered by forest! No houses, but now there are different types of houses, they are near to each other. But at the time I married there were only two houses, my husband's family house and another one near to the road." (Female farmer 8)

The development into a village had led to several changes especially a decrease in forest and native plants, but not one of the female respondents expressed a concern about this

development. However, some expressed their concern about the decreasing in land size and soil fertility, which they had observed as bias to the development of the village:

> *"All is better, apart from the land size. The land size became narrow. […] Before the land was much and good. Better than now. We could produce much crops from the land […] " (Female farmer 4)*
>
> *"Before we didn't use fertilizer, but now we use fertilizer because the land is poor and needs the fertilizer. We must apply fertilizer to get more crops." (Female farmer 3)*

The statement of female farmer 4 shows that she perceives the other changes she has observed as positive since they have improved her livelihood to the better, apart from the decreasing land size. All of the female interviewees were furthermore particularly aware of an ongoing urbanization process that took place in Zenzelima:

> *"There has been big change. Around this road there were no buildings, but now there are plenty of buildings." (Female farmer 9)*
>
> *"I think the village is going to grow and get urbanized. I think everything is going to change, I am sure there will be buildings and I am pretty sure it is going to look like a flower. There will be skyscrapers." (Female farmer 7)*

Even though several of the female farmers mentioned these changes, most of them did not find these changes threatening, but perceived them as a rather positive development. They seemed to appreciate the urbanization process and several expressed that they wished to have an urban house in the future rather than a farm and being engaged into urban activities rather than being farmers:

> *"[…] I would like to have a house instead of a farm." (Female farmer 1)*
>
> *"I wish for my children that they go to university like my oldest daughter." (Female farmer 6)*
>
> *"I wish for my family to have a private business and shop to run." (Female farmer 7)*
>
> *"I don't want to be a farmer in the future. I would like to live in the city." (Female farmer 10)*

However, they did not give a reason for their wish to leave their farming system.

Only one respondent expressed her concern about the urbanization process (FF8), since she was afraid that the government would take her land. The other females were very positive about the future development of the *kebele* and seemed to have high hopes especially in the new university that had been built in Zenzelima recently:

"There will be big change because before we didn't have this university, but now we got this university and new things, and throughout the last 5 years there has been much change so it will be more change in the future." (Female farmer 9)

4.3.2. Male Farmers Perception of Other Changes

Similar to the females, the male farmers mentioned that they had observed changes in land size, amount and type of trees, and in the water availability of rivers in Zenzelima. However, compared to the female farmers they seemed to be much more aware of the negative changes the urbanization process had and was causing.

4.3.2.1. Change in Land Size per Household

Likewise the female farmers, several male farmers mentioned that a serious change they had observed was the decrease in land size per household (MF1, 2, 4, 5, 7, 8). Three of the interviewed farmers had experienced a decrease in their land size either because they had divided parts of it between their children or because the government had expropriated them from their land and given a financial compensation instead of another property (MF2, 4, 7). Since all land in Ethiopia is owned by the state, the government can distribute land to individuals but similarly expropriate individuals of their land for the sake of public interests in exchange for compensation in advance (Amhara National Regional State Rural Land Administration Proclamation No. 133/2006 Art. 2(18)). The older farmers had either been given their land directly by the government or they had inherited it from their parents, whereas all of the younger interviewed farmers had inherited land from relatives or were landless.

The farmers mentioning the decrease in land size were worried about this development and especially concerned about the population increase:

"Before I started my land the land around was wide, but now it is narrow. […] And the land size got very small." (Male farmer 4)

"[…] Even if there is different technique to prevent population increase, but the populations increases and increases. The land became more narrow and narrow." (Male farmer 2)

The interviewed farmers between 38 and 75 years old had all 4 to 8 children and expressed that it was expected of them to divide their land between their children. This tradition is repeated by the next generation and it therefore leads to a steady decrease in land size per household:

"The land is already narrow and we gave land to our son to build a house. So for another child we need land, but how to build? " (Male farmer 2)

"I have got nothing now. I have given the land to two of my children, so I have only got the land of the back of my house. It used to be very green, there used to be wild animals like hyenas, now it is all gone. There isn't even a place to farm on." (Male farmer 7)

On the contrary the younger farmers (MF1, 9, 10) had no or only very little land to farm on compared to their ancestors, since the government had not given them any land.

> *"There used to be a lot of land to be farmed on. Now in my age I only have a little amount of land to plough on, so now the competition is higher. There used to be a huge amount of land to plough. Land was plenty. I have a very little amount of land, not like our fathers, that is not the case. […]" (Male farmer 1)*

The other reason for the decrease in land size per household is the expropriation of farm land by the government, which is mainly linked to the building of a new agricultural campus of Bahir Dar University in Zenzelima. Some of the male farmers therefore mentioned the university in a negative context and accused the university of taking their land or polluting the river next to the campus (MF4, 5, 6). This perception distinguishes the male farmers from the female farmers, who mainly perceived the university as a positive development progress. Only one of the male farmers stated that he perceived the university as an improvement and opportunity to achieve more knowledge for his children (MF4):

> *"The best thing is because of the university building here, they bring charity for us and knowledge for the learning of my child." (Male farmer 4)*

As impacts caused by the decrease in land size per household, the farmers mentioned shortage in feeding and therefore a decrease in their livestock size and a reduction in productivity, which had led to increasing poverty:

> *"[…] the land becomes smaller and smaller and the production decreases."(Male farmer 5)*
>
> *"I have become poorer. No cattle, no farm, I used to have a lot of cattle and farm in the past days." (Farmer 7)*
>
> *"[…] and then (in the old days) the production was high, because for instance one cow was giving as much milk as five cows are giving now." (Male farmer 2)*

Apart from the decreasing land size several of the male farmers, similarly to the female farmers, had observed a decline in agricultural productivity caused by decreasing soil fertility. Male farmer 1, 2, 3, 5, 6, and 10 stated that that they had to use fertilizer because the soil fertility had decreased to an extent where the use of fertilizer was a necessity:

> *"Before we ploughed the land and sow the crops without fertilizer, but now the soil need fertilizer, otherwise it gives poor yield." (Male farmer 3)*

Furthermore, they mentioned that their soils had adapted to the use of fertilizer and therefore they could not stop using fertilizer and still get a yield their household could survive on.

4.3.2.2. Change in Forest and Biodiversity

Another change that most of the male respondents had observed and expressed their concerns about was the deforestation which had occurred in large scale in Zenzelima during the past decades. Most of the younger farmers had not observed these changes personally but referred to information from older people:

> *"I didn't see it myself but I heard from my family that this area was covered by forest, but since I can remember, the land has been like this." (Male farmer 10)*

The older farmers had witnessed these changes and explained that apart from a general deforestation, they had observed that many indigenous trees had been removed and replaced by eucalyptus and that wild animals had disappeared:

> *"When I was a kid there used to be local trees. Now they are all gone and replaced by eucalyptus and mango trees. Some of the local trees are dokma and eshe. It used to be much better when these trees were around." (Male farmer 1)*
>
> *"Before it (Zenzelima) was covered by forest. There were different kind of dangerous animals like hyena and there were many thieves because it was forest. But now since the forest is removed there are no thieves and no dangerous animals." (Male farmer 2)*
>
> *"Before there were different kind of indigenous trees and most of the land here was covered by forest, but now it is destroyed." (Male farmer 3)*

One farmer further mentioned that he used to have bee-hives and produced plentiful honey, but that this was not possible anymore (MF7).

4.3.2.3. Change in Water Availability

Equally to some of the female farmers, some of the male farmers had also observed that the amount of rivers had decreased and that the water was not flowing throughout the year anymore:

"It is rare to find water. In the previous times it was very wet, we used to drink from the river and wash our closes. Now things have changed and water has become scarcer. It is hard to find water from rivers." (Male farmer 1)

"Before there was many different indigenous trees and the water was also plenty, but now there is no water and the river is very small and only in winter." (Male farmer 4)

However, none of the farmers mentioned that the decrease in water availability of the rivers was caused by a decrease in precipitation or the increase in temperature. They explained the decrease in water availability by an increased use of water due to an increase in population and irrigation:

"[…] and also the river that is close to the market, when I was young it was there throughout the year, but now only at summer. In the winter time it dries out. It is because the farmers growing chad close to the river use the water." (Male farmer 3)

"When I was young there used to be water all over the place. There used to be river and streams and ponds and water was surplus. Now the government officials had put pumps to fetch water from, but it is not working now due to overuse. "(Male farmer 8)

Even though the farmers did not directly mention that the decrease in water availability was caused by deforestation, some mentioned the decrease of water and the decrease of local trees in the same sentence (MF 1, 3, 4, 6,). This indicates that they might be aware of the linkage between deforestation and the decrease in water:

"When I was a young kid there used to be all trees, everything was green and there used to be plenty of rivers and the rivers used to be wet all year around. Now there is drought on the rivers. We are facing many problems due to the drought." (Male farmer 1)

Even though some of the female farmers had observed similar changes, they were less concerned about these changes and seemed generally to be more open to new changes than their husbands. Especially the current change of the urbanization process seemed to worry the male farmers since they feared to lose their profession as farmers due to lack of land for cultivation. The female farmers however seemed to see opportunities in this development rather than restrictions to their livelihood.

To sum up, the main changes that the interviewed farmers mentioned was the decrease in land size per household, decrease in soil fertility, decrease in forest and wild animals, and decrease

in water availability in the rivers in and around Zenzelima. Furthermore, they noted that an urbanization process was taking place in Zenzelima. Several of these changes could be linked to climate change, but most important is the influence these changes have on the ability to perceive climate change and the necessity to adapt to these changes. The decreasing land size due to the rapid population increase and the urbanization process formed a big challenge for the farmers and their ability to perceive other challenges such as climate change could therefore be limited. Furthermore, these changes have an influence on the farmers' adaptive capacity to climate change, which will be analyzed in the following sections.

