Exploring farmers'perceptions of drought in Tanzania and Ethiopia

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...For my parents and my sister...

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Here I am, writing the final words of my thesis. I have thought a lot about this moment, already while I was working on the proposal for this research back in 2003, wondering how it would feel like to be at the verge of finalizing a PhD thesis. I had written several PhD proposals that year but it was anything but certain whether I would get financial support for any of these. The day of Christmas Eve 2003, Professor Leo Stroosnijder phoned me to inform me that I would be employed by Wageningen University to 'do the job'. Four years seemed like a very long time and for the first few months it felt as if I was swimming in the middle of an ocean without any land in sight, not really knowing in which direction to swim. The research really took shape during the first round of fieldwork. Time passed by fast and the last few months before the deadline I had to run to catch up with time. Four years appeared to be rather short.

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Monique

Wageningen, 22 September 2008

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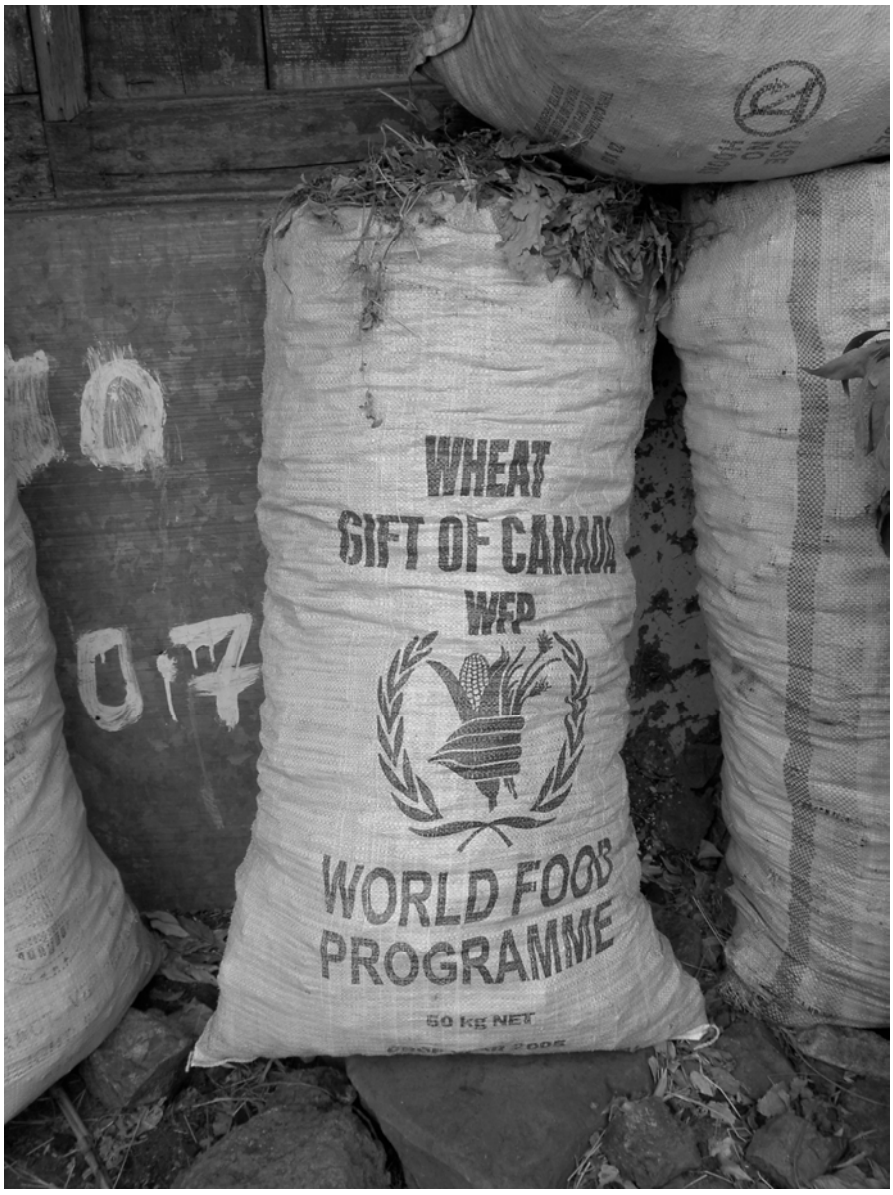
Chapter 1

Introduction



1. Introduction

1.1. Declining agricultural productivity in sub-Saharan East Africa

A goal set by the 1996 World Food Summit was to reduce by half the numbers of malnourished people in the world by 2015 (FAO, 2006: p. 31). The biggest challenge to the achievement of this goal comes from sub-Saharan Africa, where the majority of the population depends on agriculture for their livelihoods (Ehui and Pender, 2005). Average food production per capita has declined over the past 40 years (Love et al., 2006) and about a third of this region's rapidly growing population is currently food insecure (FAO, 2006). The area is endowed with poor quality soil, and about half of it lies within the arid and semi-arid zones (Ehui and Pender, 2005). It is, thus, important to overcome in a sustainable manner any difficulties which reduce productivity. Efforts to address these problems have met with limited success, which can be partially attributed to ongoing discourse about the exact causes of reduced productivity.

1.1.1. Debated issues regarding natural resource management

Scientists have long identified human-induced land degradation as a major threat to sub-Saharan agriculture. The concept of desertification emerged in the 1920s and 1930s out of concern for an expanding Sahara desert, and as an effect of mismanagement by local land users (Swift, 1996; Le Houérou, 2002) which was exacerbated by the growth of human and livestock populations. Erratic rainfall was considered a result rather than a cause of desertification.

Discussions about desertification were quite intense during the periods of drought between the 1920s and the 1940s, but all but vanished when weather conditions improved during the 1950s and 1960s (Swift, 1996). Yet Le Houérou (2002) argued that desertification was also visible at that time. The term "desertification" was again popularized at the 1977 United Nations Conference on Desertification (UNCOD), which was held after a decade of severe drought in Africa (Binns, 1997). It was generally agreed that the problem was caused by human population growth exceeding carrying capacity, and by inappropriate land use. However, disagreements existed and some described the issue as the "desertification narrative" (Swift, 1996; Herrmann and Hutchinson, 2005).

The geographical extent of the "desertification narrative" extended from studies at a local scale, mainly from the West African Sahel zone, to those at higher levels, and led to generalizations about area-specific environmental phenomena being made. These generalized ideas about desertification have also been extrapolated to sub-Saharan East Africa.

There has been a gradual change in the nature of the research, and the view that there is a complex landscape that is constantly changing, rather than just degrading, has become more popular: a process which may always have been evident to local land users (Batterbury and Warren, 2001). A commonly accepted definition of desertification came out of the 1992

United Nations Conference of Environment and Development (UNCED), where desertification was defined as: “land degradation under arid, semi-arid and dry sub-humid climates resulting from various factors including climate variation and human activities” (UNCCD, 1994). So far, no consensus exists on the extent to which human factors are responsible for desertification (Falkenmark and Rockström, 2004) and what role climatic factors play.

1.1.2. Degradation versus drought?

Development actions which focus on land degradation in Sub-Saharan Africa have not proved to be very successful in changing farmers’ agricultural practices towards a more sustainable use of natural resources. This failure is due to scientifically biased top–down approaches, resource constraints, and a lack of consensus about the major problems (Kiome and Stocking, 1995; Ringrose et al., 1996; Bekele-Tesemma, 1997; Cartier and De Graaff, 1998; Quinn et al., 2003; Tenge, 2005; Van den Bosch and Sterk, 2005). Over time, programs dealing with land degradation have become more localized and participative, which is a positive step forward. However, these programs still depart from the productivity-reducing problems identified and perceived by scientists. Subsistence farmers in this region have often been unwilling to apply conservation practices to their land because they believed that other problems, such as drought, were bigger constraints (Östberg, 1995; Beshah, 2003; Biamah, 2005; Hella and Slegers, 2006; Stroosnijder, 2008). Very little is known about how subsistence farmers in semi-arid East Africa perceive drought. Do they refer to meteorological drought, namely the context in which this word is commonly used, or to something else?

There are several biophysical variables used to quantify drought. These positivist conceptualisations completely bypass social, economic, cultural and political influences on the lives of local farmers and on the way they perceive the state of their physical environment (Agrawal, 1995). Accordingly, they are not particularly useful when it comes to explaining a farmer’s knowledge and perception of drought (Crease, 1997). A change towards a more constructivist view recognises that natural resource management is strongly influenced by human driven processes (Kuhn, 1970; Röling, 1997; Leeuwis, 1999; Stephens and Hess, 1999) that are culturally and historically constructed (Agrawal, 1995). Individuals have human agency, which means that, through knowledge processes, they attempt to gain control of the changing environment around them and give it a meaning to which they can relate. Understanding knowledge involves analysing how meaning is transformed at the interface of the actor's life world (Long, 2001).

1.2. Aim and objectives

The drought perceptions of farmers in sub-Saharan East Africa are expected to differ from scientific conceptualizations thereof. The aim of this research was to bridge this gap between farmers and scientists, so as to improve the impact of interventions aimed at

improving agricultural productivity for an urgent, dramatic and popular theme: 'drought in Africa'. The research focussed on two study areas within Tanzania and Ethiopia. The specific objectives of this study were:

1. To better understand farmers' perceptions of drought;
2. To relate farmers' perceptions to various forms of agricultural drought;
3. To explore the strategies farmers use to deal with drought;
4. To recommend how to bridge the gap between farmers and scientists.

1.3. Key concepts used

The following concepts are used throughout this thesis and will therefore be briefly explained in this subsection.

Perception refers to a range of judgments, beliefs and attitudes (Taylor et al., 1988). An individual builds up an understanding of the environment that is closest to him and makes decisions about how to respond and behave therein based on this understanding, previous experiences and his memory (Park, 1999). Social, economic, political and cultural settings influence the way in which people perceive their environment and the way they react to it (Orlove, 1980).

Land degradation is the loss of the land's biological or economical productivity (UNCCD, 1994) and includes the degradation of soil, water, climate, flora and fauna. It is a permanent decline in the rate at which land yields products useful to local livelihoods (Scoones and Toulmin, 1999a) . Desertification, as defined in subsection 1.1.1., is a form of land degradation.

Many definitions of *drought* exist. Drought is a recurrent and normal feature of a climate, although its exact meaning is area and context-specific. Meteorological drought occurs when rainfall is below a long-term average. What is considered a drought year in a humid climate might be an extremely wet year in an arid area. In an agricultural context, drought is considered a natural hazard (UNCCD, 1994; Kassas, 1995) which causes temporal changes in agricultural productivity.

Holling (2001) developed the concept of complex dynamics to describe the evolving nature of complex *adaptive social–ecological systems*. Since humans are intertwined with ecosystems, resilience should be seen in the context of integrated systems of people and nature (Richards, 1985; Rockström, 2003b). *Resilience* is the property that allows a system to absorb and utilize change (Stocking and Murnaghan, 2000), namely a system's adaptive capacity (Holling, 2001). As well as ecosystem resilience, social resilience should also be taken into account. Social resilience is the ability of groups and individuals to respond to environmental and socio-economic constraints through adaptive strategies (Bradley and Grainger, 2004: 452). Whether physical changes can be resisted – and how – depends on the economic, social and cultural contexts in which changes take place (Agnew and Warren, 1996). *Sustainable development* of a social-ecological system is the capacity to create, test and maintain adaptive capacity and opportunities (Holling, 2001).

Vulnerability is defencelessness, insecurity and exposure to risk, shocks and stress and the difficulties of coping with them. The external aspect of vulnerability is the risks, shocks and stress to which individuals are subject, and the internal element is the lack of the means to cope therewith without damaging loss (Chambers, 1989).

1.4. The study sites

1.4.1. Goima area, Kondoa District, Tanzania

Over 70% of Tanzania's population is dependant on agriculture, mostly small-scale, rain-fed farming (Hella, 2002). About 80% of Tanzania is semi-arid (Quinn et al., 2003). For semi-arid central Tanzania, land degradation has long been considered to be the major problem that is limiting agricultural growth (Hella, 2002). Many environmental problems are blamed on inappropriate watershed management, the conversion of pastoral into arable land and on the land's declining fertility, all of which factors are exacerbated by a growing population and the growth of the areas under conservation (Quinn et al., 2003), such as the Kondoa Eroded Area (see Chapter 7).

Rainfall in semi-arid Tanzania is characterized by spatial, inter-annual and intra-seasonal variability. Rainfall tends to come in the form of heavy showers of short duration, which may have the effects of low infiltration, excessive run-off and hence, soil erosion (Hella, 2002).

The Tanzanian case study was undertaken in two villages in Goima Ward, Kondoa District. Goima and Mirambu villages (population 5750 people within 1163 households) lie at the foot of the Burunge Hills, at an altitude of between 1,300 and 1,400 m.a.s.l. The Goima area is situated in the northern part of semi-arid central Tanzania, 40 km south-east of Kondoa town (Figure 1.1). It is the home of the Burunge people. Immigrants from other parts of the District, particularly from the Rangi ethnic group, have also moved there.

The area is characterized by an undulating landscape of plains and scattered small hills. Soil types generally seem to follow the toposequence. The soils on the hill-slopes contain small stones, and are sandy further down the hill, while the soils in the valley bottoms are relatively rich in clay and organic matter. The upper parts of the hills consist of bare rocks and forests. An increasing section of the Burunge hills is being cleared for farming. The land on the plains, which is not cultivated, is covered with seasonal grasses, bushes and trees. Population density is about 34 people per square kilometre (Tanzania, 2003).

The Goima area has a uni-modal rainfall pattern; rain can be expected between November and May. Inter-seasonal and intra-seasonal rainfall variability is very high. The mean seasonal rainfall, measured at the nearest meteorological station at Kondoa town, is about 670 mm. Annual potential evapotranspiration in the area is about 1,700 mm (Östberg, 1995: 31). Rivers are ephemeral, and have high peak discharges during and shortly after rainfall events.

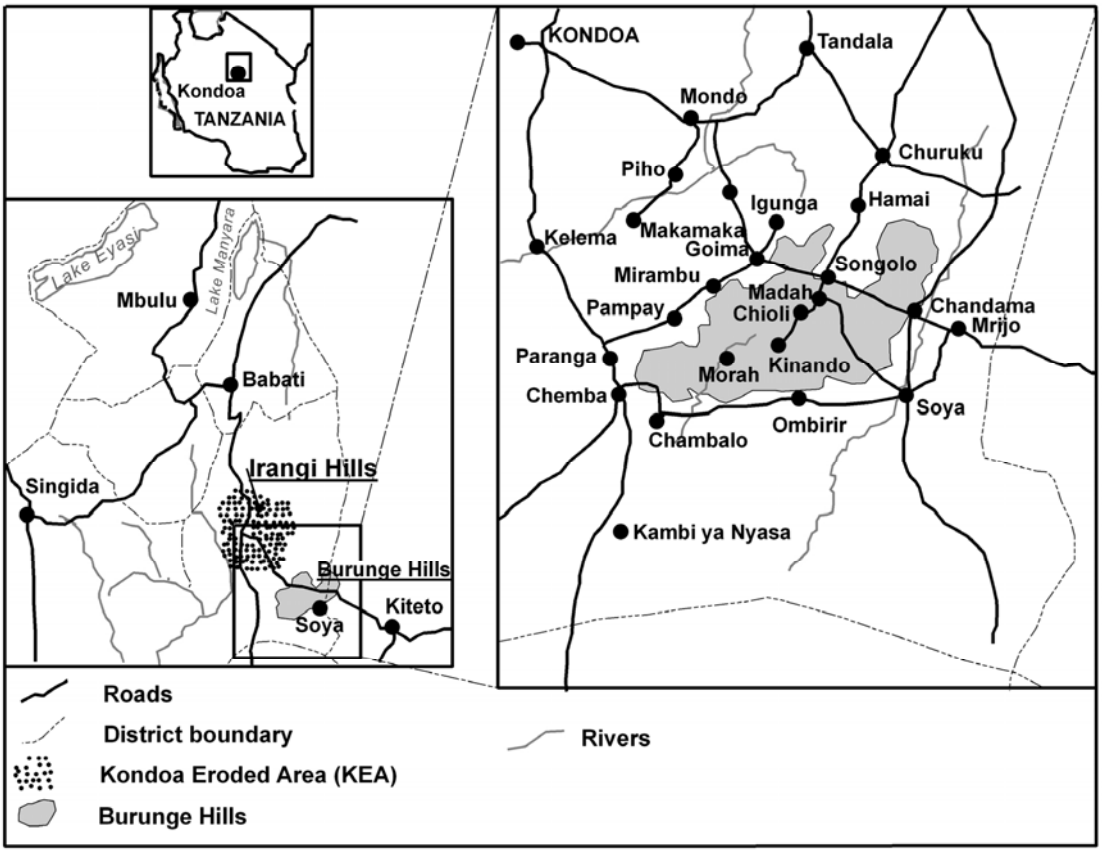


Figure 1.1. The location of Goima and Mirambu villages at the foot of the Burunge Hills in Kondoa District, Tanzania.

Farming in the Goima area is rain-fed. The local land users are small-scale farmers, most of whom rely on hand hoe cultivation. Animal traction and tractor cultivation are relatively new to the area and are relatively expensive techniques. Since rainfall is erratic, timely cultivation is crucial. Rotational bush fallow used to be practiced by the Burunge ethnic group farmers, but due to population growth this mode of farming has fallen out of practice.

1.4.2. Asfachew area, North Shoa Zone, Ethiopia

The Ethiopian highlands (above 1500 m.a.s.l.) constitute 43% of the country, and house 88% of its population (Shiferaw and Holden, 1999). Land degradation poses a serious problem for agricultural production and the food security of its inhabitants (Shiferaw and Holden, 2001; Amsalu et al., 2007), particularly since 85% of the population depends on agriculture (Mersha and Boken, 2005).

In the highland areas (Haileselassie et al., 2006), soil erosion has been estimated at 42 tons per hectare per year on cultivated land. Ethiopia has one of the highest rates of soil nutrient depletion in sub-Saharan Africa (Stoorvogel and Smaling, 1990). The reasons stated for this aggravating situation are population increase, decreasing landholding sizes, land

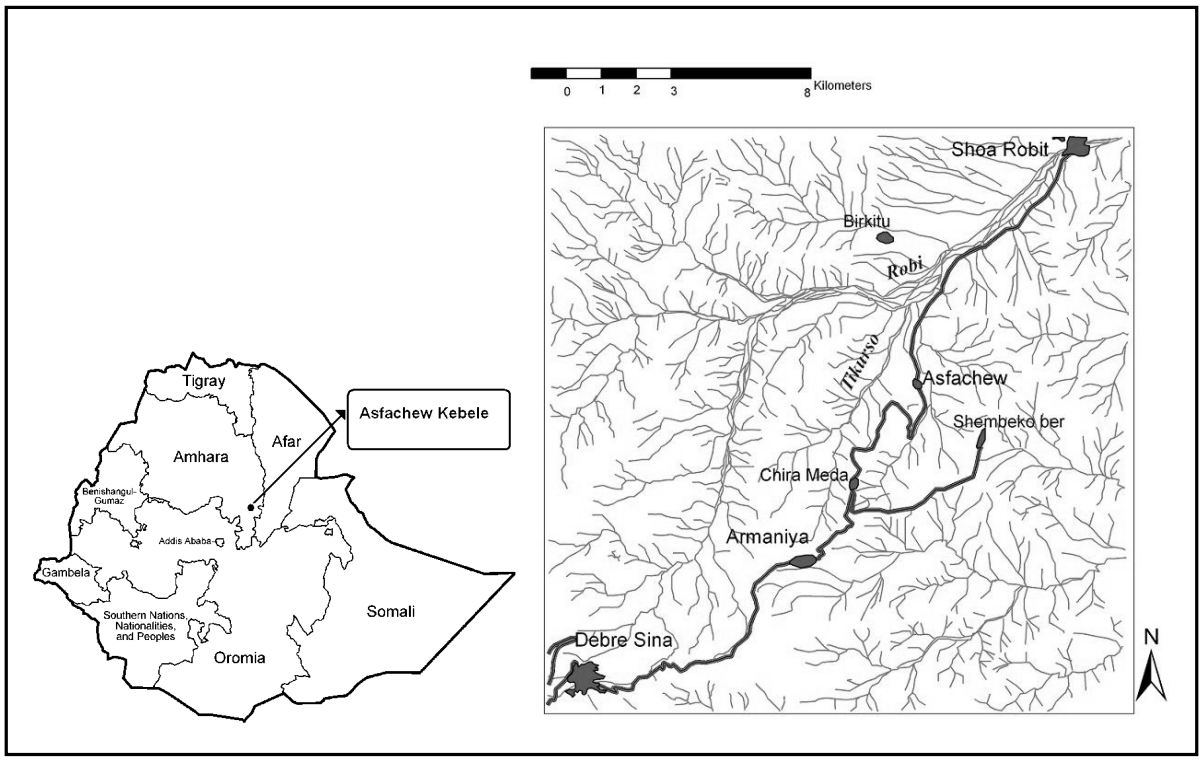


Figure 1.2. The location of Asfachew and Chira Meda villages, Ethiopia

tenure insecurity, increasing use of marginal land for agricultural purposes, deforestation, overgrazing and the limited use of appropriate conservation practices (Hawando, 1997; Shiferaw and Holden, 1999; Shiferaw and Holden, 2001; Alemayehu et al., 2006; Amsalu et al., 2007). Erratic rainfall patterns and recurrent droughts add to the food security problem (Hawando, 1997; Mersha and Boken, 2005).

The Ethiopian case study took place in two villages in Asfachew Kebele. Asfachew and Chira Meda villages (total population of about 825 people within 175 households) are situated in the North Shoa Zone, some 200 km north-east of Addis Ababa along the tarmac road which runs between the two small towns of Debre Sina and Shoa Robit (Figure 1.2). The average population density in Tarmaber Woreda, an administrative division between Zonal and Kebele level, is 185 people per square kilometre (CSA, 2006).

Chira Meda is located 15 km downhill from Debre Sina, at an altitude of 1850 m.a.s.l. The terrain is rugged. The village is constructed on a plateau, from where steep cliffs and ridges run down to different small terraces (Bekele-Tesemma, 1997). Asfachew is situated at an altitude of 1470 m.a.s.l., 5 km further down the road from Chira Meda. Asfachew has areas with moderately steep and gentle slopes, covered with colluvial depositions. The remaining land is relatively flat towards the floodplain of the braiding Tikurso River, where wide river beds are covered with deposited stones. The river has a high peak discharge both during and soon after rainfall events, and turns into small braided streams shortly after the rain stops.

The study area has a bi-modal rainfall pattern. The short rainy season, called the *belg* locally, commences at the end of January or in February and lasts for three months. The main rainy season, called *meher* locally, begins at the end of June or in July and also lasts for three months. *Meher* rains are generally more predictable, more intense and more frequent than those in the *belg* (Amsalu et al., 2007). The mean annual rainfall, measured at the meteorological stations of Debre Sina and Shoa Robit, is 1839 and 1003 mm respectively. Annual potential evapotranspiration in Shoa Robit is 1517 mm (Bekele-Tesemma, 1997). Nearly 95% of the annual crop production in Ethiopia is produced during the meher season (NMSA, 1996).

The farmers in the Asfachew area are involved in small-scale rain-fed farming. A small minority has access to rainwater harvesting pits or to small-scale irrigation. The land is tilled with ox-ploughs, except for on the steep slopes which exceed 60 degrees. Land holdings are small, being, on average, less than one hectare. No land is left fallow. Farmers who do not have the required draught animals and ploughs will rent out their land or make sharecropping arrangements with farmers who want to increase their acreage or who are landless.

1.5. Thesis outline

The next chapter will provide this study with a theoretical framework for the research carried out, and deals with issues of desertification and land degradation in the sub-Saharan context. It will describe how the concept of desertification came into being, how it has evolved and how it was re-popularized in the 1970s. Based on past and ongoing discussions and on greater insight into the inter-relationship between land degradation and drought, a framework is developed for the subsequent study of farmers' drought perceptions, and includes field indicators for the three agricultural types of drought.

Chapters 3 and 4 describe how farmers in Tanzania (Chapter 3) and Ethiopia (Chapter 4) perceive their area in terms of rainfall and drought. Chapter 3 firstly provides an outline of how to study perception and contains a framework of the elements shaping and influencing the formation thereof. This framework is then used to analyze the farmers' perceptions in both case study areas.

In Chapter 5, the rainy seasons are characterized using the long-term records of daily rainfall that represent both case study areas in Tanzania and Ethiopia. The data are analyzed for both seasonal and intra-seasonal rainfall distributions, probabilities of rainfall and dry spells, and for possible trends therein. These characteristics and possible changes are compared to the farmers' knowledge and perceptions.

Chapters 6 and 7 investigate the farmers' perceptions of drought in more detail, and focus on biophysical aspects and environmental change in the Tanzanian case study area. The sixth Chapter contains a comparison of farmers' perceptions of drought with moisture and nutrient availability to maize. The experimental set-up was based on the farmers' knowledge of how the different properties of a soil and their land management practices influence a crop's ability to resist dry conditions. Chapter 7 provides an environmental

background of the Tanzanian case study area and its surroundings, and relates the farmers' concerns about the rains to recent environmental changes in the area.

Chapter 8 discusses the strategies that the farmers in both Tanzania and Ethiopia utilize to deal with the unreliable rains. The farmers in each area are first categorized in terms of farm household types, according to their farming and livelihood strategies. Their views about their adaptive and coping strategies in dealing with the variability of the rains are investigated, as well as their opinions about the constraints that some of them have to overcome to successfully deal with this problem. Outcomes are integrated with the farm household types to assess social resilience levels according to the farmers' criteria.

Finally, Chapter 9 presents a synthesis of the research results contained in the previous chapters, and directs the focus to alternative drought actions, with the concentration being on sustainable land use and increased productivity in East Africa.

Figure 1.3. Goima area, Tanzania with the Burunge Hills at the background

Figure 1.4. Asfachew area, Ethiopia with in the front the rugged terrain of Chira Meda and at the background Asfachew.

Chapter 2

Beyond the desertification narrative: a framework for agricultural drought in semi-arid East Africa

Slegers, M.F.W. and Stroosnijder, L.
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2. Beyond the desertification narrative: a framework for agricultural drought in semi-arid East Africa

Abstract

In the twentieth century, much research was done on desertification. Desertification developed into a complex and vague construct, which connotes land degradation under specific conditions. Projects focusing on land degradation in semi-arid East Africa have met with limited success, as farmers prioritize drought as the major productivity-reducing problem. Yet studies on long-term rainfall trends have not confirmed that droughts are more frequent. In this article, we combine drought and land degradation effects into an Agricultural Drought Framework, which departs from the farmers' prioritization of drought and accommodates scientists' concern for land degradation. It includes meteorological drought, soil water drought, and soil nutrient drought. The framework increases insight into how different land degradation processes influence the vulnerability of land and farmers to drought. A focus on increased rainwater use efficiency will address both problems of land degradation and drought; thereby improving productivity and food security in semi-arid East Africa.

2.1. Introduction

In the last century, the concept of desertification, especially in relation to Africa's soils, was a much debated issue. It has proved difficult to conceptualize desertification, as it has been redefined many times. Different commissions have been set up, many conventions have been signed and long reports have been written to address the apparent problem of desertification. A great deal of research on natural resource management has focused on this phenomenon. Over the years, different insights have changed opinions on the exact causes of desertification. The evolution of the concept reflected developments in ecology.

The current and commonly accepted definition of desertification came out of the 1992 United Nations Conference of Environment and Development (UNCED). At the conference, desertification was defined as: "land degradation under arid, semi-arid and dry sub-humid climates resulting from various factors including climate variation and human activities" (UNCCD, 1994: art. 1). Land degradation is the loss of the land's biological or economic productivity (UNCCD, 1994). Even though desertification has been defined, two questions remain: to what extent is desertification human-induced? And to what extent is climate change responsible for desertification?

Scientists working on sustainable land use have identified human-induced land degradation as a major factor limiting sustainable production and food security in semi-arid East Africa. However, due to their scientifically biased top–down approaches and lack of consensus on major problems (Kiome and Stocking, 1995; Ringrose et al., 1996; Bekele-

Tesemma, 1997; Cartier and De Graaff, 1998; Tenge, 2005; Van den Bosch and Sterk, 2005) they have not been very successful in changing farmers' agricultural practices towards a more sustainable use of natural resources. Subsistence farmers in semi-arid East Africa have often been unwilling to apply soil and water conservation (SWC) measures to their land because they perceive drought as most important productivity-reducing problem (Östberg, 1995; Beshah, 2003; Biamah, 2005; Hella and Slegers, 2006; Stroosnijder, 2008).

Researchers have not looked deeper into how these farmers perceive drought. To overcome productivity problems in a sustainable way, it is important to reconcile the mismatch between the problems perceived by scientists and the problems perceived by the actual users of the environment. Population pressure in the semi-arid zones of East Africa is growing, while the productivity of the land is stable or even declining; food security and natural resource depletion are of increasing concern. We therefore argue that point of departure should be the productivity-reducing problem drought that farmers give most priority to when studying the possibilities to increase agricultural sustainability.

In this article, we put drought into a wide framework that includes land degradation effects into a concept we term "agricultural drought". It will increase insight into how different land degradation processes influence the vulnerability of farmers and their land to drought. The Agricultural Drought Framework (ADF) serves as a common ground for scientists and farmers from which the two major problems affecting productivity – drought and land degradation – can be dealt with in an integrated manner. It directs focus to more efficient use of rainwater for agriculture.

The first part of this article provides a literature review of the historical development of the concept of desertification according to discourses in natural resource management, and in line with changing insights into ecology. In the second part, we stress the need for an alternative scientific focus to approach the pressing problems of decreased productivity and food security in Africa. We propose the ADF, which integrates farmers' perceptions of their priority problem.

2.2. Desertification as human mismanagement of nature in equilibrium

The concept of desertification evolved in the 1920s and 1930s in colonial West Africa as a result of concerns about an expanding Sahara; supposedly due to the destruction of the Sahara's vegetation cover by nomads (Swift, 1996; Le Houérou, 2002). The work by Stebbing (1937) was particularly influential in the development of the desertification concept and of later discussions about this concept. Stebbing argued that the causes of desertification were indigenous land use, exacerbated by the growth of human and livestock populations. Erratic rainfall was considered as a result rather than a cause of desertification. Savannah vegetation was judged to be degraded forest. Stebbing's report was followed by a fieldwork by the Anglo-French Forestry Commission that studied this urgent problem (Aubréville, 1973). The commission refuted most of Stebbing's assertions and stated that desert borders were not moving southward. Rather, variability of annual rainfall was the

cause of temporary changes in vegetation cover. Notwithstanding these critical notes, the general notion of desertification continued to be based on ideas like Stebbing's.

Discussions about desertification were quite lively during periods of drought from the 1920s until the 1940s, all but vanished when weather conditions were wet during the 1950s and 1960s (Swift, 1996). Le Houérou (2002) argued that desertification was also visible in the 1950s and 1960s. The term "desertification" was popularized again at the 1977 United Nations Conference on Desertification (UNCOD) that was held after a decade of severe drought in Africa (Binns, 1997). At that conference, "desertification" was defined as: "A reduction of the land production potential in arid, semi-arid and dry sub-humid zones, that may ultimately lead to desert-like conditions"(Le Houérou, 1996: 134). It was generally agreed that the problem was caused by human population growth exceeding the carrying capacity and by inappropriate land use. Indicators and hazard estimators of desertification, which emphasized human-induced causes of desertification, were identified to assess and map desertification (Mabbutt, 1986; Le Houérou, 1996). Although some researchers were very skeptical about the identified causes of desertification, these remained generally accepted, strengthened by the UNCOD and a report by the UN Environmental Programme (UNEP, 1984).

These developments of the desertification concept kept pace with contemporary ideas that had developed from biological sciences, and which were based on the belief that nature was in balance. In the first half of the twentieth century, the biologist Ludwig von Bertalanffy had developed systems theory (1958; 1972). A system is a model of general nature and can be defined as: "a set of elements standing in interrelation among themselves and with the environment" (Von Bertalanffy, 1972: 417). A system can be seen as a black box with an input and an output and has the central notion of stability; disturbances are controlled through linear feedback processes.

Until the 1970s, most ecological studies had departed from the presumption of a nature in balance in which notions of stability and equilibrium played key roles (Leach and Mearns, 1996; Leach et al., 1999; Scoones, 1999; Baker, 2000; Mazzucato and Niemeijer, 2000). An ecosystem is a self-regulating system, maintaining itself through feedback processes. It shows resilience; it has the ability to return to its old situation after a disturbance, or to adapt to a new situation. When a disturbance is too severe, a system's adaptive capacity decreases to a level at which it is no longer able to cope with disturbances. The result is an ecological crisis. Examples of ecological crises are climate change and desertification.

Many studies on natural resource management have been derived from these concepts of ecology and systems theory. Leach and Mearns (1996) have summed up three prevailing ideas and theories that are based on the nature in balance paradigm, which have greatly influenced debates in ecological science about human–environmental interactions and which have shaped the desertification concept.