4.4. Adaptive Capacity of Farmers in Zenzelima

It is important to mention that I did not directly ask the farmers about which factors were limiting or enhancing their adaptive capacity. Instead I asked the farmers and the agricultural extension workers, who had stated that they had perceived changes in the climate, how they had responded to these or if they could think of a method to adapt to the new changes. Some of the responses can be classified as adaptations, whereas the driver of other responses could be multiple and therefore a classification is difficult. The farmers' responses can to a certain extend be used as indicator for their adaptive capacity. However, to create a broader picture of their adaptive capacity, I analyse the factors mentioned in section 2.3. as determinants of individual adaptive capacity; namely access to natural and man-made resources, access to information, decision power, human capacity and socio-cultural factors. I do not intend to analyse the adaptive capacity of each of the interviewed farmers, but instead I focus on the factors that generally seemed to influence the adaptive capacity of the smallholder farmers I interviewed.

4.4.1. Responding to Increasing Temperature

Of the four female farmers who had perceived an increase in temperature two answered that they had not done any adaptations to the new temperature (FF2, 10) and the other two answered that they washed themselves more often and wore lighter closes (FF1, 4). Similarly, one of the male farmers mentioned that he wore lighter closes during the night (MF4), whereas another mentioned that he washed himself more often (MF10). These responses can be classified as autonomous adaptations, since they are performed by the farmers and in direct response to a climate stimulus.

Another farmer mentioned that the increasing temperature did not affect him inside his house, because he had built a high roof (MF8). He did not mention if he had designed the roof to avoid the high temperature, and therefore it is unclear if this actually is an adaptation. However, another female farmer mentioned that she would like to have a higher roof in order to decrease the temperature inside the house (FF1). Theoretically constructing houses with higher roofs can be seen as autonomous adaptations, but in praxis other factors than perceiving the need to adapt to climate change might have influence the choice of roof.

One male farmer explained that he had placed his cattle in the shade of his house, because the animals could not adjust to the higher temperature and there was a general lack of shade outside (MF2). Even though he was the only farmer mentioning this, I observed that this practice was performed by several of the other farmers. It can be argued to what extend this action can be classified as a successful adaptation or rather as an temporal solution.

Male farmer 10 mentioned pest attacks on his stored maize as an affect of the increasing temperature and stated that he had adapted to this situation by using chemicals. Since the farmer explained that he was well aware of the connection between the pest attacks and the increasing temperature, this response can be classified as autonomous adaptation, though the future effectiveness of this measure can be discussed.

One of the interviewed farmers distinguished himself from the others. He explained that he was well aware of climate change in Zenzelima and its connectedness to other challenges such as deforestation, soil erosion and water scarcity (MF9). He stated that he and some other farmers

were taking these problems serious and that they were adapting to the impact of increasing temperature and the decrease in precipitation by planting trees and creating terraces:

> *"To prevent the high temperature I talked with my friends and tried to solve the problems by planting trees, taking care of the land. We use terraces to prevent erosion. We started farming in rows and everyone is planting trees in their backyards and I think this is going to make a big change in the climate. Generally planting trees is the only solution I think." (Male farmer 9)*

Furthermore, he was very convinced that all farmers understood the negative impacts of deforestation and therefore had stopped cutting indigenous trees and instead were planting new trees:

> *"Nowadays people are respecting the forest, no one is cutting trees and there is a big change in forestation and I think that is the reason for this good rainfall (this year). […] My greatest improvement is that I planted these trees and always when I see them I feel hopeful and I feel the need to expand them, planting more trees. I don't think there is much greater change than this. Everyone is trying to change the environment now, not like in old times when there used to be a lot of destroying the environment. Now there is not even a single farmer without mango trees or other trees in his backyard. So everyone is trying to make changes." (Male farmer 9)*

When I asked the young farmers if they had participated in felling the forest in Zenzelima, they answered that this was already done before their time and that they only cut the eucalyptus trees. However, the only natural forest that still remained in Zenzelima was located around the church, since this part was perceived as holy and it was forbidden to fell the trees. It can thus be questioned if the younger farmer were aware of the necessity to protect native trees or if they were not felling any native species solely because there were none left. The practice of planting local trees was however not widely practiced and only two of the other farmers mentioned that they had planted or were preparing to plant indigenous species like Neem tree and Sesbania on communal land around the mountain (MF1, 4). They explained that the agricultural extension workers had advised them to do so:

> *"We are growing seedlings and stone hedges around the land to prevent erosion and other climate changes." (Male farmer 1)*

However, as opposed to farmer 9 not one of the other respondents had planted new trees on their own land recently. Some of the interviewed farmers had mango, gesho, coffee or other fruit

trees on their own land (HH1, 4, 8, 9, 10), but as many did not have any fruit trees or other indigenous trees on their land (HH2, 3, 5, 6, 7). Similarly, the observations I had taken when I was exploring Zenzelima confirmed that planting local tree seedlings was a rather scarcely practiced adaptation and that most of the trees who were planted were eucalyptus. However, the statement of male farmer 9 indicates that the farmer's awareness of the need to adapt to climate changes is increasing and that some understand the importance of trees as adaptation strategy:

> *"If you plant different plants for example Neem or others it (the temperature) will be decreased. But no one plants that one." (Female farmer 10)*

4.4.2. Responding to Changes in Precipitation

All of the interviewed farmers adapted to the changing rainfall pattern by either sowing earlier or later, depending on the start of the rain. Similarly, they adapted by changing the time of harvest to the new climatic conditions. In areas with natural high weather variability, it can be argued to what extend this response can be categorized as adaptation to climate change, since it was similarly applied by farmers who mentioned that they had not perceived any climate change.

Six of the households adapted to the decrease in land productivity by using or even increasing their use of fertilizer (HH1, 2, 3, 5, 6, 10). However, since these farmers likewise were already mentioning negative effects of the use such as decreasing soil fertility and economic dependency, it can be argued that this method can be viewed as mal-adaptation rather than adaptation. The farmers seemed to understand the problematic linked to this adaptation strategy, but only one farmer mentioned that they applied other strategies to improve the soil fertility (MF1). Male farmer 1 stated that he had prepared and applied compost, according to the advice of the AEWs (MF1):

> *"The extension worker told us to prepare compost close to my home and then afterwards broadcast it on my land to increase soil fertility. But when we applied the compost there was no change, since the land is adapted to fertilizer." (Male farmer 1)*

None of the interviewed farmers directly answered that they had changed their crops or cropping system in order to adapt to the changes in precipitation. However, two farmers mentioned that they had started to cultivate teff, whereas it had not been cultivated in Zenzelima in the past (MF1, 8):

> *"[…] Even though we started cultivating teff now, in the past days it wasn't a place where teff grows, but now after we took lessons from the extension workers we are growing teff around here, too." (Male farmer 8)*

Male farmer 1 mentioned that he had tried to cultivate the improved teff recommended by the extension workers, but that it had not been successful and therefore he had stopped cultivating it. How far this failure is the fault of the farmer or of a still unfavourable climate is unclear. However, since both of the farmers did not state that they had started to cultivate this new crop due to climate change it cannot be classified as adaptation to climate change.

A major change that many of interviewed households mentioned and practiced were the growing of chad which had started in Zenzelima around 10 years ago (HH 1, 3, 8, 10). Chad is used as a stimulating drug by especially younger men in Bahir Dar and has a very high market value compared to most other crops and vegetables in the region. The farmers explained that this plant was more demanding since it needed a lot of attention and water (MF1), but that it contributed to a high share of the households' income (FF10). Since some of the farmers had mentioned that climate change especially affected their yield and thus their economic situation, growing chad seemed to be an effective adaptation to this change. Furthermore, the value per hectare is much higher than compared to crops and therefore especially convenient for farmers who experience land shortage. However, the purposefulness of this adaptation strategy as future strategy can be questioned since the growing of chad demands a high amount of water and thus consumes a high amount of the existing water resources. According to Male farmer 1 farmers in Zenzelima had to irrigate the chad, since the natural precipitation did not deliver enough moisture to the plant, and were irrigating by redirecting water from the rivers. However, since the water availability in Zenzelima already is critical it is questionable how applicable this strategy is in the future, where precipitation might decrease and evaporation increase further. However, since the growing of chad is mainly driven by economic incentives, it is further questionable if it can be termed adaptation.

4.4.2.1. Adapting to Water Scarcity

Some of the interviewed households had responded to the increasing water scarcity by increasing their effort to fetch water. Male farmer 9 mentioned that he had dug a 23 meters deep well on his land in order to find groundwater. When he discovered that there still was no water at this level, he stopped and instead went several kilometres twice a week to fetch water from the river. Other farmers seemed to do the same and female farmer 4 mentioned that they just had dug a well on their land, whereas before she had to buy water from another persons' underground source. Household 8 mentioned that they had to buy water sometimes if there was not enough water in the river and that water even was bought from the city Bahir Dar who is located about 7 km from the kebele. Especially going a longer distance to fetch water seemed to be an adaptive strategy by the female farmers and some stated that they got help from their husband or children. Sharing the increased work burden therefore seemed to be another adaptive strategy among the farmers. Furthermore, using donkeys as transportation method were applied by the farmers who could afford this.

4.4.3. Other Adaptations

Five of the interviewed farmers answered that they had not done anything to adapt to the climate changes they had perceived other than praying to god for better weather (MF2, FF2, MF3, MF7, MF10):

> *"We just pray to god. For the Muslims Allah, for the Christians god." (Male farmer 7)*

Even though they stated this, they mentioned activities later in the interviews which could be classified as climate change adaptations if they were performed out of the awareness and need to adjust to climate change. However, since most of these actions were taken due to escape general poverty, these measures cannot directly be classified as adaptations to climate change.

4.4.3.1. Engaging in Non-Farming Activities

As mentioned in section 2.6.4. diversifying the sources of income is a possible adaptation strategy to climate change since it will decrease the households' vulnerability to climatic stresses and hazards.

Diversifying the sources of income seemed to be a rather natural choice by the farmers in Zenzelima, considering the unknown development of the future. Since it was performed by several farmers interdependent of their awareness of climate change, it is similarly difficult to term this response as adaptation to climate change. Especially the younger male farmers with only very little land to farm on showed to be occupied in other activities next to their farming such as working as guard in Bahir Dar (MF3), trying to establish own business of wagon transportation (MF1), weaving (MF7), working in a stone quarry and shop (MF9) and digging for stones and selling them in Bahir Dar (MF10). Similarly, three of the female farmers where occupied in other activities to create an income (FF7, 8, 9), but women were in general engaging less in income-creating activities as men. Female farmer 9 was running a small shop next to the main road leading though Zenzelima, while Female farmer 7 and 8 were selling vegetables on the local market every Wednesday and Saturday.