1. The "climax vegetation community" states that each climatic zone supports its own type of vegetation in the absence of disturbance. Clements, a highly influential

ecologist in the first decades of the twentieth century, wrote about plant succession and the development of climax vegetation (Clements, 1916). The equilibrium between climatic factors and vegetation within a natural environment is disturbed by human interaction;

2. The second idea presumes a causal link between reduced vegetation cover and decreased rainfall. This idea was already prominent among scientists in British and French colonial empires (e.g. Stebbing, 1937). A direct link was seen between deforestation and climate change. It resulted in the establishment of forest conservation areas in tropical colonial areas to protect these areas against climate change (Grove, 1994). This idea was verified in the eighteenth and nineteenth centuries. Arid tropical areas were considered as areas that used to be more densely vegetated and used to receive more rainfall. There was disagreement about the causes of this process of increased dryness. Some scientists saw it as a result of natural processes, while others saw it foremost as the result of human mismanagement (Grove, 1994);
3. The third theory has its foundations in the Malthusian line of thinking. In 1798, Malthus wrote his "essay on the principle of population", in which he explained his pessimistic view about the inevitable effect of an increase of population size beyond the environment's carrying capacity on food supply. He argued that there are limits to growth; the world is finite and can only support a finite population (Hardin, 1968; Meadows et al., 1972). Many scientists embraced his ideas. Human mismanagement and population growth disturb the natural equilibrium, causing processes like land degradation (Stebbing, 1937; Hardin, 1968; Mazzucato and Niemeijer, 2000).

In spite of some disagreement on the paradigm of balanced nature, for most of the twentieth century, the sciences on natural resource management remained dominated by this paradigm[1] (Scoones, 1999; Baker, 2000). Discourse on the equilibrium-based conceptualizations of environmental problems and the impact of human actions on the natural environment initiated a shift towards a more nuanced view on ecological crises. This discourse influenced further developments of the desertification concept.

2.3. Changing concepts of desertification

A danger of equilibrium thinking has been the tendency to see environmental change as a movement away from equilibrium or a stable state and thus as problematic (Table 2.1). Agnew and Warren (1996: 310) discussed the failure to distinguish between environmental change and environmental problem. Environmental change refers to any change in the physically observable facet of the environment, while environmental problem refers to environmental issues that affect people's livelihoods. The relation between these two concepts has been assumed more often than it has been demonstrated, due to the paucity of

[1] For a detailed historical review on the evolution of concepts of equilibrium and non-equilibrium in ecology, see Baker (2000) and Scoones (1999).

Table 2.1. Changing conceptualization of desertification and underlying discourses in ecological sciences and regarding natural resource management

Problem vs. change	Environmental change as a problem, as degradation	Environmental change not necessarily a problem, can be deliberate change
People—environment debate	Land degradation and desertification due to human actions	People suffer due to climate change and harsh climatic conditions
GEM vs. Populist discourse	People cause desertification External interventions necessary	Local land users use land sustainably, but are hindered by external actions
Malthusian vs. Boserupian thinking	Overpopulation and overgrazing exceeding carrying capacity cause land degradation	People have adaptive capacity to deal with population pressure in sustainable ways
Equilibrium vs. non-equilibrium paradigm	Movement away from equilibrium is disruption of system Human and natural systems can be seen as independent of each other	Environment is resilient and shows resistance to change Complex reality of social–ecological interaction
Desertification	Human mismanagement major contributor to desertification and reduced rainfall amounts	Climate variability as normal feature of arid and semi-arid climates. Desertification as form of land degradation, climate change as a contributor

data, confusing definitions, or temporal and spatial variability in environmental processes. The confusion of definitions has had a major role in the inability of institutions to address the actual problems. Stroosnijder (2007) refers to the need to distinguish between land degradation, which is an environmental problem, and land development, which concerns deliberate changes in land use.

Binns (1997) refers to the discussion around the environmental problems of Africa as the "people–environment debate". On one side, people adhere to the idea that the environment is the victim of people: human action is causing degradation and desertification. On the other side is the opinion that people are victim of the environment; they suffer under the effects of climate change or the harsh living conditions in arid and semi-arid environments. Similarly, Herrmann and Hutchinson (2005) refer to the Global Environmental Management (GEM) vs. the populist discourse. According to the GEM discourse, people cause desertification, of which they are at the same time the victims. Scientists, aid bureaucrats and national civil servants are depicted as heroes who provide solutions to environmental problems. In the populist discourse, global capitalism, transnational corporations and northern consumers are the "bad guys" whose actions have caused a marginalization of local farmers and pastoralists, while the local people are considered both as victims and heroes capable of sustainable management of their natural environment.

The effect of rural population growth on agricultural production and the natural environment of Africa has been another point of discussion. According to the Malthusian

line of thinking, the increased demand for food induces unsustainable intensification and extensification of agriculture (Stebbing, 1937; Hardin, 1968). At the other end of the discussion spectrum, there is the Boserupian line of thinking of adaptive intensification of agriculture (Boserup, 1975; Tiffen and Mortimore, 1994; Tiffen et al., 1994; Kandeh and Richards, 1996). This posits that local land users are capable of sustainable land use, even under increased population pressure. The well-known Machakos case study (Tiffen et al., 1994) showed how population growth increased the sustainability of agriculture through innovative and adaptive strategies.

Since the 1970s, ecologists have moved on from the notion of nature in balance. Past policies on natural resource management were based on two erroneous assumptions: that ecosystems have one static equilibrium (Botkin, 1990; Scoones, 1999; Baker, 2000; Mazzucato and Niemeijer, 2000), and that human systems are independent from natural systems (Folke et al., 2002; Walker et al., 2002). Currently, equilibrium is considered to be far from a practical reality (Baker, 2000). It takes different forms, constantly fluctuates around a mean, and is metastable in the sense that at certain threshold values the equilibrium goes up or down a level, to an alternative stable state (Rietkerk and Van de Koppel, 1997; Baker, 2000; Schröder et al., 2005). Ecosystems can be defined by two properties: resistance and resilience (Holling, 1973; Baker, 2000). Resistance is the ability of a system to return to a state of equilibrium after a disturbance. Resilience is a measure of a system's persistence: it is the ability to absorb changes, to learn and to develop (Holling, 1973; Stocking and Murnaghan, 2001; Folke et al., 2002). The equilibrium notion is believed to be at least a simplification of more complex realities (Rasmussen et al., 2001).

The assumption of independent human and natural systems has also been superseded by recent ecological insights. Traditional ecology saw biotic components as having great influence on the ecosystem, whereas abiotic components, such as climatic conditions, were relatively stable. Consequently, human activity was seen as having a highly destabilizing effect on a system. Recent ecological insights have revealed that the most important factors contributing to ecosystem change are variability of the abiotic components of a system, such as inter-seasonal and intra-seasonal fluctuations in rainfall. This is especially the case in arid and semi-arid tropical ecosystems, where there is a great natural variability in the physical environment (Pickup, 1996; Landres et al., 1999; Baker, 2000).

Holling (2001) developed the concept of complex dynamics to describe the evolving nature of complex adaptive social–ecological systems. Since humans are intertwined with ecosystems, resilience should be seen in the context of integrated systems of people and nature (Richards, 1985; Rockström, 2003b). Besides ecosystem resilience, social resilience should be taken into consideration as a factor limiting degradation. Social resilience is the ability of groups and individuals to respond to environmental and socio-economic constraints through adaptive strategies (Bradley and Grainger, 2004: 452). Whether physical changes can be resisted – and how – depends on the economic, social and cultural contexts in which changes take place (Agnew and Warren, 1996). Sustainable development of a social-ecological system is the capacity to create, test and maintain adaptive capacity and opportunities (Holling, 2001).

General assumptions made during colonial times about desertification, deforestation, soil erosion and rainfall decline (Stebbing, 1937; Stamp, 1940; Aubréville, 1949; Grove, 1994) continued to drive much of the environmental policies in Africa until the last decade of the twentieth century. According to some scientists these assumptions have been made on false grounds, or at least have been strongly overestimated (Leach and Mearns, 1996; Swift, 1996; Binns, 1997; Bradley, 1997; Scoones and Toulmin, 1999b; Mazzucato et al., 2001; Scoones, 2001; Mortimore and Harris, 2005; Henao and Baanante, 2006; Stroosnijder, 2007). They refer to the prevailing ideas about desertification as a narrative. In the next section we will show how the desertification concept and the desertification narrative have continued to evolve and will discuss the reactions they have provoked.

2.4. The development of the desertification narrative

We showed how the desertification concept came into being, how it has developed, and how it was re-popularized in the 1970s. Desertification was seen as a human-induced process, the most important causes of which were overgrazing, overcultivation and deforestation (Le Houérou, 1996). However, there has always been disagreement about the exact causes and severity of desertification. No consensus exists on the extent to which human factors are responsible for desertification (Falkenmark and Rockström, 2004) and what role climatic factors play in this. The apparent desertification trends in Africa have generated discourses among scientists, development agencies and political institutions, some of which see desertification as a human-induced process caused by mismanagement of fragile ecosystems, while others look upon it as a narrative. The last group perceives desertification as a natural process induced by climate variability, to which both people and their natural environment show resilience (Bradley and Grainger, 2004). Local people have developed adaptive strategies to deal with disturbances.

Swift (1996) has written extensively about the history of the desertification concept and about the desertification narrative that developed out of criticism of the conceptions of the problem. Swift describes desertification as “a set of ideas about the environment that emerge in a situation of scientific uncertainty and then prove persistent in the face of gradually accumulating evidence that they are not well-founded” (1996: 73). Claims made by means of these narratives continue to be propagated for political and economic ends (Mazzucato and Niemeijer, 2000). Some refer to the “institutionalization” of environmental issues (Agnew and Warren, 1996; Herrmann and Hutchinson, 2005). Natural resource management policies were based on outdated paradigms of environmental problems and their causes (Agnew and Warren, 1996). Swift is sceptical about the desertification narrative, not because the narrative is false per se, but because it has been politically very influential even though it has been based on disputed and poorly researched ideas.

Discussions about desertification arose during or shortly after drought periods when vegetation cover was reduced due to water shortage. The desertification narrative was conveniently used by national governments to claim that local land users were not capable of using the land in a sustainable way; pastoralists in particular were accused of being

unsustainable land users. Desertification was used by governments to try to change the resource management practices of local land users. It was not seen as a politically charged or controversial concept. Aid agencies used the desertification narrative as a justification for increasing the number of requests for aid (Swift, 1996). The narrative was also convenient for scientists; their idea of climax vegetation destroyed by overgrazing fitted perfectly into the picture of desertification (Swift, 1996).

Political and economic interests have influenced land degradation discussions (Grove, 1994; Scoones, 1996) through environmental and policy narratives that demonstrate the problem and its causes (Leach and Mearns, 1996; Swift, 1996). According to Swift, the misplaced attention on the desertification debate diverted the focus from effective approaches to control soil erosion and land degradation processes. The geographical extent of the desertification narrative went from studies at local scale, mainly from the West African Sahel zone, to higher levels and created generalizations of area-specific environmental phenomena. These generalized ideas about desertification have also been extrapolated to semi-arid East Africa. Macro-scale assessments of land degradation have offered powerful messages to policy makers, however, with the risk of oversimplification and generalizations that have led to conflicting reports of degradation processes at micro-level (Muchena et al., 2005). Conclusions can only be drawn after profound area-specific research that takes into account the area's current and historical ecological and social situation (Leach and Mearns, 1996; Mazzucato and Niemeijer, 2000; Scoones, 2001; Stroosnijder, 2007).

What seemed to be a value-free and political neutral concept in the 1970s, has become a highly politicized construct. The desertification narrative has generated good discussions and new insights into the area-specific causes and appearances of desertification. Since the 1990s, more accurate and useful methodologies have been developed that are participatory, concerned with the actual users of the natural resources, and based on the indigenous knowledge and institutions of local land users (Swift, 1996). At the 1992 United Nations Conference of Environment and Development (UNCED), diverging insights were combined into a redefinition of desertification. The new definition emphasizes that desertification is not only human-made but also related to such natural factors as climate variability and change. The International Year of Deserts and Desertification in 2006 renewed interest in the urgent problem of desertification. The need for action and increased awareness has been stressed; as much as one third of the Earth's surface and over one billion people are threatened by desertification (IYDD, 2006). There is, however, little consensus on the appropriate way to assess desertification locally (Véron et al., 2006; Stroosnijder, 2007).

2.5. The need for a local perspective focusing on drought

It has proved to be very difficult to lay the desertification narrative to rest because it would undo decades of research and international debates on environmental processes and interventions (Batterbury and Warren, 2001). Studies in West Africa had shown that vegetation cover had diminished, which was proof of desertification (Helldén, 1991).

Satellite images from the first half of the 1980s show an expanded Sahara desert, while later satellite images show a retreat of the desert. Critics of desertification argue that the environment is much more resilient than previously thought. It could be concluded that the notion of desertification is erroneous, or at least that it has been overestimated (Helldén, 1991).

Satellite images merely show vegetation borders and provide no information about biodiversity or the quality of the vegetation cover. There has been a gradual change in research towards the view of a complex landscape that is constantly changing rather than just degrading: a process which may always have been evident to local land users (Batterbury and Warren, 2001). A study by Hutchinson showed that a growing portion (up to 17 %) of variability in vegetation cover cannot be explained by erratic rainfall, but might be related to management practices (Hutchinson, 1996). He argues that degradation processes are spatially complex and are no definite proof for the truth of the desertification narrative (Hutchinson, 1996).

Koning and Smaling (2005) have collated the opposing views of agronomists[2], who generally adhere to the desertification narrative and of social scientists and ecologists[3], referred to as critical authors, who reject the idea of ecological equilibrium and adhere to a co-evolutionary vision of complex dynamics between ecological and social systems (Holling, 1995). The critical authors have made some valid claims that can be summed up as "soils evolve in a complex way, farmers play a key role, and attempts at improvements should be linked to their knowledge" (Koning and Smaling, 2005). However, on certain tough realities they have no option but to agree with the agronomists. One such reality is the nutrient depletion in parts of Africa that has been induced by processes of soil degradation, denitrification and leaching. Indeed, from many studies it appears that decreased soil fertility is a problem (e.g. Stoorvogel and Smaling, 1990; Nandwa and Bekunda, 1998; Somda et al., 2002; De Jager, 2005; Gachimbi et al., 2005).

However, one should be careful when making generalizations, as other studies have shown opposite trends (Mazzucato and Niemeijer, 2000; Mortimore and Harris, 2005; Muchena et al., 2005). Studies demonstrating the adaptive capacity of local land users towards environmental recovery cannot be generalized (Boyd and Slaymaker, 2000). The Machakos case study has been criticized for its lack of historical insight and the use of selective information (Boyd and Slaymaker, 2000; Siedenburg, 2006).

Notwithstanding the fact that desertification cannot be put aside as a narrative, there are some observations to be made regarding the concept. Firstly, desertification has a wrong connotation for many people: an image of extending sand dunes of the Sahara desert devouring villages and fields. However, this is not the reality in many semi-arid areas of East Africa that are said to be suffering from desertification. Secondly, over the years, interpretations in terms of causes and effects of desertification have changed and ultimately, desertification has developed into a very broad and vague concept whose causal factors form

[2] Authors like Breman, Ehrlich, Meadows, and Stoorvogel.

[3] Authors like Holling, Gunderson, Mazzucato, Niemeijer, Fairhead, Leach, Scoones, Tiffen, Anderson.

a complex net of interactions among physical, biological, political, social and economic factors (UNCCD, 1994). It has become an almost incomprehensive and unmanageable concept to use in practice. Studies addressing desertification require an area-specific approach that does not try to grasp the entire complex concept. For these reasons, we prefer to use the term “land degradation” and we argue that there is a need for an alternative scientific focus to approach the pressing problems of decreased productivity and food security that is more neutral, simpler and that accommodates local perceptions.

In the past twenty years, more attention has been paid to stressing the distinction and interrelatedness between drought and desertification (Kassas, 1995; Le Houérou, 1996; Le Houérou, 2002). Desertification is considered as a degradation process of land resources that reduces productivity (Kassas, 1995; Hutchinson, 1996; Swift, 1996) in certain climatic zones. Drought is a recurrent and normal feature of a climate, a natural hazard (UNCCD, 1994; Kassas, 1995) that causes temporal changes in productivity. Temporal changes may easily be confused with long-term degradation (Helldén, 1991; Ringrose et al., 1996), especially during a succession of dry years.

Drought seems to occupy the middle ground in the discussion about land degradation. Development actions in semi-arid East Africa focusing on land degradation have met with limited success as local land users do not prioritize land degradation as major problem. These land users often perceive drought as their limiting factor for reaching higher production levels. Though climate variability cannot be influenced easily and directly, it would be possible to reduce the vulnerability of people and their environment to the effects of drought. In the next section we will show different drought concepts, which have been developed in the past, that can help reconcile the paradigms of scientists, development agencies, political institutions and the actual land users, thereby creating common ground for sustainable agriculture in semi-arid East Africa.

2.6. The Agricultural Drought Framework

Studies on long-term rainfall trends for semi-arid East Africa give no undisputable proof of abnormalities and thus have not confirmed farmers’ beliefs that drought has become more frequent (Nicholson, 2001; Conway et al., 2004; Seleshi and Zanke, 2004; Seleshi and Camberlin, 2006; Stroosnijder, 2008). However, the causes of drought can be more complex than a rainfall deficit (Rockström, 2003b). It is not only an absolute rainfall deficit that causes drought. A relative water shortage as a result of an unfavourable rainfall distribution or land degradation processes can also cause drought-like conditions to occur. These processes influence the efficiency of the rainfall. Farmers rarely link these processes directly to land degradation and may perceive them as drought (Stocking and Murnaghan, 2001).

In an article on the role of drought in range management, Thurrow and Taylor (1999) state that users of degraded rangelands have often claimed that droughts have become more frequent and severe, while the long-term trend of temporal and spatial precipitation has shown no change. Less productive years were identified by farmers as drought years. In cases where there was no evidence of meteorological drought, Thurrow and Taylor refer to

this “drought paradox” as some form of agricultural drought and attribute it to degradation of vegetation and to processes of soil erosion and soil crusting. Others draw similar conclusions (Rietkerk and Van de Koppel, 1997; Stocking and Murnaghan, 2001; Stroosnijder, 2008). Rietkerk (1998) claims that soil water and nutrient availability diminish through soil degradation processes. These processes increase the vulnerability of a soil to drought (Figure 2.1), and they reduce the capacity of an agro-ecosystem to absorb environmental shocks (Rockström, 2003b). Environmental conditions like soil water and nutrient availability, and vegetation cover not only show temporal variability, but also micro-scale spatial variability (Rietkerk et al., 2004; Dekker et al., 2007), which may explain why farmers do not experience similar drought conditions at a certain moment and within a small area.

Because drought affects many social and economic sectors, scientists in a wide range of disciplines have conceptualized it different ways (Vogt and Somma, 2000). Conventional notions of drought focus on biophysical phenomena identified by scientists. These completely bypass the way local land users perceive their physical environment (Stroosnijder, 2008). How drought impact on people’s lives depends on their personal

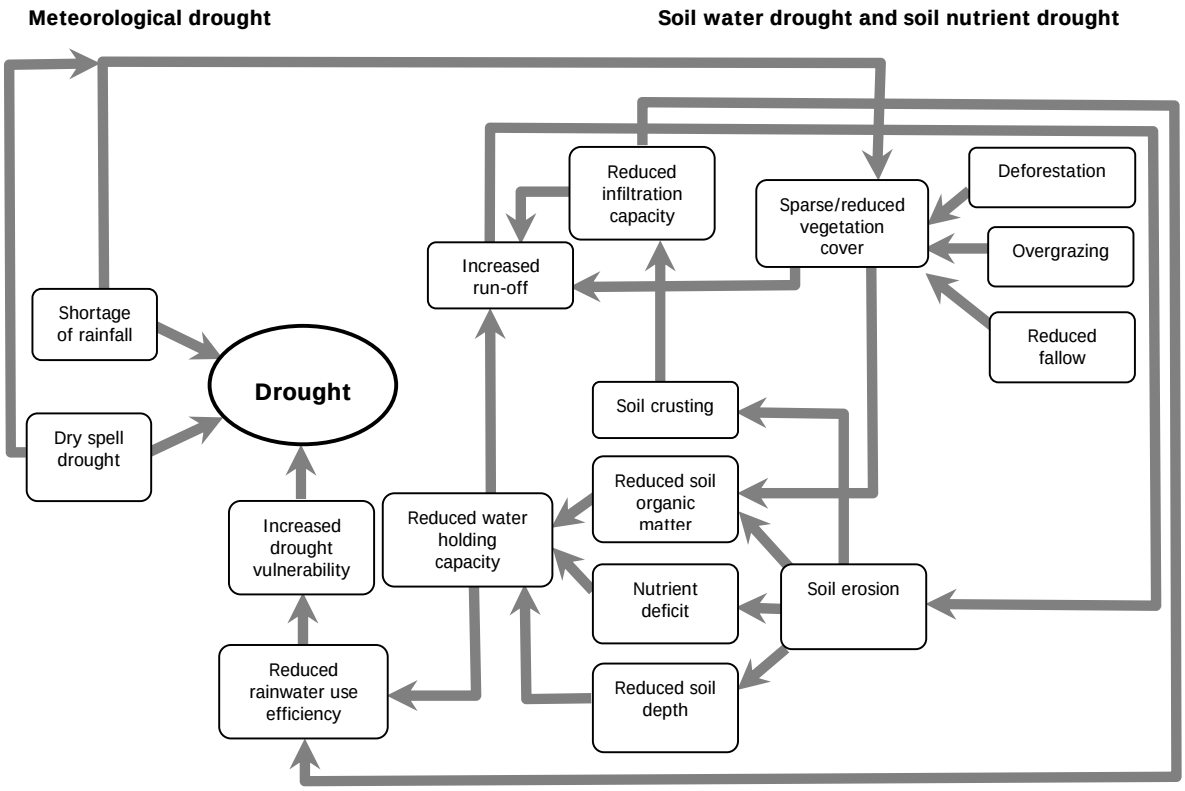

Figure 2.1. Causes of agricultural drought; meteorological drought is directly linked to drought, while soil water drought and soil nutrient drought causes drought indirectly by increasing vulnerability to drought.

situation. Thus, drought cannot be viewed solely as a physical event; the social impacts should also be taken into consideration, as judgments about a drought's severity and impacts are culturally defined (McMahon and Finlayson, 2003).

Fieldwork in West African Burkina Faso has revealed that farmers have different perceptions of drought compared with scientists working in natural resource management institutions (Slegers et al., 2005). The scientists considered drought within a narrow meteorological framework: a rainfall deficit compared to an average expected amount. However, farmers had a broader perception of drought that included land degradation processes (Slegers et al., 2005). Stroosnijder (2008) distinguishes three drought components based on insights into the inter-relation between drought, land degradation and biological productivity from the perspective of farmers. These drought components are: dry spell drought, soil water drought and soil nutrient drought. Each of these drought components will be explained below, as part of an ADF (Table 2.2).

The ADF focuses on a broad concept of drought that accommodates both scientists' and farmers' concerns. Within this framework, "agricultural drought" refers to drought-like plant stress that depresses crop growth, crop development and crop production; and which is caused by shortage of water in the crop's root zone, shortage of nutrient availability for the crop, or both. "Dry spell drought" is part of what is called "meteorological drought". The ADF contains indicators for each of the three drought types, and factors that influence agricultural drought vulnerability (Table 2.2).

Table 2.2. Agricultural Drought Framework containing three types of drought, their indicators, and general factors that influence vulnerability to drought.

	Definition	**Drought indicators**	**Influences on drought vulnerability**
Meteorological drought	A situation in which agricultural production is limited due to below-average seasonal rainfall amounts or due to unfavourable intra-seasonal rainfall distribution.	- Annual rainfall - Intra-seasonal rainfall distribution	*Natural soil properties* *Location of land:* - In toposequence - Slope *Other weather conditions:* - Sunshine - Wind *Land management practices:* - Cultivation technique - Timing - Crop type - Crop variety - Fertilizer/manure - Crop residues - Fallow - SWC
Soil water drought	Root-zone reserves are insufficient to sustain crops and pasture between rainfalls in spite of sufficient rainfall	- Infiltration capacity - Water-holding capacity - Soil organic matter - Water use efficiency	
Soil nutrient drought	Nutrient availability for the plant limits crop growth, crop development and crop production in spite of available water	- Nutrient content - Soil organic matter	

2.6.1. Meteorological drought

The word "drought" is most commonly used to refer to meteorological drought. Efforts have been made to design a universal definition of meteorological drought that would fit all localities and situations. These definitions reflect climatic abnormalities and are based on a deficit of rainfall from a long-term average. The hazard posed by meteorological drought depends on the rain's timing in the season together with other climatic factors, such as temperature and wind (NDMC, 2006). However, perceptions of the meaning of meteorological drought vary significantly. Extended research on meteorological drought and drought mitigation in Europe has shown that it is impossible to make one single definition of meteorological drought because any approach to define it reflects regional and ideological differences (Vogt and Somma, 2000; Lloyd-Hughes, 2002). What would be considered as meteorological drought in a humid area may be considered as a wet year in a semi-arid area.

Semi-arid areas of Africa have great rainfall variability between and within years and have a high atmospheric water demand (Barron, 2004). Within the ADF, meteorological drought is conceptualized as a situation in which agricultural production is limited due to below-average seasonal rainfall amounts or due to unfavourable intra-seasonal rainfall distribution.

Indicators of meteorological drought are total seasonal rainfall and intra-seasonal rainfall distribution. Within a year, the total amount of rainfall may be normal, yet extended dry spells within the rainy season may cause total or partial crop failure (Barron, 2004). This type of meteorological drought can be termed "dry spell drought" (Stroosnijder, 2008).The timing of dry spells within a crop season is crucial for later crop development or even for crop survival. In the initial stage of a plant's emergence and in the stages of crop development, a plant is especially vulnerable to dry conditions.

2.6.2. Soil water drought

Rainfall deficit and unfavourable rainfall distribution are not the only causes of agricultural drought. Soil water drought occurs when there is a deficit of soil water in the root-zone for sustaining crops and pasture in between rainfall events (Lloyd-Hughes, 2002) whereas rainfall has been sufficiently available. Various land degradation processes negatively influence soil physical properties (Stroosnijder, 2008) and ultimately decrease a soil's water infiltration capacity and water-holding capacity (Figure 2.1). This reduces rainwater use efficiency and increases a soil's vulnerability to soil water drought.

Soils in semi-arid African ecosystems are susceptible to soil water drought. Naturally, the vegetation cover is not very dense. As a result of low biomass availability, soils are low in soil organic matter. Soil organic matter enhances a soil's capacity to store water. Rain showers in this climate zone have a high intensity and are highly erosive; land with a sparse vegetation cover, or fields with crops in an initial development stage are especially vulnerable to soil erosion. Little rain water is trapped by the sparse vegetation or juvenile crop. The lesser water will infiltrate into the soil, the more water will run off, and the higher

vulnerability to soil degradation will be (Van de Graaf and Breman, 1993). Soil depth decreases as a result of soil erosion, which will reduce the soil's water-holding capacity. Another effect of soil erosion can be surface sealing, which reduces infiltration capacity of a soil. Mainguet refers to this reduced infiltration capacity as "edaphic" drought (Mainguet, 1999).

2.6.3. Soil nutrient drought

Soil nutrient drought occurs when nutrient availability for the plant limits plant growth, crop development and crop production more than water availability (Stroosnijder, 2008). Crops require nutrients, and a deficient nutrient uptake by a plant causes soil nutrient drought. Nutrients are made available for crops through processes such as mineralization of organic matter and weathering of minerals (Janssen et al., 1990). Nutrients are taken up by the roots of a plant through soil water. Soil water releases nutrients from a soil and transports these to plant roots. Soil nutrient drought occurs even though sufficient water is available to meet crop needs. Not the entire stock of a nutrient available in a soil can be taken up by a plant. Total uptake of one nutrient available for a plant depends on the availability of other nutrients in a soil. This is according to Liebig's law of the minimum. This law states that plant growth is limited by the nutrient most scarcely available according to the plant's needs (Janssen et al., 1990; Knecht and Göransson, 2004). When the potential supply of a nutrient is the limiting factor for crop growth, the whole stock of that nutrient available for the plant will be taken up. The actual uptake of other nutrients will be below their potential supply (Janssen et al., 1990); their uptake is limited by the most scarce nutrient. When more nutrients are taken up by a plant than are returned to a soil, nutrient stocks of a soil will gradually deplete, increasing the vulnerability to soil nutrient drought (Van de Graaf and Breman, 1993).

2.6.4. Agricultural drought vulnerability

The drought vulnerability of land and its users increases when any of the three types of agricultural drought occur. Whether drought occurs – and if so, which drought type – depends on the most limiting of all resources that plants need for their growth and development. Each drought type has its specific factors that influence drought vulnerability. Different drought types can occur concomitantly within an area and successively in time. It is difficult to look at each of the three drought types in the framework as isolated processes. Drought types are linked in causal factors and effects, and as such influence each other. Therefore, it is important to consider agricultural drought as a whole when studying drought vulnerability. There are general factors that influence all three drought types and thereby agricultural drought vulnerability (Table 2.2). These general factors can be divided into four categories.

First, every soil type has its intrinsic properties that influence water infiltration and water-holding capacity. Clay soils have a low infiltration capacity, especially when the soil

is dry, but their water-holding capacity is high. Sandy soils, on the other hand, have high water infiltration and low water-holding capacities.

Second, the slope of the land and the location within a toposequence influence soil moisture content. Sloping land has more run-off than flat land. The location in a toposequence influences the soil properties and water availability as well. Run-off water contains soil particles and nutrients from uphill. These soil particles and nutrients are deposited on bottom land; as a result of this sedimentation, the bottom soils are deep and fertile compared to soils higher up in the toposequence.

Third, other weather conditions play a role in drought vulnerability besides a season's total rainfall amount and its intra-seasonal distribution. Soil water evaporates faster in a hot and sunny dry period than in a cool and cloudy dry period. Evaporation also increases with wind speed.

Fourth, a soil's drought vulnerability is influenced by land management practices because land management influences water use efficiency (Stroosnijder, 2008). Deeper cultivation allows water to infiltrate more easily, but at the same time has the risk of reducing soil fertility when less fertile subsoil is mixed with more fertile topsoil. The timing of agricultural practices is crucial in an area where rain may come in only a few concentrated rain showers.

A crop's water and nutrient requirements differ for each development stage, as does a crop's drought vulnerability. The latter is dependent not only on the crop's development stage; it is also dependent on crop type and crop variety.

Each crop has its own soil fertility requirements. Soil fertility management is an important influence on drought vulnerability. The use of fallow, manure, compost and crop residues will increase the soil organic matter content and will diminish drought vulnerability. However, it should be taken into account that the availability of these resources is limited in semi-arid East Africa. It was shown that land around the homestead and land used by rich farmers has a higher fertility status (Zingore et al., 2007).

The use of conservation technologies such as SWC measures (Stroosnijder, 2008), rainwater harvesting (Hatibu and Mahoo, 1999) and conservation agriculture techniques (Knowler and Bradshaw, 2007) helps in several ways when these are carefully selected according to local conditions and use of the land. It stimulates the infiltration of water into the soil, thereby reducing run-off. When using a combination of SWC measures and other practices that stimulate land cover, water holding and water infiltration capacities, the run-off water will be better manageable. This will improve the efficacy of SWC structures during intensive showers. With less erosion, fewer nutrients will be removed by run-off. Some conservation techniques increase biomass and will have a positive influence on soil organic matter content, while others reduce evaporation by increasing soil cover (Knowler and Bradshaw, 2007; Stroosnijder, 2008).

2.7. How to reduce agricultural drought vulnerability?

The objective to reduce agricultural drought vulnerability is a challenging one. In semi-arid East Africa soils are generally poor; rainfall is erratic and when it falls, it often comes in highly erosive showers. Even within an area of uniform rainfall distribution, soil moisture and nutrient contents vary due to a variety of factors, as explained above. A complex of relations between soil, water and plants influences agricultural drought vulnerability. There is no straightforward way to assess agricultural drought vulnerability. It not only depends on biophysical factors such as climate conditions and soil properties, but also on management factors such as the land use, the management practices of local land users and their strategies to cope with drought. The farmers who live in this region have a limited availability of resources. Efforts to reduce agricultural drought vulnerability should therefore be area-specific and take into account local perceptions and management practices.