One household mentioned that they had sold their livestock in order for their daughter to migrate to Saudi Arabia (HH7):

> *"The last cow we sold to help our daughter to go to Gidar (Saudi Arabia). We spend 10.000 and we sold the cattle for 8.000 Birr and borrowed the remaining 2.000 Birr. […] she is sending money for us." (Female farmer 7)*

In this case the household gave up a big part of their farming activity and even lend money in order for their daughter to migrate to another country. Especially the interviewed female farmers expressed that they wished for their children to go to university instead of becoming farmers and they were all very proud to mention the level of education of their children even though I never asked a question that was related to their education. One young male farmer mentioned that he spend a high amount of money on school fee for his daughter in order for her to get a good education (MF9). These actions indicate that most of the farmers wished for their children to occupy in other activities than farming, which likewise can be seen as adaptation strategy, but which mainly was applied due to other reasons than adapting to climate change.

Even though the above mentioned actions are chosen in order to escape poverty, and therefore cannot directly be classified as adaptations, these measures imply that farmers are/will be less dependent on their farming output and likewise will not be affected similarly by further climate changes.

4.4.3.2. *Ekub* - Traditional Saving Systems

Two of the interviewed farmers mentioned that they were engaged in a traditional form of saving and credit system called *Ekub* (MF1, FF8). In this system a group of villagers pay a certain amount of money regularly and the amount is rotationally lend to every single participant in this group. One of the farmers mentioned that he had raised the money to establish his own wagon transportation business through this form of micro-financing (MF1). Another female told me that she had worked very hard to raise the money to be part of the ekub and that she was the last person in the group to receive the loan, since it is allocated by lottery (FF8). Together with her husband she had spend the money on improving their house and since they had a very high roof and a comfortable temperature inside, this seemed to be an effective measure against the increased temperature.

Even though engaging in these forms of saving and credit systems is not classified as a direct adaptation, it is a tool in order to reach some adaptations and therefore an important activity in adapting to climate change.

4.4.4. AEWs Response to Climate Change

According to the interviewed extension workers they were adapting to climate changes by providing farmers with free advice on the conservation of natural resources (AEW 2, 4). All AEWs mentioned that they advised the farmers to do water, soil and forest conservation. As part of this strategy they advised the farmers to plant local trees on communal land in Zenzelima and even provided them with free tree seedlings (AEW3). Furthermore, they stated that they advised the farmers to grow forage on their own land, to build terraces against soil erosion, and to use biogas instead of charcoal or wood to stop deforestation (AEW2, 3). In order to adapt to increasing pest population due to higher temperatures, the agricultural extension workers stated that they were advising farmers in Zenzelima to use chemicals and to locate their storage away from hot places like the cooking place and instead locate it in places where there is aeration (AEW4).

Giving these advises to the farmers can be classified as planned adaptations, since they are performed by the agricultural extension workers who are executing the strategies designed by the government. However, the success of these advices seems to be rather low since most of the interviewed farmers were not applying any form of natural resource conservation measures. According to the AEWs 289 (5%) female and 1494 (27%) male farmer in Zenzelima were using their services. They could not say how many of the farmers actually were applying these conservation measures, but they stated that most of the farmers approached them in order to get inputs rather than advice (AEW2).

The AEWs did not mention the use of fertilizer as adaptive measure to climate change. However, this was the main advice that farmers in Zenzelima applied as response to the lower yields which they mainly related to decreasing amount of precipitation. Once more it can be

argued how far using fertilizer can be classified as adaptation/maladaptation to climate change, since the use is interdependent of the farmers' awareness of climate change.

4.4.5. Availability of and Access to Natural and Man-made Resources

As mention in section 2.3.2 the adaptive capacity of a farmer is among others influenced by the availability of natural and man-made resources and on the access to these. The lack of different resources will therefore limit the adaptive capacity of an individual and thus the household. All of the interviewed farmers' adaptive capacity seemed to be especially influenced by the low availability of water, farming land, agricultural inputs, and economic resources and by their access to these.

4.4.5.1. Availability and Access to Water

Diversifying the farming system by growing different types and varieties of crops is a good adaption method to climate change. All of the interviewed households were both cultivating crops and holding livestock, and did not specialize in only one field. However, most of the farmers were only cultivating maize and finger millet. Furthermore, only one of the households cultivated vegetable (HH10), five of the households cultivated mango, gesho, coffee or other fruit trees on their own land (HH1, 4, 8, 9, 10), and four households cultivated chad (HH 1, 3, 8, 10). Three of the female farmers explained that they were not able to cultivate vegetables or fruit trees because there was no or only limited amount of water available (FF2, FF3, FF5):

> *"Because there is no water here, we have no fruit trees." (Female farmer 2)*
>
> "*I don't grow vegetables because there is no water here. […] If water is available here, I will plant vegetables and different crops. But now there is no water, how do you do it?" (Female farmer 3)*
>
> *"Because of shortage of water I don't grow any of these (vegetables and fruits)"(Female farmer 5)*

Male farmer 4 mentioned that he had observed that farmers in Gedro, a village also belonging to Zenzelima but bordering to Lake Tana, were performing better because they used irrigation. However, when he tried to apply this strategy on his mango trees he was forced to stop, because there was no water available and he could not afford to buy water in such high quantities. Similarly, some interviewees mentioned that they would like to cultivate chad, since this crop has a high market price and a high value per land unit. However, since the crop likewise is very water demanding mainly farmers located closer to a water source were cultivating chad. These farmers were likewise also able to cultivating fruit trees and therefore the access to water increased their adaptive capacity compared to the farmers located farther away from a water source:

> *"If I would have land near to the river I plan to plant chad, but now I don't have any land near to the river I only plant eucalyptus." (Male farmer 5)*

The farmers with no access to a near water source among others grew eucalyptus trees in order to diversify their income. During my interviews I did not fully discover if the farmers were aware of the negative consequences of growing eucalyptus, but one female farmer answered that she could not grow vegetables on her land since the eucalyptus entailed that there was no water available (FF2). Farmers who cultivated eucalyptus or who were located close to eucalyptus plantations were therefore further limited in their adaptive capacity, since the eucalyptus created an unfavourable environment for other crops.

4.4.5.2. Availability and Access of Agricultural Land

Apart from diversifying the cropping system diversifying the farming system by keeping livestock or increasing the existing livestock size is a strategy to adapt to the change in precipitation that causes failure or a decrease in crop yield. All of the interviewed households were holding livestock, and most of them had 1-2 oxen and 1-2 cows. However, in order to increase the livestock size more land for grazing and/or feed for the animals would be required. According to the agricultural extension workers they were advising the farmers to grow forage on their land, but since most of the farmers already faced challenges by their low amount or lack of farming land, they were not able to apply this adaptation strategy. Furthermore, communal land that could be used for grazing was declining through to overgrazing, urbanization, and due to a general increase in livestock density caused by the increase in population density. Two households even mentioned that they had to reduce their livestock size, because there was not enough feed for the animals (MF4, 8, FF4):

> *"[…] since food for the animals is costly we needed to sell some of the livestock." (Female farmer 4)*

Furthermore, some farmers mentioned that they could not apply other agro-ecological adaptation strategies, such as planting trees against soil erosion or water conservation, since their land was already very narrow and they could not afford to lose the space the trees would require:

> *"Because the land is very narrow I didn't plant any trees." (Female farmer 10)*

It can therefore be argued that farmers with more agricultural land likewise have a higher adaptive capacity than farmers with less or no own land.

Among the interviewed households the amount of land was low, but especially the very young farmers (HH1, 9, 10) and one very old farmer (HH7) had less or no own land compared to the other farmers. Household 7 had no own land anymore since they had divided it among their children, which they explained was custom in Ethiopia. Household 2 and 4 mentioned that their land size had decreased because the government had expropriated them from some of their land in order to build the university campus. Female farmer 6, 8 and Male farmer 8 even

mentioned that they were afraid that the government would take their land in the future, which reflects the countries' land tenure insecurity. Another farmer mentioned that the tenure insecurity affected their future farming strategy:

> *"Because the university is near to my home we will change our farming strategy because this will become city." (Male farmer 5)*

Since the lack of agricultural land and tenure insecurity limits the farmers' ability to apply some agricultural adaptation strategies, it can be argued that these factors likewise influence the farmers adaptive capacity to climate change. However, Male Farmer 9 had purposefully planted trees on his land in order to reduce climate change, even though he was one of the farmer with the lowest amount of land.

4.4.5.3. Availability and Access to Agricultural Inputs

In order to apply adaptive measures (i.e. using drought resistant varieties, growing vegetables, or planting trees) these inputs need to be both available and accessible to the farmer.

Male farmer 1 mentioned that he wanted to plant trees, but that he was limited in the lack of available seedlings:

> *"The government is training us to plant more seedlings but that is not happening. We are preparing the shared land for planting, but we haven't got any seedling yet." (Male farmer 1)*

AEW1 likewise stated that the farmers' use of agricultural inputs was limited by the general low availability of these inputs, since the government faced problems with the delivery of improved seeds, highbred livestock species, and seedlings. Only three of the interviewed farmers used improved seeds (MF1, 3, 5) and only one of the farmers used high breed cattle (MF8):

> *"The extension workers tell us to have improved breed cattle, foreign cattle, and to replace the local cattle with them. They are expensive but we are trying to replace them by time. " (Male farmer 8)*

However, apart from the general low availability of improved seeds and breeds, the farmers' use of these inputs seemed rather to be influenced by their ability or lack of ability to access the inputs due to limited economic resources.