Efforts that strive for more efficient use of rainwater most likely target agricultural drought. Studies in the south of the Sahel show that of every 100 mm of rainfall, only 10 to 30 % is actually used by vegetation (Stroosnijder and Koné, 1982; Falkenmark and Rockström, 2004), while 30 to 50 % of the infiltrated water will finally evaporate and 10 to 30 % will disappear through underground flow. Another 10 to 25 % of the rainfall will run off immediately (Falkenmark and Rockström, 2004). A useful approach developed within the discipline of eco-hydrology focuses on this partitioning of rainfall. This approach divides rainfall into productive and unproductive, and into green and blue rainwater (Falkenmark and Rockström, 2004). The portion of the rainfall that infiltrates into the root-zone, green water, will partially be used by crops and vegetation; it is termed productive green water. The remaining portion of green water will evaporate, and is unproductive at that moment. The portion of the rainfall which disappears through overland and underground flow, blue water, does not contribute to production in that area, and therefore is unproductive at this scale.

More efficient use of rainwater can be achieved by reducing biophysical deficiencies that cause agricultural drought (Rockström, 2003a). The most obvious and commonly known way to reduce rainfall deficiencies is to optimize blue water use through rainwater harvesting and supplemental irrigation (Rockström, 2003a). This reduces the vulnerability to dry spell drought (Barron et al., 2003). However, more can be gained by using an integrated approach that targets the productive use of both blue and green water. This can be achieved by improving soil water and soil nutrient properties. Rockström (2003a) showed that an integrated water and land management approach that improves rainwater availability, techniques and timing of cultivation practices and soil nutrient management practices has a positive effect on yield and water productivity. When a bigger portion of the rainfall is eventually used as productive green water – a practice called “more crop per drop”– vulnerability to agricultural drought as a whole will decrease. It will be a good alternative for classical SWC programs because the starting point can be farmers’ priority problem drought, while taking into account land degradation concerns.

2.8. Conclusion: towards a common ground

Desertification has developed into a politicized concept, and has become a very broad, complex, and vague construct. The severity of desertification and land degradation has not always been correctly assessed, which has led to overestimation of these processes that cause environmental stress. Initiatives to determine which areas in the world are threatened by desertification and to assess causes and severity of desertification have not been very successful because different processes take place at local scale: each environment shows a different level of resilience to environmental stress, while local land users have adopted different adaptive management strategies to cope with environmental stress.

Over time, programs dealing with land degradation and desertification have become more localized and participative, which is a good step forward. However, programs still depart from the productivity-reducing problems identified and perceived by scientists, even though local land users in semi-arid East Africa identify another priority problem: drought. This difference in the perception of the problem limits the success of scientists working on problems of land degradation and desertification. A new approach is needed, that takes as its starting point the farmers' priority problem of drought. It can be the missing link towards more sustainable and productive agriculture.

It is impossible to influence the amount and timing of rainfall. Therefore, more efficient use of the available rainwater, more "crop per drop", is desirable. More efficient use of rainwater will reduce drought vulnerability. It can be achieved by optimizing the use of rainwater that infiltrates in the root-zone and of water that otherwise disappears through overland and underground flow, thus by reducing a soil's vulnerability to agricultural drought.

In this article, we have presented a framework on agricultural drought (ADF) containing three drought types – meteorological drought, soil water drought, and soil nutrient drought – and that concentrates on drought vulnerability. This framework focuses on how agricultural drought influences drought vulnerability, and how types of agricultural drought relate to land degradation processes. The ADF directs focus to rainwater use efficiency and offers an alternative approach to the classic SWC programs undertaken to increase the sustainability of land and water management practices. It takes into account farmers' priority problem drought and scientists' concern for land degradation.

The development of the ADF was only the first step towards an approach that focuses on farmers' priority problem of drought. It should be remembered that the framework approaches drought scientifically. The next – crucial – step is to study farmers' perceptions of drought and drought vulnerability, to answer the question of what farmers really mean when they complain about drought; and to translate these into the scientific drought types within the ADF.

Figure 2.2. A farmer posing in front of his garden with rainwater harvesting pit in Asfachew, Ethiopia.

Chapter 3

“If only it would rain”: Farmers’ perceptions of rainfall and drought in semi-arid central Tanzania

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3. "If only it would rain": Farmers' perceptions of rainfall and drought in semi-arid central Tanzania

Abstract

Farmers in semi-arid East Africa prioritize drought as their major productivity-reducing problem, while scientists identify soil degradation as a major threat. The question that needs to be addressed is how farmers perceive drought. Insight into farmers' perceptions of drought could be the missing link towards increased and sustainable production. During the period from 2004 to 2006, a study was conducted in Goima Ward, Tanzania. The study included questionnaires with mainly open-ended questions (N=120), in-depth interviews, group discussions, field visits, picture assignment and one-day seminar with farmers, extension workers, government officials, and scientists. Farmers saw drought in a broader perspective than that of deficient rainfall. Drought indicators were area-specific. Farmers recognized differences in drought vulnerability between soil types, location and state of land, land management practices and farmer types. Drought risk was perceived to have increased. Farmers' perceptions can be related to the scientific concept of agricultural drought. Since the amount of rainfall cannot be influenced, the efficiency of the rains can be a focal point for addressing farmers' concerns about drought. Any viable strategy to reduce farmers' vulnerability to drought and to improve productivity should be integrated into farmers' existing strategies to adapt to and cope with ecological insecurity.

3.1. Introduction

During recent research on sustainable land use in semi-arid East Africa, scientists identified human-induced land degradation as a major factor limiting productivity, while farmers ascribed declining harvests to drought (Östberg, 1995; Beshah, 2003; Biamah, 2005; Slegers, 2006; Slegers and Stroosnijder, 2008; Stroosnijder, 2008).

Lack of consensus on major problems as well as scientifically biased top-down approaches have limited the successful transition towards more sustainable use of natural resources (Slegers and Stroosnijder, 2008).

Slegers and Stroosnijder (2008) have presented a historical overview of how natural resource degradation has been approached scientifically by an in-depth discussion on the development of the desertification concept, its subsequent reactions and the development of the 'desertification narrative'. Generalized ideas about area-specific phenomena were extrapolated to other areas such as semi-arid East Africa. It remains unclear and debatable to what extent desertification has human-induced causes and what role climate variability plays.

Binns (1997) refers to the discussion around environmental problems of Africa as the 'people–environment debate' in which on the one side human action is considered as

causing degradation and on the other side people are considered as victims of the environment. Recent ecological insights show that natural and human systems are intertwined rather than independent and should be considered as complex adaptive social-ecological systems (Holling, 2001).

Different processes take place at local scale: each environment shows a different level of resilience to environmental stress, while local land users have different adaptive management strategies to cope with environmental stress. Slegers and Stroosnijder argue: “the need for an alternative scientific focus to approach the pressing problems of decreased productivity and food security that is more neutral, simpler and that accommodates local perceptions”.

In spite of debated issues, the reality is that soil degradation processes such as nutrient depletion are taking place in parts of semi-arid East Africa. Agricultural land degradation can be expected to depress world food production by 30% in the next 25 to 50 years (Pimentel, 2006). In sub-Saharan Africa, average food production per capita has declined over the past 40 years (Love et al., 2006). Currently, a third of the fast-growing population is food insecure (FAO, 2006). These figures, even though they may well be overestimated, do indicate the need for action.

Over time, programs dealing with land degradation have become more localized and participative, which is a good step forward. However, programs still depart from the productivity-reducing problems identified and perceived by scientists. Very little is known about how subsistence farmers in semi-arid East Africa perceive drought. Do they refer to meteorological drought, the context in which this word is commonly used, or to something else?

This article deals with how farmers in a semi-arid area in Tanzania perceive drought. The case study analysis is based on a theoretical model of elements shaping and influencing drought perception, drought risk perception and subsequent behaviour.

3.2. Methodology

A case study approach was applied in this research. The field study was carried out in Tanzania and in Ethiopia. This article will only cover the work done in the first country; however, reference to the Ethiopia case will be made occasionally. The study in Tanzania covered two villages in Kondoa District: Goima and Mirambu, which are situated along the Western foot slopes of the Burunge Hills. Both villages will subsequently be referred to as Goima, which is also the name of the ward in which these villages are situated. Goima was selected for study because a previous study had found that farmers related reduced production to erratic rainfall rather than to soil erosion or reduced soil fertility, which were not considered as serious problems (Östberg, 1995).

The research took place in the period from November 2004 to September 2006, and was conducted in two phases. The first, an exploratory phase of three months, was used to get acquainted with the area and its farmers, and to make contact with other stakeholders in the study areas.

Table 3.1. Population statistics of Goima and Mirambu and information about survey sample.

	Goima	**Mirambu**	**Total**	
Population size (people)	3880	1870	5750	
Survey Sample Size	80	40	120	
Average household size			4.9	
	Burunge		**Rangi**	
Ethnic group HHH[a] (%)	75		25	
	Male Burunge	**Female Burunge**	**Male Rangi**	**Female Rangi**
Sex and ethnicity HHH (%)	58	18	20	4
Religion (%) Muslim	16	14	100	100
Christian	77	81	0	0
Animist	7	5	0	0
	100	100	100	100

[a] Head of household

A baseline questionnaire (N=120) with mainly open-ended questions was used to get general information about the area and its population (Table 3.1); their land, livelihoods, assets, farming practices, and problems perceived. The sampled households were selected using a stratified random sample from local officials' lists. Only the household heads were interviewed. Farmers' answers served as guidelines for further discussions in the second phase of the study.

The second phase took place during the 2005-2006 cropping season. This second phase was used to follow farmers' activities during a six-month period, from sowing to harvest, to discuss issues regarding agricultural practices, their land, weather conditions and drought perceptions and other related issues that came up in the course of the study.

Information was gained through informal talks; field visits; in-depth interviews; a picture assignment, in which farmers described images; and a series of group discussions. The field study in Goima finished with a multi-stakeholder seminar with farmers, village extension workers, local-level agricultural government staff, and scientists (Hella and Slegers, 2006). The case study in this article is based on the knowledge and insights gained through all these methods.

3.3. Theory of drought perception

3.3.1. Elements shaping drought perception

Taylor et al. (1988) have specifically depicted how four coherent elements shape drought perception (Figure 3.1). Experience is an important factor influencing an individual's perception of drought. Previous drought experiences shape an individual's memory and are an important influence on how someone defines drought. What one remembers as a drought depends on how an individual defines it; while on the other hand, what an individual defines as drought depends on the droughts one remembers. The way drought is defined and the way

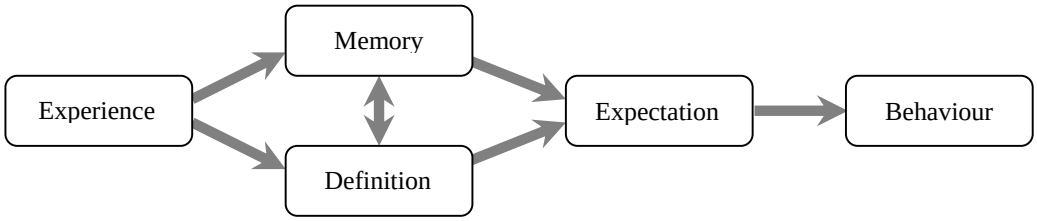

Figure 3.1. Elements shaping the perception of drought (Taylor et al., 1988).

past droughts are remembered, influence an individual's expectation of future droughts and one's behaviour. Behaviour can both be re-active and pro-active.

Perception refers to a range of judgments, beliefs and attitudes (Taylor et al., 1988), from which it can be inferred that perception is neither universal nor static, but rather a value-laden, dynamic concept. What an individual identifies as a drought depends on his environment and its characteristics (Heathcote, 1969).

3.3.2. The perceptual environment

To understand local perceptions of environmental problems, it is important to link human behaviour to the environment (Orlove, 1980; Agnew and Warren, 1996). Human beings observe the world around them and act according to what they see. Sonnenfeld (1972) has classified the physical environment, which he termed human environment, into four nested levels based on the significance they have for humans (left side of Figure 3.3). Burgers et al. (2000) have applied these four levels of the human environment to describe farmers' situations, not only in terms of their physical environment, but also in terms of their social and political environment.

The first and broadest level, the geographical environment, is the same for all human beings, but has no meaning to them. It can be considered as the universe external to the farmer, of which he is unaware such as relief and climate. The second level is the operational environment, in which an individual operates. It includes the natural characteristics of a farmer's area, and his social and political environment (Burgers et al., 2000). Both the geographical and the operational environment are objective environments: they have objectively measurable or quantifiable elements (Sonnenfeld, 1972).

The third level is the perceptual environment, which is that part of the operational environment humans are conscious of through organic-sensory sensitivity, learning and experience, but toward which no conscious or observable behaviour is directed (Sonnenfeld, 1972; Burgers et al., 2000). Meaning can be derived from nature itself, like temperature, but can also be given to it through values and culture (Sonnenfeld, 1972).

The fourth level is the behavioural environment; that part of the perceptual environment of which the individual is aware and to which he responds (Burgers et al., 2000). Interpretation of reality is an outcome of values and meanings that have been derived from the environment (Grossman, 1977; Burgers et al., 2000). People do not just adapt to the environment but shape it both physically as well as from the possibilities they see (Croll and Parkin, 1992).

An individual builds up understanding of the environment that is closest to him, makes decisions on how to respond and to behave in that environment (Park, 1999). Social, economic, political and cultural settings influence the way people perceive their environment and the way they react to it. These settings influence the goals of human environmental actions, the distribution of resources, and the constraints people experience (Orlove, 1980).

3.3.3. Influences of values, beliefs, knowledge and culture on perception

Human environmental behaviour may be considered as a reliable indicator of human perception (Kates, 1970), even though an individual's behaviour may be influenced by values and interests (Sonnenfeld, 1972). For a farmer who considers erosion on his land as problematic, reaching short-term production goals may outweigh the long-term but delayed benefits of investments in soil and water conservation (SWC) measures. According to Ajzen (2002), the intention to act is influenced by three personal beliefs.

1. Behavioural belief is the belief that certain behaviour results in a desired outcome. When an individual believes that certain behaviour results in a desired outcome, he will be more inclined to perform it than when he doubts the effect of that behaviour.
2. Normative belief is the belief about normative expectations that other people have: the perceived social pressure to perform or not perform certain behaviour (Ajzen and Madden, 1986; Ajzen, 2002).
3. The belief of perceived behavioural control refers to: "people's expectations regarding the degree to which they are capable of performing a given behaviour, the extent to which they have the requisite resources and believe they can overcome whatever obstacles they may encounter" (Ajzen, 2002: 676-677).

Belief of behavioural control consists of two separable control components: perceived self-efficacy and perceived controllability. Perceived self-efficacy is an individual's confidence in one's own ability to perform certain behaviour. The (lack of) confidence in one's capacity determines how much effort someone will make to get a desired outcome (Van Paassen, 2004). Controllability is an individual's belief that he can decide at his own will to perform or not to perform a behaviour (Ajzen, 2002).

Belief of behavioural control may be incomplete due to internal locus of control: factors that are internal to an individual, such as knowledge, skills, and willpower; as well as due to external locus of control: factors that are external to an individual, such as time, money, and opportunity (Ajzen, 2002).

The theory of planned behaviour requires an extensive investigation of individual belief structures which is not realistic when studying a large population. Individuals create shared social realities, values and norms, and make sense of their environment through culture (Jones, 1990). Cultural meanings are historically and socially bounded. By including a cultural boundary, Jones enables a more generalized investigation of belief structures that

does not require an investigation of individual beliefs (Figure 3.2). Behavioural diversity cannot be accounted for by ecological and genetic differences. Culture is an important factor in the formation of an individual's perception. Cultural adaptation takes place through socially transmitted information, or social learning processes (Alvard, 2003).

Van der Ploeg (1991) demonstrates the influences of a cultural boundary and social learning processes on agriculture. Farmers within a particular geographical and social setting develop a general farming style, a generally accepted mode of farming that can be considered as culture. When an agricultural practice becomes a habitude it gets something natural, it will gain a normative character and become subject to social control.

That a general farming style exists does not mean that all farmers have an exactly similar mode of production. Individual farmers have divergent strategies and means to reach expected productive goals, based upon individual beliefs, values, knowledge, ability and opportunities.

Knowledge both shapes perception and is shaped by perception. An individual constructs knowledge by a great number of decisions, previous ideas, beliefs and images and by the way he categorises, codes, processes, and gives meaning to his experience (Arce and Long, 1992). Through knowledge and experience, beliefs become more realistic and stronger. Knowledge is formed within an individual's life-world: a lived-in world that is largely taken for granted (Van Paassen, 2004). The life-world is a social world and can be considered as part of Sonnenfeld's perceptual environment. The cultural boundary in Jones' model both filters and defines an individual's beliefs, values and knowledge, thereby influencing behaviour (Jones, 1990).

3.3.4. Perception of drought risk

Perception of a climate is based on economic and social impact it has on personal lives (Meze-Hausken, 2004). People who depend on their natural environment have resilient and adaptive capacities to cope with natural hazards (Douglas and Wildavsky, 1982; Oliver-Smith, 1996). However, not all people within a locality are evenly vulnerable to drought.