Since more of interviewed households used fertilizer than improved seeds and breeds could indicate that fertilizer is both more available and accessible to the interviewed households. Most

of the farmers who mentioned their use of fertilizer expressed a concerning dependency on the use and stated that they would spend a high share of their income in order to be able to purchase the fertilizer (MF2, 5, 6):

> *"After I plough and sow my land I have to sell half of it to buy other things. The land is not productive without fertilizer so I need to buy expensive fertilizer and cannot afford another things such as bees or goats." (Male farmer 2)*
>
> *" [...] from year to year we have to use more and more fertilizer" (Male farmer 3)*
>
> *"[...] And also the price of certified seeds and fertilizer increased .[…] Whenever there is something extra we sell maize, finger millet and teff to buy fertilizer." (male farmer 5)*

Male farmer 2 even stated that he was not able to purchase other agricultural inputs since he was forced to use his money on fertilizer. It can therefore be argued that farmers using and being dependent on purchased fertilizer are limited in applying climate change adaptation strategies, since they will have fewer economic resources. Their adaptive capacity will thus be lower than the farmers who are not dependent on purchasing fertilizer.

4.4.5.4. Availability and Access to Economic Resources

As already mentioned, availability and access to economic resources highly influences the adaptive capacity of the interviewed farmers.

I did not ask the farmers about their income and therefore I cannot express which of the households had a higher adaptive capacity due to their higher availability of economic resources. In general households selling chad seemed to have a higher income (HH 1, 3, 8, 10) compared to the other interviewed households. The ability to spend the available economic resources on adaptive measures however seemed to be lower for the households depending on purchasing fertilizer (MF 1, 2, 3, 5, 6, 10).

Furthermore, especially the female farmers apart from lacking the availability of economic resources also had no or only limited access to these. The main reason for this is that most of the female farmers I interviewed were responsible for tasks in the household which did not create an income, but which likewise were of great importance to the household. Only three of the interviewed female farmers were engaging in income creating activities (FF7, 8, 9). The other women were depending on their husbands to give them money and when I asked the male farmers about their responsibilities in the household several mentioned *"giving money to my wife".* The females high work load further made it difficult to engage in income creating work. Only female farmer 9 and 10 mentioned that their husbands would help them in the household, while the other interviewees stated that the male household members' would not help them with household tasks and therefore they would have no or only very little time for other activities.

Female farmer 3 mentioned that she wanted to buy an oil extraction machine to increase her income, but that her husband allocated the money and would not give money to her for this purpose, but rather spend it on other purposes:

> *"I would like to have a machine for oil extraction for a little industry, but my husband does not want to save money for this purpose. He spends it on other purposes.[…] He works, but he gives money to other family members like the child of his brother or sister." (Female farmer 3)*

The economic dependency on the husband and the lack of access to the household's economic resources therefore performs a great limitation to the adaptive capacity of female farmers. According to AEW2 female farmers' ability to apply adaptation strategies, such as the use of improved seed or breeds, are mainly limited by their lack of resources:

> *"[…] They (female farmers) are wise to accept the new technology, but their income, the payment for the technology, getting this one is difficult for them." (AEW2)*

Furthermore, limited access to transportation and safety keeps the women from occupying in income creating activities. These observations were confirmed by the head of women affairs department of ORDA:

> *"[…] The work burden is another problem, the major problem, that the women are tied to the house and that protects women to go out to project works and to generate income. Because this household work doesn't have any pay. There is no pay. They work 24 hours, 24 hours without any rest, but there is nothing to pay for her. The men go out to work on the farm and they fat animals and bring to the market and get some money, […] but the women is restricted to the household. There is no resource ownership, because the man works and gets the resource so it belongs to him. He controls that money, he controls the resource so the women has no control over the resource."*
> *(Speaker of Women affairs department, ORDA)*

It can be argued that the limited availability of economic resources affects the adaptive capacity of farmers more or less equally. However, farmers being dependent on purchasing expensive fertilizer have less access to their available money, since they are forced to spend a high share of their resources on the purchase of fertilizer. Furthermore, the adaptive capacity of most of the interviewed female farmers was further affected by their lack of access to the existing resources due to cultural constraints.

4.4.6. Availability and Access to Information

As mentioned earlier the adaptive capacity of an individual is highly influenced by his or hers access to new information and knowledge. As part of the interview I asked the farmers about their main sources of information, knowledge and advice to improve their livelihood. The

answers of the interviewees showed that there was a general distinction between the source and type of new information of the interviewed male farmers and female farmers. The female farmers mainly mentioned that they improved their household by observing others homes and mainly the neighbours:

> *"If I see beauty in others homes, if I can, if I have the ability to do that, I try to do that." (Female farmer 8)*
>
> *"If I see some new things and if I can apply it I do, if not than not. For instance if this thing need much money I cannot apply it, but if I can apply it for this purpose, I do. " (Female farmer 6)*
>
> *"I see from other people around. For example my mother didn't use this stove for cooking, but I saw it from my neighbors and now I am using the same." (Female farmer 10)*

The women's source of innovation and new information seemed therefore to be achieved to a high extend from visual observation, while traditional knowledge mainly was acquired through parents or other family members. Furthermore, several of the female farmers mentioned that they achieved advice from the health extension workers and that the advices were mostly concerning topics related to the household:

> *"The health extension workers came here and advised us. They show how to build toilets and this stove (refers to the injera stove), but I already made one before they came."(Female farmer 10)*

Female farmer 4 mentioned that the agricultural extension workers had come to her house in order to give advice on livestock, but that she had not taken this advice. Female farmer 9 mentioned that the agricultural extension workers had come to her house, but that they had left when they saw that her husband was not there.

The male farmers seemed to have a more complex and broader communication and exchange of knowledge compared to the females. Apart from one farmer (MF7), all the interviewed male farmers mentioned the agricultural extension workers as source of information and advice. Furthermore, some mentioned their neighbours and other farmers:

"I exchange knowledge with the neighbours; which crops are good, which ones are bad for the land, and what kind of fertilizer to use. The extension workers give advice to us, about how to plant and how to apply fertilizer." (Male farmer 3)

"Yes, today there is exchange of knowledge which is close to our development because there are people where the minds are very wise and take something from another one. [...] There is exchange of knowledge (between villages). For instance the village around, Gedro, they use irrigation management." (Male farmer 4)

"We are a group of five farmers who work together and are advised by the extension workers and we exchange knowledge together." (Male farmer 6)

"All the agricultural technology and improvements I learned them from the extension workers and from my friends. "(Male farmer 8)

"I get information from the extension workers how to plant the maize in rows. Otherwise, as I am young I get information from old people from other farmers who are ploughing the land."(Male farmer 10)

These responses indicate that farmers communicate with elder or other farmers to achieve traditional knowledge, whereas new information and innovations are achieved by communication with the AEWs and other modern farmers. However, most of the male farmers referred to an *exchange* of knowledge, which indicates that knowledge and information is actively flowing between farmers instead of being only given or taken. The access to agricultural information among the male farmers seemed thus to be functional; however, the availability of information on climate change and adaptive practices was limited.

Only one of the interviewed farmers mentioned that he achieved information about the weather through modern media (MF8):

"[…] I listen to their prediction on TV every night on the weather channel." (Male farmer 8)

The access to this kind of information increases his adaptive capacity compared to other farmers. However, most of the farmers did not possess a television or electricity and had only little or no access to other modern media and electronic information.

Overall, the male farmers' access to information was higher compared to the female farmers, due to their broader interaction with other people. As mentioned earlier, the female farmers mainly stayed inside or around the house and therefore their contact with other people and likewise their sources of new information was limited:

> *"[…] Men have better information, better knowledge because they are in the public sphere. They go to the outside to the nearest city or to the nearest town they move and they get different information from the farmers, the market and everything, better than women. Women are tied to the household." (Speaker women affairs, ORDA)*

The male farmers ability to adapt to climate change is therefore potentially higher compared to the female farmers, since their access to information was better. However, the general low availability of information on climate change and agricultural adaptation strategies decreased the adaptive capacity of the farmers equally.

4.4.7. Decision Power

The power to decide is a further factor influencing individual adaptive capacity. When I asked the male and female farmers how decisions were made in their household, surprisingly all of the interviewees stated that decisions were made together. However, after some deeper questioning 10 of the 20 interviewees expressed that the husband held a higher decision power, whereas the decision power of the wives were their ability to negotiate the decision (MF1, 3, 7, 8, 10 & FF3, 4, 5, 7, 8, 10):

> *"We make the decisions together. [...] (Laughs) Sometimes decisions are made by me alone." (Male Farmer 3)*
>
> *"Decision making is always together. At least we communicate with each other." (Female farmer7)*
>
> *"Sometime I take over the decisions myself, but most of the time we do that together." (Male Farmer 8)*
>
> *"It is a negotiation. […] I am the leader, but my wife is the negotiator (laughs)." (Male Farmer 10)*

Interestingly, there was no age relation between the different answers. It could be expected that the younger couples were more likely to have an equal level of decision power, but this was not the case.

Four of the households did give disagreeing answers about decision making (HH1, 4, 5, 8). In households 4 and 5 the women stated that the husband held a higher decision power and in household 1 and 8 the male farmer stated that he had a higher decision power, while their partners stated that decision always were made together. It is thus questionable if the interviewees lied or truly perceived their decision power differently from their partners. Furthermore, the interviewees may understand the term "together" differently. Some may understand it as being part of the decision rather than having equally power in deciding.

However, since male farmers are earning and allocating the income of the household their power to decide is likely higher.

The male farmers had in many ways a higher availability and access to natural and man-made resources, information and a higher decision power than the female farmers, and it could therefore be argues that their adaptive capacity is likewise higher. However, all respondents,

regardless gender, performed only few to no actions to the impact of climate change and their lack of action must therefore further be influenced by other factors.

4.4.8. Individual and socio-cultural factors

The adaptive capacity of an individual is further determined by his/hers human capacity which is influenced by ones capacity for variation and retention. As mentioned in section 2.3.3 v*ariation capacity* is an individual's ability to generate new ideas and alternative solutions to problems, whereas the *retention capacity* refers to the ability of an individual to evaluate and therefore be able to select and apply new ideas to solve a problem. Three factors are determining an individual's variation capacity: 1) the ability to retrieve or recall information from the memory storage, 2) flexible thinking, and 3) openness to new experiences.
The first two factors are influenced by the level of knowledge, experience and education, whereas last listed requires the critical questioning of traditional practices and believe in one's ability to manipulate the environment.

It is not in my interest to analyze the exact memory ability or the ability of flexible thinking of the interviewed individuals, since this would have required another data obtaining method. In general both genders seemed to have an equal ability to recall memories, since only one of the females interviewed answered that she could not remember 10 to 20 years back (FF2):

> *"I don't know how the weather was 10 to 20 years ago. How to remember this?*" *(Female farmer 2)*

However, through my qualitative questions I observed some patterns especially between male and female farmers concerning their *openness to new experiences*.

4.4.8.1. Openness to New Experiences

Being open to new experiences is especially important in order to implement new agricultural adaptation measures. It can thus be argued that farmers who are more open to new experiences likewise have a higher adaptive capacity.

Male farmer 1, 2, 3, 5, 6, and 10 mentioned that they had taken advice from the AEWs concerning the use of fertilizer and male farmer 2, 3, 9, 10 mentioned that they had started row-cultivation after the advice of the AEWs. Male farmer 1 further mentioned that he had build stone hedges around his land in order to prevent soil erosion. This indicates that the interviewed farmers were not reluctant to new farming practices. Their use of improved seeds and agro-ecological methods, such as water and soil conservation was however rather scarcely practiced. As mentioned before, only two of the interviewed farmers mentioned that they used improved seeds (MF1, 5) and one farmer mentioned that he used high-breed cattle (MF8). The limited use of improved seeds and high breed livestock might mainly be caused by the farmers lack of economic means and the low availability of the inputs, but it could also be due to the farmers limited openness to these new inputs.

Furthermore, only one of the interviewed farmers prepared compost and stated that he stopped this practice since he could not see an immediate benefit from this practice (MF1). This practice requires to a higher share openness instead of economic resources, and it can thus be argued that the farmers' openness to new farming practices might be linked to perceiving a profit from the new practice before applying the measure. This was confirmed by AEW3 who explained that most of the farmers in Zenzelima cultivated eucalyptus against the AEWs advice to plant indigenous trees, since eucalyptus would grow faster and therefore have a higher economic value for the farmer. Furthermore, the AEWs mentioned that the farmers in general were sceptical to new methods until they would see the results by another farmer, which was confirmed by one of the farmers:

> *"The farmers don't accept new technology quickly, he accept it if he sees it is doing well on another person's farm. When he sees the result he comes to the extension workers and asks." (AEW2)*
>
> *"I started to cultivate chad because I saw someone getting advantages from it and I have learned from the experience from my friend." (Male farmer 8)*

According to the agricultural extension workers the farmers' lack of openness to new methods and technologies was a general phenomena of the kebele:

> *"Some don't want to accept new technology and some because of lack of resources. People in this kebele do not want to learn about new things or accept new technology, because they are not educated and because of cultural aspects. Sometimes I go to farmers (without them contacting me) and teach them. Some accept the new technology, some don't. Most of the farmers who accept the new technology are younger farmers." (AEW1)*

The AEWs further mentioned that the farmers mainly would come for input such as fertilizer and new seeds but rarely for advice. In order to give advice on farming strategies they needed to approach the farmers themselves, and they mentioned that this sometimes caused that farmers would use the inputs incorrectly. Furthermore, the AEWs mentioned that teaching the farmers to use new inputs such as highbred hens was difficult (AEW2). This scepticism to the new agricultural inputs could likewise hinder farmers in applying new varieties or crop types, which are better suited to the new climatic conditions.

As mentioned earlier, the interviewed female farmers were in general more open to new changes that they had observed during the last 20 years compared to their husbands and expressed a more positive attitude to the changes that were taking place in Zenzelima. Furthermore the AEWs stated that female farmers showed to be very open to new farming methods and innovations:

"[…] They (female farmers) are wise to accept the new technology, but their income, the payment for the technology, getting this one is difficult for them." (AEW2)

"[…] female are wise to accept the new technology […] the new female generation is very fast to accept educational participation, they score high rather than male in their generation.[…] If we train the female it is more preferable than men, because they accept and they are productive rather than male and not only outside but also how to manage her home.[...] Without female participation nothing stays! " (AEW3)

The farmers who used new farming practices might be more open to new agricultural adaptation strategies and their adaptive capacity is thus higher compared to farmers being reluctant to new farming practices. Especially the female farmers had a higher openness to new experiences which increases their adaptive capacity compared to the male farmers.

4.4.8.2. Believe in the Ability to Manipulate the Environment

Another factor, determining ones openness to new experiences and likewise increasing the variation capacity, is the believe in being able to manipulate the environment. When speaking of believe in being able to manipulate the environment, it here refers to the ability to adjust to climate changes in such way that the environment becomes suitable again.

Especially Male Farmer 1, 9 and 10 showed personal strength and innovation to improve their livelihoods. Both Male Farmer 1 and 10 sought for the solution outside the farming system and had established their own wagon transportation business:

"To get more income I am trying to run my own business of using a wagon transportation, and I am engaged in Ekub (Ethiopian saving program). Or though it is so hard and tuff to cope with this situation. We are trying our best to win the situation we are in." (Male farmer 1)

Male Farmer 9 distinguished himself from the other interviewed farmers since he expressed that he was very passionate about gardening and actively applying adaptation measures against climate change. In contrast to all the other interviewed farmers, he did not grow up on a farm but had inherited his piece of land from his godmother. Even though he was limited by low availability of water, land and knowledge, he had managed to establish a mango plantation and was planning on cultivating coffee and holding goats. This shows that the availability of resources and knowledge can influence the ability to adapt to climate change to some extent, but that it to a high share also is determined by individual characteristics:

> *"I planted the trees because I am interested in growing plants and I want the place to be like a park and I want to expand it to a recreating park because the place is so quiet and the atmosphere is so good. I used to enjoy when people have a good time in recreation parks and I always wanted to have one for myself. And I loved gardening and my goal was to find a land and make it like that. And now I got the change and am proceeding that plan. And I carrying the water all the way up* (lives far away from the river) *to the plantation, but I think for my purpose it is worth it."* (Male Farmer 9)

He further expressed a strong believe in the ability to change the environment through planting trees:

> *"I am certain that in the future, if everyone plants trees and takes good care of the environment, if they replace after cutting a tree, as I do, I am sure there is going to be a very big change in decreasing temperature. If the development is going to continue like this there is going to be a huge positive change in the environment. I am sure. […] I think my land is going to be very beautiful in the future. I am planning to grow larger trees on the border sites and smaller trees in the middle like coffee and mango and also I am planning to grass the land all over. So it is going to be very beautiful." (Male Farmer 9)*

On the contrary, especially the farmers who expressed that god was giving and controlling the weather and the environment had a lower believe in their ability to change the challenges they were facing (FF3, 9, 10 & MF 2, 3, 5, 7, 8):

> *"God is greater and only he knows." (Male farmer 2)*
>
> *"The weather is a gift by god, it cannot be changed by human beings." (Male Farmer 3)*
>
> *"We couldn't do anything about this. We just pray for god and hope for the best, that's all we have been doing." (Male farmer 8)*

This lack of believe in oneself hinders innovation and action and seemed further to limit the farmers who had perceived climate change in applying any adaptive measures. Some farmers further believed that the government would help them with improving their situation:

> "Now there is no water accessibility but for the future the government says there will be a line. " *(Female farmer 4)*
>
> *"I think the government is going to help us to improve our living standard and we are just going to hope for the best. Governments are concerned so we hope they will do best for us." (Male farmer 7)*

This general reliance on the government can be beneficial in order to implement planned adaptations to climate change, however it can likewise hinder autonomous adaptations.

Generally, the lack of believe in changing the environment was more dominant for female farmers, since most of the women seemed to lack believe in their own ability, strength and knowledge. This became especially clear through their very shy appearance in the interviews. Most of the female interviewees signalized that they were uncomfortable with answering the questions in the beginning of the interview, but some increased their confidence gradually during the interview.

According to the head of the women affairs department of ORDA there is a long tradition in the Ethiopian culture that women are not supposed to reflect and express their ideas and opinion, which explains their shyness:

> *"You know, women when they come to the meetings with their husbands they become silent, because in the culture they grow up they don't speak up in front of the husband or in front of anybody. This is you know shaming for them. Due to this culture women are silent in the meeting and are not fast to talk to you, they are not fast to talk, but they know everything…inside. But the culture you know protects them from to speak more." (Speaker of Woman Affairs, ORDA)*

One female farmer even excused herself by saying that she was not educated and therefore not good in answering the questions (FF5). Many of the females believed that their lack in education limited their abilities and possibilities and increased their dependency of their husband:

> *"If females are more educated and build their capacity I think they will be more competitive and more able to face problem by themselves without the men." (Female farmer 7)*

Especially the older female farmers had little to no education, which was mainly due to their early marriage at the age of 8 to 13:

"[…] It is one of the problems of this Region, because early marriage protects them (women) from education. Education protects them from knowing what, having big thoughts, having big money, and they become poor. They get marriage very early, so they lose their life. But now they begin at school, there are many you know. Before they got married as teenagers, 8 years, 9 years, 10 years, 12 years. But now the government's proclamation already protected under age (under 18), it is forbidden. [...] So by now these girls are at school." (Speaker of Women Affairs, ORDA)

The compliance of the law however seemed to be challenging, since the youngest interviewee was 18 years old and stated that she had been married for 4 years (FF10). However, especially the older females mentioned that they had perceived great changes in the role of women and they perceived education as tool to empowerment:

"Yes, there is change. Female now they know their rights, they ask their rules; they ask anything, about poverty, property, about right and wrong things, everything." (Female farmer 7)

"I have one girl who is going to university, so I think it will change. […] I wish for my children that they go to university like my oldest daughter." (Female farmer 6)

"For my children, for the next generation, they will work together, decisions are made together. They will be equal." (Female farmer 10)

Interestingly, more male farmers stated that they had observed changes in the role of women than the women themselves, which could indicate that many of the women still do not know about their rights and have not been informed by their husbands or others.