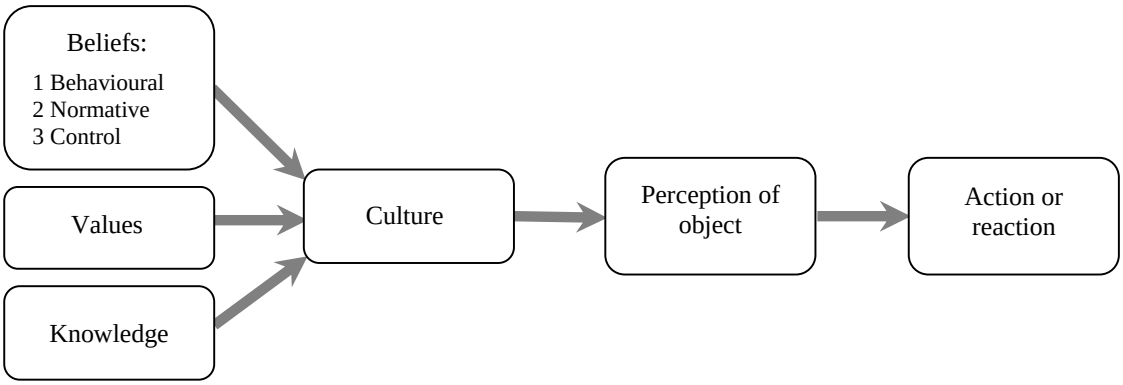

Figure 3.2. Factors influencing formation of perception and subsequent (re)action (based on Ajzen and Madden, 1986; Jones, 1990)

Based on Chambers' (1989) definition of vulnerability, Watts and Bohle (1993: 118) introduced three 'coordinates' of vulnerability to crises, risk and shocks:

1. the risk of exposure (exposure);
2. the risk of inadequate coping strategies (capacity);
3. the risk of severe consequences and of slow or limited recovery (potentiality).

Like any natural hazard, future droughts cannot be predicted. Based on past experiences, one can make a risk assessment, as a way to deal with risks. Attitudes towards risk depend on individual personalities (Douglas and Wildavsky, 1982). Kates (1971) ascribes variation in personal expectations of future hazard occurrences and of personal hazard vulnerability to three factors. The first is the way one perceives hazard events mainly in terms of magnitude, duration and frequency. The second factor is the nature of personal encounters with previous hazard events in terms of recency, frequency and intensity. The third factor is determined by the individual's view on nature, level of tolerance, and feeling of fate control. A common reaction of farmers in semi-arid Africa regarding drought is that it is an 'act of God' on which humans have no influence (e.g. Lindskog and Tengberg, 1994; Östberg, 1995; Slegers et al., 2005). Park (1999) argued that people develop a fatalistic attitude of having no control over their own future by attributing responsibility of future hazard to a higher power or authority.

Not only personal expectations regarding natural hazards, but also general perceptions of hazard risk differ from real risk. A society produces its own selected view of the natural environment that influences one's consideration of hazards (Douglas and Wildavsky, 1982). There is no clear view on how perceived risk of drought relates to actual risk due to the 'prison of experience': human experiences that limit realistic risk perception, either because human perception of hazard risk is greater or because it is lesser than real risk (Ferrier and Haque, 2003). Saarinen (1966) states that perception becomes more accurate and discriminating when people have had more and direct experience with natural hazards, even though occasionally farmers may have the tendency to over-emphasise hazard-free periods. Droughts of most recent years and classic droughts are recalled, while intermediate years and droughts are lost from memory (Saarinen, 1966; Ferrier and Haque, 2003). Heathcote (1969) refers to the relation between actual drought occurrences and reported ones by local people as the 'curve of perception'. In areas of low drought incidence, the figures of the two agree. In areas of high incidence the reports seem to fall short compared with the actual occurrences. People seem to shift the threshold upward for what they call drought (Heathcote, 1969), which makes them underestimate the chance of the hazard reoccurring (Kates, 1971; Lybbert et al., 2003; Johnson, not dated).

Figure 3.3 integrates previously discussed models into a model depicting factors that shape drought perceptions; that influence coping strategies, i.e. reactions to drought, and adaptive strategies, i.e. anticipation to the possibility of drought re-occurring in the future.

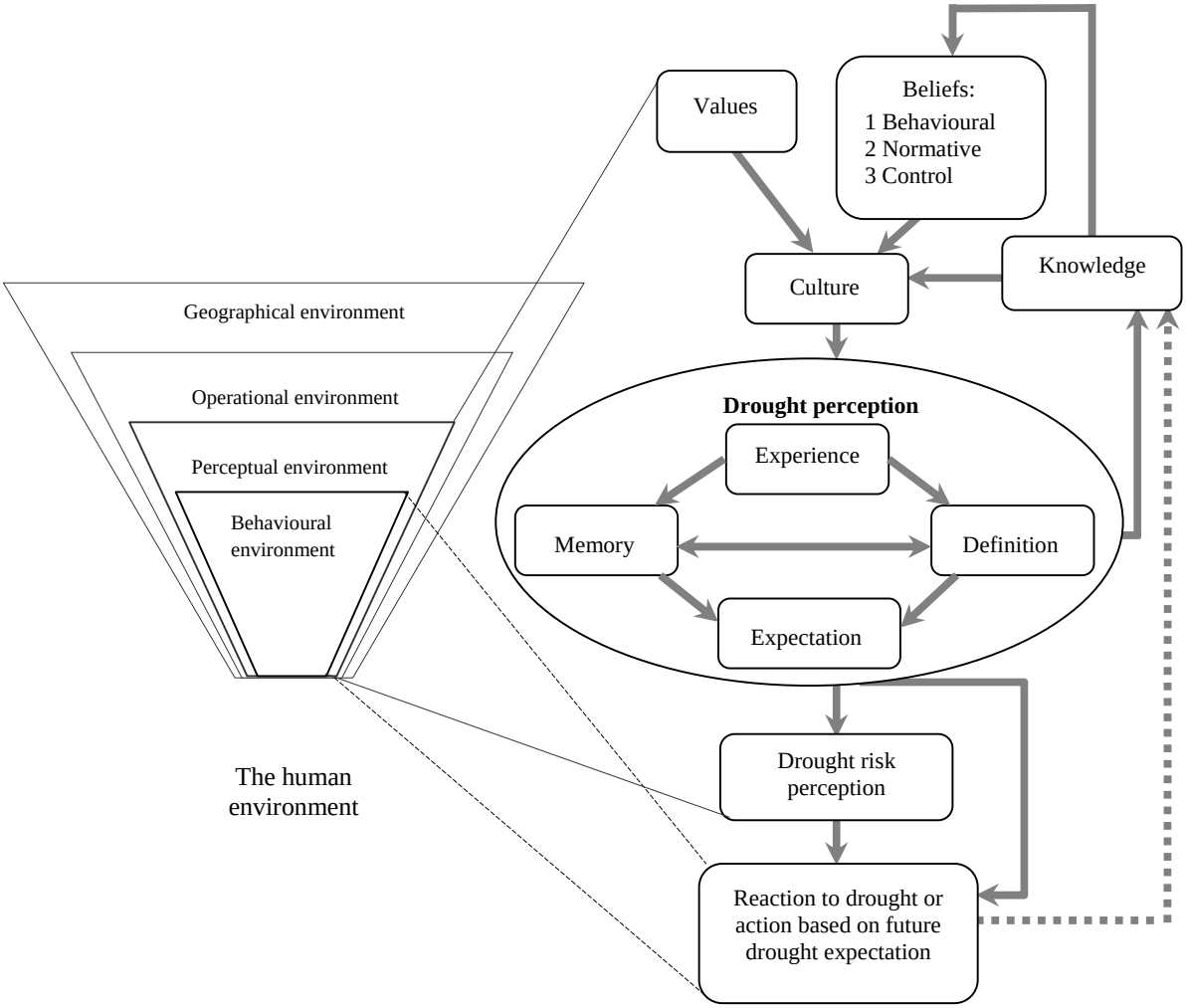

Figure 3.3. Elements shaping and influencing drought perception within the perceptual environment.

3.4. Farmers' perceptions in Goima, Tanzania

3.4.1. Perceptual environment

Physical environment

Goima is situated 40 km south-east of Kondoa town. It lies at the foot of the Burunge Hills, at an altitude of between 1300 and 1400 m.a.s.l. The Maasai Steppe is situated across the Burunge Hills east of Goima. The area has an undulating landscape of plains and scattered small hills. Soil types generally seem to follow the toposequence. The soils on the hill slopes contain small stones, are sandy further down-hill, while soils in the valley bottoms are relatively rich in clay and organic matter. The upper parts of the hills consist of bare rocks and forests. An increasing part of the Burunge hills are being cleared for farming, both legally and illegally. The land on the plains, which is not under cultivation, is covered with seasonal grasses, bushes and trees. Rivers are seasonal and have high peak discharges

during and shortly after rainfall events. Water flow in rivers mostly disappears within a day after a rainfall event.

Rainfall and water availability

Goima has a uni-modal rainfall pattern. Rain can be expected from November to May. Inter-seasonal and intra-seasonal rainfall variability is about 25%. The average seasonal rainfall measured at Kondoa meteorological station is 650 mm. The limited data available for Goima, indicates that annual rainfall there is less than 550 mm, while potential evapotranspiration in this area is about 1700 mm per year (Östberg, 1995: 31-32). Because of its high intensity, the rainfall is very erosive.

Not only rainfall is a problem, but the availability of water altogether. No structure is present to provide villagers with water throughout the year. The only sources of water in the long dry season are small earth dams, and shallow wells in the dry river beds, which the farmers dig out themselves and which disappear with the next big rain. During the rainy season and shortly thereafter, many shallow wells are visible in the dry river bed. As the dry season extends the shallow wells are dug out deeper, until they reach beyond four metres in depth (personal observation).

Towards the end of the dry season, women and children spend most of their day or night waiting for their turn at the well and it may take up to half an hour to fill up a bucket with water. Some people travel a distance of 10 km on foot or with donkey cart to neighbouring areas where water is more easily found. Farmers who have some money, buy water at a price of 200 Tanzanian Shilling (TZS)[1] per bucket of 20 litres.

The wells in Goima village, which are for common use, reduce in number during the dry season to avoid competition over water between nearby wells. The wells in Mirambu village are privately dug. Many households or groups of households have their own well in the dry river near to a silted-up concrete dam that dates from the Colonial period.

Population

Kondoa District has an average population density of 35 people per km^2 (NBS, 2003). The area surrounding the Burunge Hills is the home of the Burunge ethnic group. This small ethnic group traditionally practised rotational bush fallow, kept livestock and hunted. The Burunge nowadays are subsistence farmers. Migrants have settled in and around the Burunge Hills in the past three decades. This immigration has been the result of two developments. The first is the villagization (*Operasheni Vijiji*) as part of the *ujamaa* policies of Tanzania's first President, J.K. Nyerere, in the early 1970s (Hyden, 1980; Mung'ong'o, 1995). By bringing rural people, previously living scattered around, together into villages, access to public services such as health care and education, would improve. Farmers who already lived on the location of the newly established villages had to share land with newcomers. Fields further away from the villages were, as appeared later, temporarily abandoned. This policy has increased pressure on the land in and immediately surrounding these villages.

[1] 1 US$ is equivalent to 1200 TZS.

The second development was the establishment of the HADO project in the Kondoa-Irangi Hills, north of Goima. This area was identified as highly degraded and following a political decision was closed to livestock in 1979. The Kondoa Eroded Area (KEA), as it is termed, is inhabited by the Rangi ethnic group. The Rangi, are subsistence farmers and for many households also livestock is an important asset. Closing the KEA for livestock made many Rangi migrate to, or to set up a second household in nearby areas outside the KEA, like Goima, where land was available (Östberg, 1986; Mung'ong'o, 1995).

De jure political structures on ward and village level are not very dominant. Ward extension officers are not very active and village meetings are not visited by many people. The traditional structures are stronger. Village leaders and sub-village leaders are selected by the people themselves. Each sub-village has its own selected group of elders who are the first to mediate in case of disagreements. Village authorities organize occasional community work. Depending on the strength of the sub-village leaders, more or less farmers showed up.

Land tenure

The Burunge have always had land abundantly available and felt that land is open for everybody to use. They practised a system of rotational bush fallow. When clearing bush, some trees would be left as well as stumps to enable regeneration. After two or three years of cultivation, when the land's productivity had reduced, a piece of land would be given back to nature and new bush would be cleared. Newcomers were provided with land to produce their food. Since the 1980s, farmers have started to cultivate their land permanently, removing and de-stumping most trees. According to farmers, there is no longer land without an owner in Goima. Increasing numbers of farmers have sought land in neighbouring areas, while land is being cleared further uphill. To clear new land, a farmer should seek permission from the village-level government. Permission is granted after approval by village members in a meeting and by the extension workers who assess suitability in terms of erosion risk. Land is inherited from father to son; however, an increasing number of daughters inherit land from their parents. Most farmers have up to 4 hectares of land (Table 3.2).

Since the land is increasingly scarce, it has become a commodity. Farmers used to give land to other farmers for temporary use. Nowadays, some farmers have started to rent out or to sell their land. While ten years ago farmers still perceived that land was abundantly available (Östberg, 1995), now they have growing concerns about the future generation.

Table 3.2. Percentage distribution of land holding size in hectares.

Head of household		**Male Burunge** (%)	**Female Burunge** (%)	**Male Rangi** (%)	**Female Rangi** (%)
Land holding size (ha)	≤ 2	17	57	12	40
	2-4	36	38	40	20
	4-6	17	5	32	0
	>6	29	0	16	20
	Total	100	100	100	100

Some farmers, mainly the Rangi, have anticipated this future problem by clearing or buying large amounts of land to secure land for their (grand)children. Young farmers increase their acreage by renting land in neighbouring villages, or by clearing land in the Maasai steppe, where plenty of land is still available. This leads to occasional problems with the Maasai, who claim grazing rights in the same areas.

Land use

Traditionally, farmers used conservation tillage (*kukatia*) on their land. Small holes were dug by hand hoe and seeds were put in. Different crops were mixed in a field, even within the same planting hole. The land was cultivated with the first weeding. Nowadays, a combination of cultivation techniques is used. *Kukatia* is mainly used to sow before the onset of the rains, because the land is difficult to till when it is dry. Immediately after onset of the rains, farmers cultivate their land. Most farmers cultivate with hand hoe. Hand hoe cultivation after the onset of the rain is done using one of two techniques: *sesa* meaning that the land is cultivated flat, or *matuta* meaning ridge cultivation. An increasing number of farmers use an oxen plough or even tractor, which are relatively new and expensive techniques[2] for the farmers. Contractors come into the area with their tractor to plough farmer's fields.

Farmers who use oxen plough or tractor can cultivate most or all of their land in one day, while by using hand hoe it may take more than a month. To cultivate two hectares of land, a farmer needs only a few hours with a tractor, one or two days with oxen plough, or a month with hand hoe. About one week after the last rain, the soil has become too dry for seeds to come up. Cultivation continues after resumption of the rains. Most important crops are maize, red sorghum, white sorghum, bulrush millet, finger millet, and beans. Crops are often mixed, either between rows, within rows, or within the same planting hole.

Colonial SWC structures, which were constructed using forced labour, have been abandoned since independence. Through agricultural extension, farmers have adopted ridge cultivation as a way of preventing soil from washing away by water. This technique is, however, only practised when using hand hoe, while more and more farmers prefer to use oxen plough or tractor. This will facilitate timely cultivation, but it also quickly decreases soil fertility. Another development in the area is a declining availability of land due to population growth and immigration. Where in the past a farmer would abandon a field after some years, now land is increasingly seen as a valuable asset and cultivated every year. Productivity of the land has decreased over the years due to continuous use. This becomes clear to farmers when they compare harvests with newly cultivated land in neighbouring areas.

Livestock

The 2005 survey showed that about one-third of all farmers keep livestock, mostly in small numbers. The most common animals kept are chicken (47%), goats (37%), donkeys

[2] Renting a tractor costs 24 000 TZS per hectare, renting an oxen plough costs 16 000 TZS per hectare, hiring a daily labourer (hand hoe) costs 4000 TZS per hectare.

(17%) and cattle (18%). It is seen as an important source of income, security, and status. However, it is not easy to keep livestock due to diseases, low availability of water and poor grazing during large parts of the year. For this reason, relatively few farmers keep cattle. Farmers with large numbers of cattle move long distances in search of water and grazing grounds. In the off-season, livestock roams freely on most of the land. Few farmers prohibit post-harvest grazing.

3.4.2. Farmers' perceptions of rainfall

Expectation of rainfall

Before the onset of the rains of the 2005-2006 cropping season, the weather became a growing concern for the farmers in Goima, the rest of Kondoa District, and even most of Tanzania. The delayed start of the rainy season was a good starting point to discuss rainfall with farmers. According to Goima farmers, their area has medium rainfall because the rains in a normal year are sufficient to assure them of a good harvest. However, 90 % (N=120) of the farmers felt that the productivity of land could only increase if there would be more rainfall. The area is known to have an erratic rainfall pattern, which is also apparent from farmers' responses. Answers about the start of the rainy season ranged from "October" to "the end of January", and that of the end of the rainy season was "the end of March" to "the end of June". Farmers expect a rain shower by the end of October. This first rain should not be considered as the start of the cropping season for two reasons. Normally it will take another month for the next rain shower, so shoots from seeds would dry and wither. Besides, the first rain is for the grass, bushes and trees to sprout; this is a gesture to welcome the rain and by using this first rain "you may chase it". By the end of November or early December, the farmers expect the rains to really start. In February, farmers expect a two-week dry spell, after which rains should resume. The rains will reduce in magnitude and frequency by the end of April. Starting from mid-May, small rainfalls are expected only along the hills.

Prediction of rainfall

The natural environment provides a wide source of knowledge about weather conditions to those who have learned to read and interpret its signs, or who can draw from experience. The farmers of Goima have many ways of reading the signs from their natural environment (Table 3.3). Different ways of forecasting were explained by farmers. Some signs were generally recognized, while others were only mentioned by one or a few farmers. Reading the signs was often considered by the farmers who did not have this knowledge as a traditional practice known and practised by the elderly people. This is not completely true because also some younger farmers were able to indicate similar signs.

Almost all farmers who use the signs as predictors claimed not to act upon them. Rather, they used signs as an indication. The signs were said often to be right, but could not completely be trusted upon as "sometimes we are fooled by the signs": signs sometimes give a wrong indication or contradict. In the case of contradicting signs, farmers trust one sign more than the other. Experience tells farmers that the stars are more predictable than the

Table 3.3. Signs of nature for predicting rainfall and rainy season.

Sign	Prediction good/bad year	Prediction rain	Predicting end of season
Trees[a]	Good year: -Many flowers and leaves on baobab -Baobab flowers open and stay long on tree -*Mgunga* tree flowers in February Bad year: *Mgunga* tree flowers early or twice	Rain is near: Flowers drop from baobab	Last rains: Only along hills. Red leaves on the *Maasai* tree in the hills announce these last rains No more rains: Leaves of *Maasai* tree drop
Stars[a]	Good year: Big star visible in the west at 6 a.m. and 7 p.m. in certain period in dry season Bad year: Star in west not visible/big		
Moon[c]	Good year: Moon is high up in the sky around first rains		
Wind[a]	Good year: Northern wind just before first rains	Rain is near: No or very weak wind with high temperature No rain: Strong wind blows away clouds	
Whistling mountain[b]	Good year: Hear wind whistling around Mgubai mountain around 5 a.m. in November		
Whirlwind[b]		Rain is near: See small whirlwinds blowing up dust	
Clouds[a]		Rain is near: Clouds build up in afternoon, heavy clouds in evening, at same time high temperature and no wind Cumulus clouds and stratus clouds mixed Rain may come: Heavy clouds all over in morning No rain: Heavy clouds in morning while it is cold	
Thunder storm[b]		Big rain is near: Hear thunderstorm and see lightning	
Temperature[a]		Rain is near: High temperature, sweaty weather at night and in morning No rain soon: Cold in morning	
Timing of rain[a]	Good year: First rain in December Bad year: First rain in January	Expect rain: At same day of the month as rainy days in previous months Rain is near: Rain has started in nearby areas	
Direction and amount of rain[a]	Good year: First rains come from the east Bad year: First rains come from west	Big rains: Come from east Small rains: Come from west Big rains expected: When previous rain was big Bad rain: There is 'ten-cell leader' rain	
Flood[b]	Good year: M*buga* soil in Adia (west) floods with first few rains		
Birds[b]	Good year: Black birds passing the area in December Bad year: Black-and-white birds passing area in December		End of season: Birds are nesting
Termites[c]	Good year: Many termites seen		
Wasps and tsetse fly[c]			End of season: See many tsetse flies and wasps

[a] Generally recognised, [b] Recognised by several farmers, [c] Recognised by one or few farmers

trees. Since farmers consider rainfall to be "the work of God", no one can really predict what will happen; there may be some 'divine' intervention because of human misbehaviour (Östberg, 1995: 127).

Trees are most commonly used as indicators for long-term predictions; whether the season will be good and when the rains will start. Goima has many baobab trees, which are considered as special trees. How the baobab tree can forecast the rains is a mystery to farmers: "it is God's work because it sprouts at the driest time of the year".

Star watching is also commonly used by farmers to predict the coming season. Similar to the trees, the stars were interpreted in different ways. Differences existed about the size of the star and about the exact period of visibility.

Weather conditions (*hali ya hewa*[3]) are discussed continuously by everyone and are mostly short-term indicators for rainfall. Only the wind (direction) and origin of the rain can be long-term predictors. It may take a few days before rains actually start after the first day with good signs. When asking farmers about the '*hali ya hewa'* today, farmers would react by stating that "conditions look good/bad today", followed by an analysis of weather conditions since last evening.

Farmers do a great deal of cloud watching every day to see the type of clouds, the direction and speed at which the clouds are moving, often to conclude that "these are not the clouds that bring rainfall" or "these clouds will move to another area to drop the rain". When a combination of cumulus and stratus clouds is seen, it is a sign that the clouds are building up, forming rain. One farmer explained how hot air from the earth's surface is trapped by light, small clouds. The heated clouds (stratus) rise beyond the heavy clouds (cumulus) that are made of snow. The warm clouds melt the snow, which results in rainfall.

Farmers also have expectations based on previous rainfall events of that same season. When previous rains were big and covered a large area, more downpours are expected. When the rain was small and very local, then no good rains are to be expected. Farmers call it 'ten-cell leader' rain (*mvua ya kibalozi*), as only a small part of the village (10 households) may receive rain, while the neighbouring part remains dry (cf. Meze-Hausken, 2004, p. 23 on Ethiopia).

The current situation is also compared to previous seasons by looking at the start and the pattern of the rains. Based on this analysis, they assess whether the season currently looks good. Farmers are careful with drawing premature conclusions. They know weather conditions can change any moment. "We do not know whether the year is good until harvest".

Farmers are very much concerned about the rainfall in neighbouring areas for two reasons. Firstly, farmers have land and relatives in these neighbouring areas. It is important for farmers to have a strong social network as it will help them to gain access to resources and to increase security (cf. Mazzucato and Niemeijer, 2000 on Burkina Faso). Secondly, it is a means to calibrate the unpredictable rainfall (De Bruijn and Van Dijk, 1995), as it will tell them something about when to expect rain in Goima. The first and the best rains tend to come from the east. When the rains have started in the eastern Kiteto District, they expect

[3] '*Hali ya hewa*' is not only used to refer to weather conditions; it also refers to more general conditions.

the rains to start in Goima after two weeks. When the first rains have fallen, they look at a nearby area in the west, Adia, which is situated in a depression with heavy clay soils and poor drainage. When this area floods with the first rains, livestock will have enough water and the year looks promising.

Influences on rainfall

Even though the rain is "the work of God" and cannot be influenced, 92% (N=120) of the farmers believe that trees bring rainfall. Trees stop the wind that brings clouds. Farmers found proof of that in a forest reserve on the way from Dodoma to Kondoa, where farmers have experienced higher air humidity and better rainfall compared to Goima. Extension and education have strengthened ideas of farmers about the positive influence of trees on rainfall.

Farmers mentioned several reasons why trees are being cut in Goima. Some farmers go into the forest to clear land for cultivation. Nowadays, some farmers cut all trees on their fields as they want to use a tractor or oxen.

The Burunge traditionally have an animistic belief. The spirits of their ancestors live in certain caves in the Burunge Hills and in some trees, which are sacred. Under these trees, the elders used to sit to discuss important matters. The sacred trees cannot be cut or damaged. When a dry spell extends for a month, a group of Burunge elders, known to be descendants of the first settlers of the land, meet under a sacred tree to discuss the matter. The problem may have different causes, which are considered one by one.

Firstly, someone may have stopped the rain. Several people in Goima and surrounding villages are known to have inherited the knowledge to stop the rain using witchcraft. The rain can be stopped at any time. When the elders suspect someone to have consulted a traditional specialist for this purpose, they will visit that person to confirm their idea. The area, especially around trees, is searched to find traditional medicines that had been placed there. When no suspect is found, a witchdoctor is consulted to ask who has stopped the rain. Traditional medicine from a witchdoctor is used to break the spell. The start of the 2005-2006 seasonal rains was suspected to be delayed due to witchcraft. After a witchcraft spell had been undone in Songolo, a neighbouring village, the rains finally started. The Rangi farmers also believe in this witchcraft. None of the farmers felt that the rainfall can be positively influenced.

When there is no indication of witchcraft, a second cause is considered. The Burunge ancestors may be dissatisfied, possibly because one of the sacred trees had been damaged or cut. The elders take action by visiting several witchdoctors in different areas to find out how their ancestors can be satisfied. The elders receive information from the witchdoctors on how to pray and, if there is a need for it, to sacrifice a black sheep. After receiving this information, the elders initiate a rain-praying ceremony (*hhoiru*) to satisfy the spirits living in the sacred trees. They ask for forgiveness of their sins and to bring rain. They move along the village periphery visiting the sacred trees in the village while praying and sometimes sacrificing a black sheep.

With the arrival of a Roman Catholic mission, the arrival of many Rangi immigrants who are Muslims, and the establishment of a mosque, the Burunge belief has lost ground (Table 3.1). The Catholic Church does not allow Christians to participate in the traditional ceremony. An increasing number of people go to church or to the mosque to pray for rains. In spite of this change and the official restriction, Muslims and Christians of different ethnic groups do take part in the rain-praying ceremony. The sacred trees and the ceremonies involving these trees remain important.

When there are no signs of 'rain-breaking' (Sanders, 2003: 84), the dry spell is considered as natural: "the work of God" against which nothing can be done, except to pray and to wait for rains to start.

3.4.3. Farmers' perceptions of drought

Drought descriptions and indicators

Farmers talk about a 'good year' or 'bad year' when evaluating a crop season. Any problem that limits harvest causes a bad year, but water deficiency constitutes the principal problem. Most commonly, farmers described this problem based on weather conditions – the amount or distribution of the rainfall and sunshine (Table 3.4). When there is strong sunshine (*jua kali*), the soil will dry fast and the crops will burn easily.

Amount and timing of rainfall and sunshine should be in balance. This is especially important when the season reaches February, the month in which farmers expect a dry spell. The crop should be strong enough to withstand the dry spell, which according to farmers may extend to a total period of four to six weeks. Only the few farmers who have short-growing varieties and who have the opportunity to immediately plough the land after rains have resumed will be able to re-sow at this stage. Others will just put in seeds that require a

Table 3.4. Drought descriptions and indicators as percentage of all answers.

	What is drought? % (N=175)	**How can drought be recognised? % (N=171)**
Shortage of/erratic rainfall	28	2
Very strong sunshine/it is too hot	27	11
No rainfall	10	2
Crops/plants dry /seeds don't germinate	7	42
No moisture in soil/soil is dry	-	9
No/shortage of (drinking) water/dry river	7	9
Does not know	6	8
It is dry/it is dusty	6	1
Drought-resistant crops fail	-	3
Poor harvest due to rainfall shortage	3	-
Food shortage/poor harvest	2	2
Hardpan/soil is hard and difficult to till	2	4
Soil exposed due to deforestation/cutting trees	1	1
The will of God	1	1
Crops burned	-	2
There is no grass (for grazing)/soil is bare	-	2
Land is exhausted/infertile/empty	-	1

late sowing date without tillage. When the rains stop earlier than expected, crops may dry before the grain has fully developed. This is a bigger risk when the first rains had a late start.

Not all farmers were familiar with the word drought (*ukame*). According to farmers, drought is a word that was introduced to them through radio and extension. Farmers have adopted the word to describe their situation whenever their production is negatively affected by unfavourable weather conditions, the same way it is used on the radio or by extension officers. Farmers feel that they do not use the word in the right context, as for them *ukame* should be used to describe a season without any rainfall. Farmers believe that they have never experienced real drought, as they receive at least some rain every year.

Not all farmers differentiated between *ukame* and *jua kali*. According to some farmers, any period without rain is *jua kali*, whether a period is cloudy or sunny. Others differentiated between *ukame* and *jua kali*. The soil stays moist for a longer period during cloudy days compared to sunny days and it takes longer before plants suffer from water stress. Certain farmers who did differentiate mentioned that *jua kali* occurs every year: it is a temporal phenomenon from which a crop can recover. *Ukame* happens occasionally: only when harvest is negatively affected.

Drought indicators are related to weather conditions, but most commonly to the influences on the farmers' environment. Some of the drought indicators that were mentioned by only a few farmers in the baseline questionnaire were commonly mentioned during interviews and group discussions and, therefore, are probably more important than appears from Table 3.4.

Drought impacts on vegetation and crops were most important drought indicators for farmers. Goima farmers are mainly subsistence farmers, and a loss of production is what hits them hardest. When drought-resistant crops such as millet and sorghum fail, it is a sign that rainfall and sunshine were really unbalanced.

However, farmers related drought not only to loss of production, but also to low availability of water for livestock and humans. A few farmers felt that the annual unavailability of water during the dry season is part of the drought problem and stated that every year there is drought.

Another indicator is the belief, mainly among Burunge farmers, that fertility is not only in the soil, but is a relation of soil and water (cf. Östberg, 1995 on the Burunge and Mazzucato and Niemeijer, 2000 on Burkina Faso). Water gives the land strength and fertility. When there is no fertility or moisture in the soil, the land is 'empty' and nothing will grow. This reasoning was mainly heard from older Burunge farmers.

Expectation and experiences of drought

Farmers base their expectation of a season partly on their knowledge of the signs of nature and on their experience with previous years. They have a standard rule regarding timing of rainfall and dry spells in a 'normal' year and based on this, have a special memory for deviant years. Special years will thus be remembered. Deviant years a long time ago were remembered by fewer and mainly the older farmers, while the memory of the exact year was less precise. The crop season of 1997-1998 was remembered by many because of

too much rainfall. They referred to it as an El Niño year (cf. Nicholson and Jeeyoung, 1997; Indeje et al., 2000). The most recent three seasons, 2002-2003, 2003-2004 and 2004-2005, were bad years due to erratic rainfall and were remembered as such by many farmers. Food stocks had diminished due to these consecutive bad years.

At the time of the field study, in February 2006, Kondoa District Council distributed more than 800 tons of maize among 181 villages. Nearly half of the population of Goima and Mirambu villages was identified as short in food. In both Goima and Mirambu, five tonnes of maize was sold at a subsidized price to a predetermined group of food-short households and one ton was distributed for free among the elderly and disabled. The 2006 situation shows, some farmers face crop failures and food insecurity after one or a few bad years, while others are not affected to the same extent.

3.4.4. Farmers' perceptions of drought risk

About 60% of the sampled farmers perceived an increased frequency of drought years, while 65% perceived an increased severity of drought years. A third of the farmers perceived a decrease in drought frequency and severity. In the group discussions, farmers agreed that the number of drought years had increased from roughly ones every five to once every three years. The female farmers and the younger farmers (up to 30 years of age) felt more strongly about a negative trend in drought frequency and especially about a negative trend in drought severity.

A more equally shared feeling was that the weather pattern has become less predictable. This feeling may also feed farmers' concerns about drought frequency and severity. "Nowadays, the clouds pass by and bring rain to other areas, even when all good signs for rain are present in the morning". The farmers in the discussion groups agreed that the destruction of the forest in the hills may be a major factor contributing to this change of predictability. Farmers have lost confidence in other signs of nature as well.

Farmers have experienced that not every household has a similar risk of crop failure or of food insecurity in a bad year. Farmers recognized that people as well as their land show differences in drought vulnerability. Farmers related differences in drought vulnerability to weather conditions, land characteristics, land management techniques and farmers' characteristics.

Weather conditions

Rainfall shows great variability in its spatial distribution. Farmers referred to the 'ten-cell leader' rains in bad rainfall years and to the favourable weather conditions in and surrounding the Burunge Hills. Farmers felt that the land in this area was less drought-prone because it receives more rainfall during a longer period. The rain-bearing clouds at the end of the season only pass along the hills. More women than men referred to weather conditions in relation to drought vulnerability.