"Because the equality is given by the government, the females became equal with man in the case of decision making and property. Everything changed. Before when I got married I didn't know her and also my wife didn't know me. Our family chose for us, but this has changed. And also before no one asked for separate property, but now the government gives equality so the man and female get equal when they separate." (Male farmer 6)
"For the future and the new generation, I teach my children to become equal." (Male farmer 7)
"There is a big change from the past days. Now the role of women has changed a lot, also there are some people who don't accept this, but my wife and I we always are on the same page." (Male farmer 9)

4.4.9. Female and Male Farmers' Adaptive Capacity in Zenzelima

The results indicate that the interviewed farmers were mainly influenced in their ability to adapt to climate change by the availability and their access to water, agricultural land, agricultural inputs, economic resources, and information on agricultural adaptation strategies. Therefore farmers with a lower access to the above listed factors had a lower adaptive capacity compared to farmers with a higher access to these factors. The adaptive capacity of the interviewed female farmers was generally lower than the male farmers, since the women had less access to especially economic resources and information, and therefore less decision power. Since personal skills and quality traits further influence the adaptive capacity, farmers being more open to new agricultural practices potentially have a higher adaptive capacity. Farmers expressing a lack of believe in being able to adapt to climate changes have further a lower adaptive capacity compared to farmers believing in their ability to adapt to the new climate conditions.

Since the adaptive capacity of all the interviewed farmers were limited by several of the above listed factors there is much need and potential to increase their adaptive capacity in order to avoid significant losses in their agricultural production and to secure their future livelihood.

5. Discussion

As analyzed in the previous chapter, the main factors that influences the farmers in Zenzelima in applying agricultural adaptation measures are their unawareness of the need to adapt to climate change and their low ability to adapt. These findings will be discussed and compared with findings of other studies in the following.

5.1. Awareness of the Need to Adapt

As stated earlier the adaptive capacity of a farmer determines his/hers options to adapt to climate change and thus gives an indication of his coping range. However, most importantly the farmer needs to be aware of the necessity to adapt in order to use the resources of her/his adaptive capacity. With other words, having a broad adaptive capacity does not automatically mean that an individual will adapt, but requires apart from their willingness especially their awareness of the necessity to adapt. In order to realize the need to adapt the farmer needs to be aware of climate change and its impact.

A study by Marshall et al. (2013) concluded that Australian farmers with a higher awareness of climate change also tended to have a higher adaptive capacity. Since more of the interviewed male farmers had perceived changes in climate and therefore were more aware of climate change than the female farmers, it can be argued that their potential to adapt is higher. The reason, why only four of the interviewed female farmers answered that they had perceived changes in the climate during the last 20 years, could be multiple. As mentioned earlier it could be linked to their field of responsibility, which is mainly inside and around the house. It could also be that the question of climate change might have been too abstract for the women, since they are challenged by their everyday tasks, which require a high amount of energy and time and therefore allows little time for reflection. Most of the interviewed female farmers were aware of changes, which can be linked to climate change, but without connecting them to climate change. For example the decrease in water availability was to a higher extent affecting female farmers. Most of the females were aware of the decrease and had therefore naturally adapted by using less water in the household, by using more energy and time to fetch water, or by sharing the task with other family members. Their capacity to adapt to these changes might therefore still be in the same range as the male farmers even though they were less aware of the linkage to climate change.

According to Smithers and Smit (1997) perceiving changes in weather as climate change can further be challenging, since it is not easy to distinguish natural weather variability from climatic trends. Increasing frequency of extreme events are generally easier perceived than changes in means. Especially in areas that face natural high annual variability in temperature and precipitation the difficulty to recognize changes in statistical parameters increases. Especially the young farmers, who had perceived climate changes, could therefore simply have experienced a decade with higher temperatures, since they did not have enough years to compare their observations with. Likewise the other respondents mentioning climate changes could have referred to weather variability instead.

Smithers and Smit (1997) further note that the challenge of coping with today's climatic variations might not allow the luxury of reflecting about possible climate changes several decades ago (Smithers & Smit, 1997).

Furthermore, being aware of climate change does not necessarily imply a recognition of the need to adapt. Despite some farmers' awareness of climate change, the use of farming adaption strategies by the interviewed farmers was very low, which could indicate that the awareness on the necessity to adapt is likewise low. Smithers and Smit (1997) state that the awareness of the need to adapt depends on the perceived importance of the impact of climate change, and to which extend these changes disrupt human activities. Grothmann and Patt (2005) state that people potentially underestimate the likelihood of the hazard affecting them, which therefore hinders their awareness of the need to adapt. Since other factors were highly challenging the interviewed farmers' livelihood, it can be argued that the necessity to adapt to climate change is of lower priority to them.

Maddison (2007) analyzed farmers' perception of climate change and their adaptations in 10 African countries (amongst these Ethiopia) and concludes that farmers with the greatest experience of farming were more likely to notice climate change, but educated farmers were more likely to imply adaptation strategies. Fankhauser and Tol (1997) further state that timely recognition of the need to adapt to climate change requires access to reliable and detailed information, but furthermore the ability to process the information.

In order to increase the farmers implementations of adaptive measures to climate change their awareness of the need to adapt therefore needs to be increased.

5.2. The Ability of Farmers in Zenzelima to Adapt to Climate Change

In the following sections the factors that potentially influences the farmers adaptive capacity in Zenzelima will be discussed and compared to similar studies in Ethiopia and other countries in Africa.

5.2.1. Availability and Access to Natural and Man-made Resources

The interviewed farmers adaptive capacity was highly influenced by the low availability of water, agricultural land, agricultural inputs, and economic resources and/or their limited access to these. These findings are similar to other studies surveying the adaptive capacity of smallholder farmers in Africa.

Legesse (2013), who also studied the adaptation of farmers living in Bahir Dar Zuria district to climate change, found that the farmers' ability to adapt mainly was influenced by their lack of knowledge on adaptation strategies, and their lack of economic and technical resources. He concludes that the adaptive capacity of farmers in Bahir Dar Zuria district is very low and further challenged by other factors such as diseases and poverty.

Bryan, Deressa, Gbetibouo, and Ringler (2009) found that a large percentage of Ethiopian farmers did not make any adjustments to their farming practices, despite having perceived changes in rainfall and temperature. They (ibid.) conclude that the main barriers were the farmers' lack of access to land, information, and credits.

A study by Maddison (2007), who compared Ethiopian farmers perception of climate change and their adaptation to nine other African countries, found that the main reasons for Ethiopian farmers lack of response to climate change was lack of information about climate change and knowledge on adaptation strategies, lack of access to water, appropriate seeds, loans, market access and lack of security of property rights. Especially lack of water, appropriate seeds, property rights and market access was hardly mentioned as a barrier in the other nine African countries he analyzed (Maddison, 2007, p. 51).

Di Falco et al. (2011) conclude in their study that the main reason for Ethiopian farmers' lack of applying adaptation strategies are lack of information, followed by their lack of land, money, and shortage of labor.

5.2.1.1. Agricultural Land, Expropriation and Urbanization

One of the main limitations that the interviewed farmer mentioned was the decrease of agricultural land caused by an increase in population density and by governmental expropriation for non-agricultural purposes. In order to discuss this issue it is important to understand that the land reform implemented in 1975 by the regime of Derg, which claimed all land in Ethiopia to be state property, still accounts today (Di Falco et al., 2011). All land is therefore owned by the state and the government can distribute land to individuals but similarly expropriate individuals of their land for the sake of public interests in exchange for compensation in advance (Amhara National Regional State Rural Land Administration Proclamation No. 133/2006 Art. 2(18)).

Two of the interviewed households mentioned that some of their land had been "taken by the government" and that they had obtained another piece of land in exchange or economic compensation, while others feared that the government would take their land. The interviewed farmers seemed to be unsatisfied with the economic compensation; either because they found it insufficiently or because they claimed not to have received it. According to Haregeweyn et al. (2012) most of the farmers do not know how to handle the economic compensation and a general problem is that the farmers often do not buy other land from the monetary compensation. Instead they allocate it in the bank without knowing what to do with it, use it for renting land or draught animals, or spend it on home consumption. Apart from a monetary compensation, the farmers are often promised access to credits and trainings in exchange for their land, but often the compensation is not enough to replace the benefits obtained from the land or promises are not kept (Haregeweyn et al., 2012). Unfortunately I did not ask the farmers about the use of the economic compensation, but one farmer mentioned that he had used the money to rent another piece of land (MF4). However, the other farmer, who had stated that the government took some of his land, did not rent land in exchange and it is thus rises the question, what he used the money on. The farmers could use the economic compensation to improve their farming system on their remaining land by investing in improved seeds, seedlings of vegetables and woody perennials, and other input necessary to establish an agro-ecological farming system. However, if the risk of losing the land without an adequate compensation is too high, it will impede the farmers from investing in future minded inputs and natural resource conservation strategies.

Especially when looking at the development around Bahir Dar and Zenzelima during the last 50 years, it becomes clear that the urbanization process is fast, and how far Zenzelima still can be

classified as rural farming area in 2050 is questionable. According to a study by Haregeweyn et al. (2012), the urban area of Bahir Dar expanded from 279 ha to 4830 ha at an average rate of 88 ha per year during 1957 to 2009. The greatest expansion occurred to the east (in the direction of Zenzelima) due to the presence of the Abay River and the availability of land suitable for housing construction. Due to the increasing expansion of the city the quantity of available agricultural land has been declining in the region due to its change to urban or other non-agricultural uses, while especially impacting the livelihood of small-scale farmers situated in the outskirts of the city. Between 2004 and 2009 2878 farm households situated in the outskirts of Bahir Dar city were expropriated and their land replaced by urban and other non-agricultural uses. Haregeweyn et al. (2012) surveyed 271 of the 2878 expropriated households and detected an average loss of 0.89 ha agricultural land per household, a total loss of permanent trees of about 48 %, and a total decrease in livestock population of 24 %. The decrease in livestock population size was primarily linked to the shortage of feed entailed by the shrinkage of land holding size. These results are similar to the statements of the interviewed farmers in Zenzelima, who mentioned a decrease in forest and livestock size due to decreasing land holding size.

Furthermore, Haregeweyn et al. (2012, p. 154) predict that the size of urban area in Bahir Dar in 2009 will double by 2024. If this prediction comes true the farming systems in Zenzelima like they exists now will not be possible anymore. Farmers will either need to resign their farming practices and engage in non-agricultural activities or they will need to optimize their existing farming systems to be as space efficient as possible. A method to compensate for the decreasing land size is to increase the production on the available land. The farmers in Zenzelima were already doing this by using inorganic fertilizer, but many of them stated that the soil fertility decreased continuously, which forced them to increase their use likewise. This strategy makes the farmer extremely dependent on expensive fertilizer and many of the farmers expressed that they already struggled to raise money for the purchase of fertilizer. Another way to increase field productivity is to raise the soil organic matter content of the fields and increase the amount of harvestable products by planting poly-cultures or using agro-forestry systems. Especially the land around the houses, where some farmers already had fruit trees, could be potential poly-culture gardens with a variety of different fruits, vegetables, and herbs.

According to Altieri (2009) using agro-ecological practices and techniques can further increase the water use efficiency. Water is a key driver in agriculture, and water scarcity can therefore decrease production and increase food insecurity (Hanjra & Qureshi, 2010). Since the low availability and access to water was one of the main factors hindering the farmers in Zenzelima in applying agricultural adaptation strategies, special attention should be given on the use of water. Especially since the ongoing urbanization process and the increase in population size further can be expected to decrease the already critical level of water availability in Zenzelima. If the amount of annual precipitation declines as predicted by Aylew et al. (2012) in the future, this will make water conservation practices even more important. However, since many of the adaptation strategies require a higher input of water in the beginning, the adaptive capacity of farmers will be extremely low if water is completely unavailable.

5.2.1.2. Availability and Access to Agricultural Inputs

One factor that was influencing the adaptive capacity of the interviewed farmers was the shortage of improved agricultural inputs such as improved seeds and seedling, high-breed livestock, fertilizer, pesticides, and animal feed, and their limited access to these.

According to IFPRI (2010, p. 7) Ethiopia's agricultural sector faces shortages of improved seeds, due to an underdevelopment of the market. This is believed to be caused by the inaccurate planning for demand, productivity gaps and financial constraints of contract grower, and misalignment in processing and delivering by the public and private sector. Furthermore, the farmers' demand for improved seeds is low, since they are insufficiently informed about the benefits of improved seeds or because they are unable to purchase the comparable expensive seeds. Therefore, only 3-6 percent of seeds for cereals and pulse crops are being supplied by the formal commercial seed sector in Ethiopia. The majority of farmers in Ethiopia acquire seeds mainly from the traditional informal seed sector, where farmers save seeds from their crops and use them in the following planting season or trade/buy them informally (IFPRI, 2010, p. 9).

According to IFPRI (2010, p. 2) increasing the use of good quality seeds and improved seeds could increase Ethiopia's food production significantly. Especially the use of drought and pest tolerant crops is an important climate change adaptation strategy. In Ethiopia the governmental organization *Ethiopian Seed Enterprise* (ESE) dominates the commercial seed production (in 2008 80 percent of the seeds were produced by ESE), but they are facing challenges with demand planning, insufficient capacity to rapidly respond to farmers needs, and constraints to physical resources (IFPRI, 2010, p. 12). To increase the availability of improved seeds it is therefore important that the government expands its existing breeding and seed production system or the share of private companies on the market. Focus in their breeding program should lay on tolerance to climate change related stresses. Furthermore, increasing the demand of farmers by educating them on the importance on seed quality is similarly important. Likewise, it is important to ensure that farmers have access to the improved seeds both geographically and economically.

Several of the interviewed farmers mentioned the use of fertilizer, but they likewise explained that their access to the input required a high share of the households economic resources, since inorganic fertilizer was an expensive commodity. They further stated that their use of inorganic fertilizer had created a dependency, which they could not escape, since the soil was not productive without the use of the input anymore. According to The International Fertilizer Development Center (IFDC) (2012) fertilizer prices in Ethiopia are relatively high due to high transaction costs for marketing and distribution. The use of inorganic fertilizer means that the household has less economic resources to spend on other products. Therefore breaking the farmers dependency on inorganic fertilizer could be a possible option to increase their ability to apply other agricultural adaptation strategies and thus increase their adaptive capacity. This could be achieved by teaching the farmers alternative strategies on how to increase the soil fertility.

5.2.1.3. Availability and Access to Economic Resources

Apart from the farmers' general lack of economic resources, women are even more affected since they further have only very limited access to the available money. Their decision power is

therefore lower compared to their husbands, which restricts them in suggesting and applying farm level adaptation strategies. As explained earlier the main reason for this is their lack of engagement in income generating activities. To increase women's access to money several conditions must be improved.

One condition that needs to be changed is their disproportionately low access to land and other productive assets. At the state of 2009 only 17.8 percent of the land holders in Amhara were women, despite the fact that joint allocation and registration of land in the names of both the husband and wife has been made possible in 1997 by the Federal Rural Land Administration (MoA, 2011, p. 46). The wife has thus the legal right to be registered as holder of the land together with her husband, but the law has been ineffectively implemented and therefore the land of most of the female farmers belongs to their husbands and they are thus denied inheritance rights. Adding the females' name on the land registration document is therefore necessary to increase their decision power.

Another condition that should be changed in order to increase the decision power of women is their cultural role of being responsible for the livestock, but mostly not being allowed to sell them. Since the holding of the animals takes place in or around the house, the females are bound to the household and thus cannot engage in other income generating activities. Simultaneously, she is not the holder of the money that her work creates, since it is the husband that sells the animals on the market. Is places the female farmers in a position where they have a high work load, without access to the monetary outcome. These traditional roles therefore need to be changed in order to empower the rural women.

Concerning the decreasing agricultural land size, farming in small-scale poly-cultural farming systems could be a necessary strategy to maintain farming in Zenzelima. These small, but high productive gardens could very conveniently be managed by women. Their cultivation of different vegetables would furthermore increase the households' nutritive quality and the surplus could be sold on the market or to neighbours. However, it is important that the females would be allowed access to the market, which would give them access to an income and thus increase their decision power in the household. By involving females in other income creating activities the adaptive capacity of the household could be enlarged, since their contribution to the households' income would result in a higher availability in economic means.

Fortunately, the role of women is changing positively. I observed that even though the livestock market was significantly dominated by male vendors in Zenzelima, a small but increasing share of the farmers selling poultry were women. Furthermore, many of the male and female interviewees stated that the role of women had changed significantly and especially the elder female farmers mentioned that they were happy to see that younger females seemed to have more opportunities than they had. Most of the female interviewees mentioned that they believed that the equality between men and women would increase for the future.

5.2.2. The Importance of Information and Networks

Lack of access to information on possible adaptation strategies is another determinant that limits the adaptive capacity of farmers in Zenzelima and a general problem for farmers all over Ethiopia according to Di Falco et al. (2011) and Maddison (2007). The agricultural extension service is a potential source of information on agricultural adaptation strategies and farmers

contact with extension workers was often found to influence their probability of adapting to climate change (Maddison, 2007; Obayely, Adepoju, & Idowu, 2014) . However, most of the interviewed farmers in Zenzelima had contact to the AEWs whereas their adaptation measures were very low. This could be explained by the AEWs lack of knowledge of farm level adaptation strategies (especially agro-ecological farming methods), since their main advices concerned the use of inorganic fertilizer, improved seeds and high-breed animal livestock. The AWEs seemed to be aware of the importance of natural conservation practices, but they understood these implementations as separate techniques which are not incorporated into the farmers existing cultivation system. Therefore, the farmers' use of natural resource conservation has been very low, since the farmer perceives them as uneconomically. In order to increasing the farmers´ knowledge on farm level adaptations to climate change, it is therefore necessary to educate the AEWs on these practices and further to establish a network of knowledge exchange between farmers, since the outreach of the AEWs is limited.

Bryan, Deressa, Gbetibouo, and Ringler (2009) similarly states that social networks and social capital can make it possible for individuals and communities to manage climate risks collectively. As examples that facilitate adaptation they list the provision of informal sources of credits, and the spread of information about climate change and appropriate adaptation strategies. According to Vygotsky (1978) (cited in Munune, Schwarz, and Kibanja (2005)) the individual learns to successfully adapt to the environment by interacting with others and therefore creating a network is an important tool to broaden ones adaptive capacity. By observing others the individual learns to improve his life and this new learning contributes to the individual's repertoire of skills. In order to adapt to new challenges or a changing environment, the individual must continually seek resources from the outside, typically from the cultural environment, which improves his mental functioning and increases his ability to solve problems (Munune et al., 2005). Granovetter (1973) (cited in Munune et al. (2005)) states that dense networks in which everyone knows everyone else and have strong ties to each others are effective for institutionalizing and socializing norms and values, but impede change and innovation. He argues that weak ties can be seen as parts of extended networks in which individuals meet acquaintances occasionally and without having a strong tie to them. These acquaintances have their own dense network and therefore occasionally contact between the two individuals from two different networks can lead to an exchange of knowledge and information and bring new views and ideas to a community.

According to the interviewees the male farmers' in Zenzelima seemed to be part of a dense network with some weak ties. Their main sources of information are their close neighbors, but several communicate infrequently with the agricultural extension workers to whom they have no close relationship. Furthermore, several of the male farmers are occupied in activities that take place outside of the village and therefore their potential to observe and achieve new ideas and innovation is higher. Likewise their opportunity to meet new individuals to whom they can form weak ties and exchange knowledge and information is higher. This shows that the male farmers' lack of knowledge on adaptation strategies to a higher extent is caused by the general lack of available information rather than on the lack of an existing network or knowledge exchange.

In contrast most of the female farmers stated that their main source of information were their close neighbors, to whom they all had a very tight relationship. Due to their ligation to the house

and close surroundings they had none or only very few weak ties outside of this network and most of the women had no contact to the agricultural extension workers. According to Granovetter's theory the input of new ideas and innovations to them is therefore limited. The female farmers' ability to increase their network is furthermore limited since cultural constraints and the lack of economic resources limit their ability to increase their geographic range of action. One female farmer even mentioned that she thought she could improve their farm if she could stay more outside of her house (FF4). It is therefore important to keep these conditions in mind when educating farmers, so both female and male farmers will have access to information. Trainings should take place in their houses, since their high work load and cultural constraints prevent them from attending trainings outside their normal surroundings.

5.2.3. Human Capital

Apart from access to resources and information the adaptive capacity of an individual is highly determined by his/her human capital in the form of skills and other personal qualities. Furthermore, individual and social-cultural patterns determine the individual adaptive capacity and his/her response to a climate change stimulus. Bryan et al. (2009) states that farm-level adaptations might not be applied due to personal characteristics, economic conditions and the policy environment. To understand what limits individual abilities and choices, it is therefore important to view these in the context of individual and socio-cultural conditions.

5.2.3.1. Openness to New Experiences

As stated earlier, openness to new experiences is fundamental to generate new ideas and solutions to problems. When projected to climate change, openness to new farming practices and technologies is fundamental in order to adapt.

According to Deressa, Hassan, and Ringler (2011) one reason for farmers lack of openness to new technologies and adaptation strategies is that they are only applied, when the farmers see that the profit from using the new technology is significantly higher than the old method. Likewise Legesse (2013) found that adaptation measures by farmers in Bahir Dar Zuria district were profit driven rather than climate change driven. Therefore, it can be argued that the farmers need an incentive in order to apply an agricultural adaptation measure to climate change.

Maddison (2007) states that in order for farmers to apply land conservation techniques they need to be aware that the technology exists and perceive that it is profitable. Furthermore, he explains that farmers learn gradually about the best farming techniques and that learning can be of three types; learning by doing, learning by copying, or learning from instructions. Learning by doing requires experiments that can be time consuming and costly, learning by copying requires that someone else applies the method first, and learning from instruction requires an instructor (Maddison, 2007, p. 11). In the case of the farmers in Zenzelima learning about new adaptation strategies by doing was rather scarce and only one farmer mentioned that he mainly learned about farming by doing (MF9). This approach seems therefore less likely as successful approach to increase the farmers' use of agricultural adaptation strategies. However, some farmers mentioned that they had applied new crop types (mainly chad) after having observed other farmers cultivating the crop and being successful. This type of learning should therefore be used to make the farmers familiar with agro-ecological farming methods. The agricultural

extension workers could use *demonstration sites* where they use agro-ecological farming methods and make the sites accessible to other farmers in order for them to observe the success and lose their scepticism towards new farming methods. This type of learning likewise requires that farmers have the access to an instructor; in this case agricultural extension workers or other farmers who are willing to share their experiences.

Woman in Zenzelima generally seemed to be more open to change, new farming practices and innovations than men. Doss and Morris (2001), who studied the association of gender on farmers openness to new farming strategies, including the use of new varieties and fertilizer in Ghana, found that gender did not have an influence on the probability of adapting if both female and male farmers had the same level of education, access to land and labour, communication with extension service, and market access. However, a higher share of female farmers in Ghana had a significant lower probability of adapting since they had a lower access to the earlier mentioned resources (Doss & Morris, 2001). It is thus questionable if female farmers per se are more willing to apply new adaptations or if this is specific for the studied case area Zenzelima. In any case, including female farmers in the process of adapting to climate change is especially important, since they contribute to half of the agricultural labour. Their greater openness to new practices might thus be beneficial to promoting agro-ecological practices, but since cultural norms highly influence their ability to participate in trainings special attention must be given to these conditions when designing training programs.

5.2.3.2. Farmers Livelihood Choices and Values

All farmers in Zenzelima seemed to be restricted in their ability to adapt by their lack of economic resources. Without these, agricultural input to improve their systems cannot be purchased. Obayely et al. (2014) found that increasing the access of credits to farmers in Nigeria would decrease their diversification to non-farm activities, and increase their probability of using agricultural adaptation measures such as soil and water conservation practices. Two of the interviewed farmers in Zenzelima stated that they were engaged in a traditional saving program called *Ekub,* which is a communal micro-finance program. In these programs individuals or a household has the possibility to collect enough money to invest agricultural adaptation measures which could improve his farming. However, the two interviewed farmers who mention this had used the money on non-agricultural items instead.

Banerjee and Duflo (2012, p. 102) state that lack of access to information or resources is not always the reason that keeps people from implementing beneficial strategies, but that individuals to a higher extent are affected by their own choices than by their lack of access to resources. In their (*Ibid.*) surveys in different countries in Africa they discovered that many people stated that they were suffering from food insecurity, while owning technological equipment such as radio, television, and mobile phone. The costs of such commodities are high for the average African population and purchasing such a commodity therefore mostly requires several months of saving. From an outsiders point of view it would seem more meaningful to spend the saved money on food or other investments that would decrease or end the households' food insecurity, but Banerjee and Duflo (2012, p. 60) argue that poor people prioritize these commodities instead of food simply because they want to give some beauty to their everyday life in poverty. This indicates that the choices of farmers are highly influenced by

individual preferences and values and therefore the access to credits or natural resources does not necessarily mean that farmers apply agricultural adaptation strategies.

Furthermore, Banerjee and Duflo (2012, p. 172) state that the choices of women and men in poor countries are different when they experience an excess in income. Women are more likely to spend the extra money on food, school fee and medical care for their families, whereas men rather spend the excess money on tobacco, alcohol and other personnel articles. The authors believe that the reason for this is the socio-cultural agreement, that it is the role of a woman is to feed her family while it is accepted for men to be egoistic. Woman will therefore feel obligated to use the extra money on food, school fee and medical care for the whole family since it is expected of her, whereas men will not feel this obligation.

It can thus be argued that a woman's access to economic resources will increase the adaptive capacity of the household, since her choices might be more beneficial to the household than her husband's.

5.2.4. The Role of Governance to Adapt to Climate change

Adger and Tompkins (2004) state that adapting to climate change not only requires individuals' acting but also adjustments by governments, by civil society and through collective action. Therefore the most appropriate and effective adaptation responses will occur if they are applied on multiple levels (Adger & Tompkins, 2004).

As stated earlier a main objective in choosing to adapt is the awareness of the necessity to adapt. The Ethiopian government therefore needs to be aware of the necessity to adapt to climate change in order to perform planned adaptations. When this awareness is gained, it needs to be transferred to all levels. In the case of climate change, Conway & Schipper (2011) suggest that climate change concerns should be integrated into existing or planned policies and institutions at national level and of multilateral organizations, donor agencies and of other relevant bodies. Since the agricultural extension workers function as the executing instance of the government on local level, they become a central figure in raising the awareness of the farmers and in promoting agricultural adaptation strategies. Di Falco et. al (2011) found that information given by extension workers increased Ethiopian farmers' probability of adapting to climate change and therefore increasing the access to extension services could raise the awareness of the need to adapt and the adaptive capacity of farmers in Zenzelima. However, this requires that the agricultural extension workers are well trained on agricultural adaptation strategies to climate change.

Apart from information on adaptations, Fankhauser & Tol (1997) highlight that individuals need to have the right incentives in order to adapt efficiently. Therefore, the government should promote the use of varieties that are adapted to the new climatic conditions and create conditions in which farmers perceive an economic benefit from applying adaptation strategies. Adger and Tompkins (2004) further highlight that the adaptive capacity of a society is related to capital assets and especially sustainable resource management requires government structures that are empowered to make collective decisions. They (ibid.) further state that these capital assets will only be used effectively through appropriate institutions. Since especially lack of water and agricultural land was limiting the adaptive capacity of farmers in Zenzelima, the government holds a central role in securing the sustainable use of these. Especially land

degradation through uncontrolled livestock grazing on communal land can be controlled by governmental interaction and by creating alternative practices. Finally the institutions that limit the adaptive capacity of women in Ethiopia needs to be discarded in order to enhance women's access to education, information, economic resources and decision power.

6. Conclusion

Only few of the interviewed farmers used agricultural measures to adapt to climate change. This was mainly due to the farmers low awareness of the need to adapt and by their low ability to adapt. The low awareness of the need to adapt was not linked to the awareness of climate change, since many of the interviewed farmers had perceived changes in temperature increase and changes in precipitation. It might however be linked to their focus on other changes in their natural environment and to their everyday challenges.

The main factors influencing the farmers adaptive capacity was availability of and access to water, agricultural land, agricultural inputs, information on agricultural adaptation strategies, and decision power. The low availability of water was influencing all of the interviewed farmers, but farmers located close to eucalyptus trees referred to less available water for other crops. Furthermore, farmers located closer to a water source were more likely to cultivate vegetables, fruits, chad, and endemic trees, compared to the farmers living farther away from a water source, and their adaptive capacity was therefore higher. The low availability of agricultural land was influencing all of the interviewed farmers, but farmers below the age of 30 had less land compared to older farmers, and they were thus more influenced by this factor in their ability to perform agricultural adaptation measures.

Low availability of seedlings and improved seeds was further influencing the farmers adaptive capacity, but more importantly their access to agricultural inputs due to limited economic resources was influencing their ability to perform agricultural adaptation strategies. Some of the interviewed farmers were dependent on purchasing expensive inorganic fertilizer and had therefore fewer economic resources available for other adaptation measures. Most of the female farmers had only limited access to economic resources, since they were not engaging in income creating activities and therefore dependent on their husbands, who were allocating the money. This dependency further limited their power to decide and therefore their adaptive capacity.

Yet another main factor influencing the farmers adaptive capacity were the availability and access to information on agricultural adaptation strategies. Several of the male farmers had a broad network with other farmers and agricultural extension workers and their access to information were thus higher compared to the interviewed female farmers. However, the general low availability of information on climate change and on agricultural adaptation strategies limited the farmers ability to perform effective adaptations to climate change equally.

Finally, individual human capital and institutions were influencing the interviewed farmers access to the above listed means and influenced their ability to imply adaptation strategies to climate change.

In order to increase the farmers adaptive capacity to climate change the awareness of the need to adapt needs to be increased, information on effective agricultural adaptation strategies should be promoted, the farmers access to agricultural inputs should be increased and institutions that limits the adaptive capacity of farmers should be discarded.

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