Characteristics of the land

Farmers perceived differences in drought vulnerability based on the characteristics of the land (Table 3.5). The first characteristic was soil type. Farmers mainly classify soils based on colour (white, red, black, or mixed) and based on texture (light or heavy) (cf. Schechambo et al., 1999: 15). The white soils are light and the black soils are heavy, while the red soils can be both heavy and light. Farmers consider heavy soils as most fertile and light soils as least fertile and least suitable for growing maize, as it will become 'dormant'. All farmers agreed on these soil characteristics and on the limitations these soils have regarding agriculture.

A farmer who cultivates a heavy soil generally cannot start cultivation immediately after the first big rainfall. Their land is very hard when dry and needs a lot of water before it is workable. Water infiltrates easily and deeply into the sandy or light soils, which enables immediate cultivation after the first big rainfall.

Farmers stated that in a normal year production on the heavy soils is better than on the lighter soils. However, productivity loss of in a bad year is highest on heavy soils. Two farmers explained this variety in crop performance between good and bad years in more detail. The limiting factor for crop growth in a bad year is water, which is more easily

Table 3.5. Drought vulnerability as perceived by farmers.

Differences in drought vulnerability based on:		**Most vulnerable to drought:**
Weather conditions	Rainfall	Areas with less rainfall
	Sunshine	Areas with *jua kali*
Land characteristics	Soil type	Black soils
	Soil texture	Heavy soils
	Water holding capacity	White soils
	Water infiltration	Heavy soils
	Fertility	Tired soil
		Heavy soils
	Erosion sensitivity	Land on slopes
		Land where livestock is grazing
	Location of land	Land on slopes
Land management practices	Timing of cultivation	Missing the rain
	Cultivation technique	Hand hoe cultivation
		Tractor cultivation for many consecutive years
	Weeding and thinning	Bad timing of weeding
		Not thinning
		Number of weedings
	Crop type	Maize
	Manure	Manure burns crop, but manure also increases water holding capacity
Farmers	Ability	Weak farmers
		Lack of labour
		No livestock
		No food reserves
		No money
		Hand hoe cultivators
		Farmers with only heavy soils
	Attitude	Lazy farmers

available in light soils. Whereas the limiting factor for crop growth in a good year is soil fertility, which is better in heavy soils.

Soil fertility loss due to continuous use was explained as ‘tiredness’ of the soil. Tired soils are considered as more vulnerable to the effects of a bad year. This is a reason why the Burunge used to give back the land to the forest after two or three years of cultivation. The use of fallow has reduced dramatically due to increased population pressure. In general, farmers appreciate land which has never been cultivated before, which they refer to as ‘virgin’ land.

Land located on slopes was considered by some farmers as less vulnerable to drought, as explained in subsection 4.4.1., and by others as more drought vulnerable. Water tends to run off fast, which limits infiltration and increases a soil’s vulnerability to soil erosion. The infertile sub-soil is exposed when the fertile top layer is washed away. The mainly black soils in the valleys are considered to be more fertile due to deposition of fertile topsoil from upslope.

Besides run-off water, livestock is considered as a major contributor to soil erosion. Wherever livestock passes or grazes, soil is trampled, loosened and washed away by the rain, leaving deep paths that can develop into gullies. Farmers also fear that land where livestock grazes will seal, which limits the soil’s water infiltration capacity. Female farmers in the sample did not mention soil types; they related drought vulnerability more often to soil quality. The richer farmers were not so much concerned about the influence of soil quality on drought vulnerability.

Land management practices

Farmers perceived differences in drought vulnerability based on their land management practices. The one who does not miss the rain has the best chance of harvesting enough to satisfy his household’s needs. A commonly heard phrase was: “there is no bad timing of the rains, only bad timing of farmers”. A farmer should start cultivation immediately after the first rainfall. If a farmer delays, the soil may already be too dry to work on, forcing them to wait until the next rain. Farmers also considered timely weeding as important as it avoids competition for water. Farmers weed twice or thrice. Farmers sow more than one seed per planting hole. Therefore, crops have to be thinned. This is done simultaneously with the first weeding.

Farmers who are able to plough their land by tractor or with oxen are less vulnerable to drought; they are able to finish cultivation when the soil is still moist. Their plot will have a uniform germination, which is very important according to farmers. Another advantage considered by farmers is that tractor cultivation enables water to infiltrate deeper into the soil. However, farmers are concerned that tractor cultivation for consecutive years will reduce yield because fertile topsoil mixes with infertile subsoil. Some farmers complained about the low availability of tractors. They have to wait for their turn, while some farmers with good contacts are favoured.

Crop choice influences drought vulnerability because crops have different water and fertility requirements. Maize requires fertile soil and is most vulnerable to shortage of

rainfall. “The maize goes to sleep and doesn’t wake up when the rains return”. Millet and sorghum will sprout again when exposed to dry spells at early growing stages.

Farmers do not have uniform ideas and experiences with manure application in a bad year. Some farmers have experienced ‘burnt’ crops, while others experienced an increased water holding capacity of the soil. Generally, younger farmers were less concerned about this negative effect of manure. The advice of some of the farmers was to use two-year-old manure. Fresh manure is too strong; it is too ‘hot’ and should ‘cool down’ before application on the land.

Timely cultivation and weeding are generally seen as the most important measures to limit the risk of reduced production due to drought. When the rain starts later than expected, half of the sampled farmers delay cultivation until the rains start, while a third of the farmers sow part of their land before the rain starts. Some farmers add manure, cultivate using oxen or tractor or change to drought-resistant crops or short-growing varieties. Some strategies, such as mechanized cultivation and use of short-growing varieties were not mentioned by the poorer households; they cannot afford these strategies.

Farmers’ characteristics

Farmers identified one’s ability and attitude as major influences on drought vulnerability. These to a great extent influence the choice of land management practices. A farmer’s ability is related to resource availability. Those with the least resources have limited options to cope with problems or limited potential to recover from hazards. Weak farmers, the old and sick may not be able to work fast enough to cultivate and sow as much land as they need, while the poorer farmers cannot afford to buy short-growing varieties or to plough mechanically. The richer farmers in the sample did not mention management practices in relation to drought vulnerability.

A household that has problems handling the work is not necessarily vulnerable to drought because of the availability of other resources. With food in stock, a household may have enough food to survive a year with low harvest or to organise a communal labour day on his field. When a farmer has financial reserves or some food or livestock to sell, he can hire daily labourers, oxen plough or tractor. This way he is able to plough and sow a large piece of land in one day, and to have it weeded in time.

Many farmers who lack this ability will have to do daily labour on other farmers’ land to get enough food. Since labour opportunities coincide with peak season at their own fields, the daily labourers are not able to work their land on time and will not produce enough food for subsistence, which again forces them into daily labour.

In a bad year, many fields are fallowed because the soil had become too dry before the end of the sowing period. Farmers who cultivate by using hand hoe are not only perceived to be more drought vulnerable because of the smaller acreage they can cover, but also because water does not infiltrate as deep into their soil as when using oxen or tractor. When they fear that year will be a bad one, farmers who have the resources to hire a tractor or oxen-plough might expand their normal acreage to maintain usual productivity. Especially farmers who

only cultivate heavy soils have a higher risk of missing the rain and are considered to be vulnerable to drought.

The second influencing factor on drought vulnerability was farmers' attitude. 'Lazy' farmers do not work according to their ability. Certain farmers did not want to waste their energy and resources when they had no expectations of good rainfall that season. Rangi farmers commonly complained about lazy farmers who prefer to drink local brew in the afternoons rather than working. They mainly referred to Burunge farmers because Rangi are predominantly Muslim and do not drink alcohol. Every day at different locations in the village, there are households selling local brew. About three-quarters of all Burunge who participated in the questionnaire sell local brew as a source of income.

3.5. Discussion and conclusions

3.5.1. Elements shaping perception of drought

Farmers feel that they have never personally experienced a drought in its strict meaning (Figure 3.4). They adhere to the principle of drought being complete crop failure due to absence of rainfall, the land being bare and dry. One's perception depends on one's environment and its characteristics (Heathcote, 1969). Farmers use drought in less severe situations to refer to a year with reduced crop production due to deficient rainfall or an imbalance between rainfall and sunshine. The length of the expected dry spell was a major concern in relation to crop failure. The word drought was learnt through extension and from the radio. Farmers prefer to talk about a bad year or about *jua kali*, as there is always some rainfall and often it is the sun that burns the crop.

Farmers remembered the extreme and the most recent years with reduced productivity (Saarinen, 1966; Ferrier and Haque, 2003) because of the impact that such years had on personal lives (Meze-Hausken, 2004). The older people recalled extreme seasons of many years ago.

Droughts may be expected in the future, but no prediction can be made. Farmers believe that it is up to God to decide the timing and amount of rainfall. However, it is not possible to state that farmers have a fatalistic attitude. Some farmers believe that drought is just as much caused by untimely farming as by rainfall deficiency. Farmers believe that trees bring rainfall. Most farmers feel that the variability of rainfall has increased over the past decade or two, which some of the farmers related to deforestation. This belief is strengthened by agricultural extension services. Studies on Burkina Faso and Ethiopia also show that farmers related drought to deforestation (Meze-Hausken, 2004; Slegers, unpublished; Slegers et al., 2005).

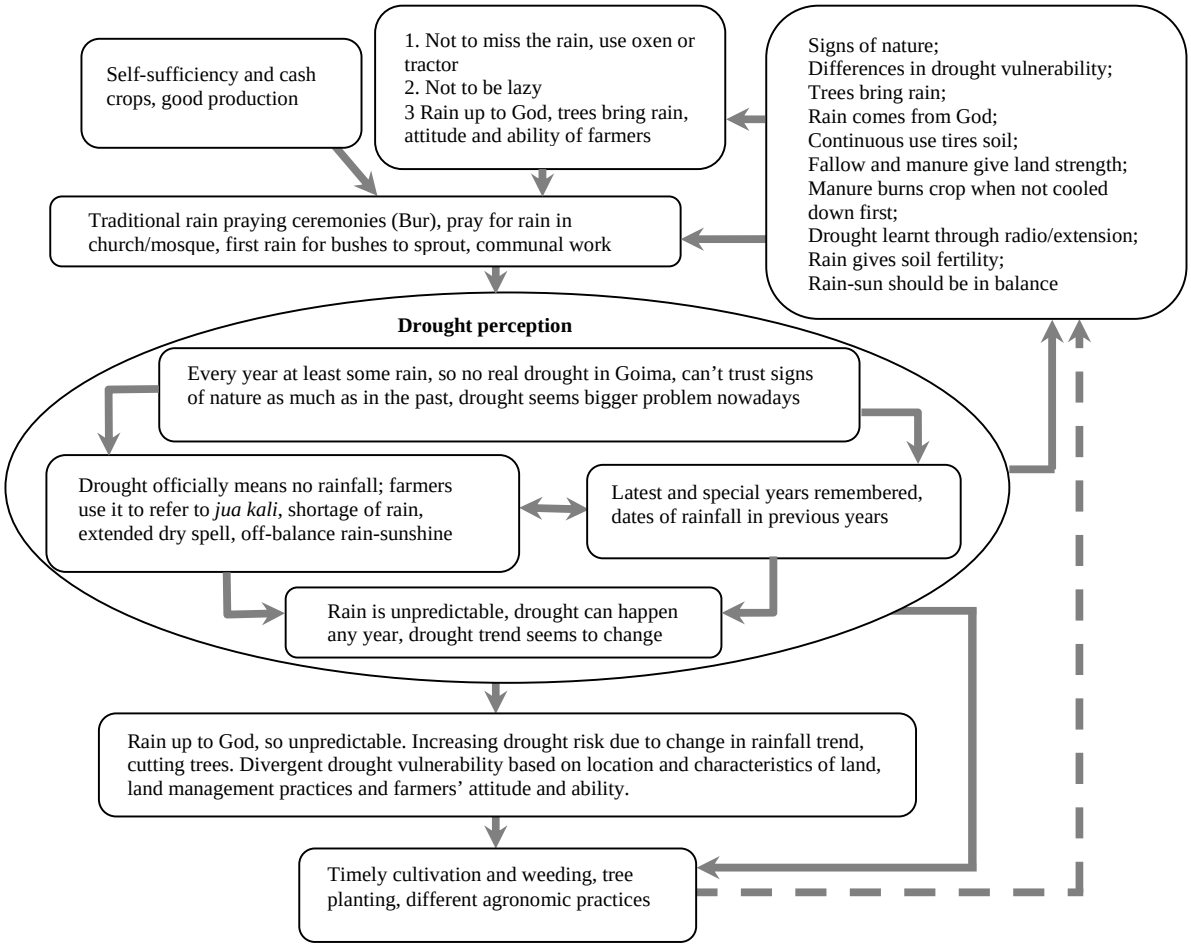

Figure 3.4. Elements shaping and influencing drought perceptions in Goima.

3.5.2. Perceptional environment

Drought perceptions are area-specific constructs influenced by local biophysical, social, cultural, economic and political conditions. This case study has demonstrated that farmers do not consider drought in strictly meteorological terms. Farmers had detailed knowledge about their environment and their soils. Farmers had area-specific knowledge about how soil properties, location of land, changes in their physical environment and land management practices create differences in drought vulnerability. Studies about drought perceptions in Burkina Faso (Slegers et al., 2005) and Ethiopia (Meze-Hausken, 2004; Slegers, unpublished) showed similar results.

Access to land was not a limiting factor. To have use rights over less drought vulnerable land was not valued to the extent that farmers use it as a strategy to be less vulnerable to drought. This was the case in Ethiopia (unpublished), where farmers had user rights over a very small piece of land or even had no user rights. The options one has in terms of management practices were higher valued by Goima farmers because these can make a big difference in terms of timing and amount of land cultivated. In bad rainfall years

parts of the land were left uncultivated because the soil had dried before farmers were able to cultivate it.

3.5.3. The influence of values, beliefs, knowledge and culture on perception

Farmers want to be self-sufficient and to be able to have some extra produce to sell. Farmers have developed certain farming styles (Van der Ploeg, 1991) based on experiential knowledge about the rainy season. Timely cultivation is one of the most important elements therein. Rainfall was considered as the major limiting factor for a productive season. “If only it would rain, our harvest will be good”, was a phrase commonly heard (cf. Östberg, 1995: 31 on the importance of the rains for farmers' well-being). Good timing of agricultural practices can make the difference between being food-secured or food-short. Farmers who do not practise timely cultivation but who have ability to do so are considered as lazy farmers. Farmers value keeping reserves, either in cash, food or livestock. It will help them to survive one or a few consecutive bad years.

Cultural understandings of insecurity give people a frame of reference to understand the ‘hostile’ world around them and to cope with ecological insecurity (De Bruijn and Van Dijk, 1995). Farmers’ indigenous ‘ecocosmological’ knowledge has given farmers an explanation of misfortunes that are beyond their own control, such as rainfall-related problems, by which these become manageable (Croll and Parkin, 1992). Douglas and Wildavsky (1982 p.31) refer to the ‘mystic participation of culture’ to explain abnormalities. However, for certain people, parts of this ecocosmology have lost credibility and were substituted by alternatives from higher authorities (Croll and Parkin, 1992); examples of which will be shown here.

Farmers generally agreed that the rain comes from God. He decides when and how much it will rain. When God or ancestors are dissatisfied, e.g. when sacred trees are cut, the farmers will be punished through the rain. This belief and related rituals are “based on moral or physical trespasses against the gods” (Strauss and Orlove, 2003: 7). Farmers also believe that certain people have the power to stop the rain by using witchcraft. The rituals are losing ground because of the ‘new’ religions that have given farmers different understandings and other ways to pray for rains.

The farmers have extensive knowledge about different signs of nature that tell something about rainfall. Farmers have strong traditional beliefs about how all natural phenomena come from the hands of God; the rains as well as the signs of nature.

Experiential knowledge seemed to be most important for farmers and it tells them not to blindly trust upon the signs of nature. Farmers perceived that the signs have lost accuracy in recent years. Especially young farmers lost interest in these signs. Increasingly, farmers trust forecasts from the District Agricultural Office and the radio. Most commonly used signs are current weather conditions.

Traditional and ‘outside’ knowledge are not strictly separated or contradicting. Farmers compare different signs, forecasts and experiences from previous seasons and base their expectation of the current season on this comparison. This will further shape farmers’

experiential knowledge about the reliability of different signs and forecasts. At the end of the 2005-06 season, most farmers concluded that both traditional and 'expert' forecasts had been right. Orlove et al. (2000) showed how certain Peruvian and Bolivian farmers used to predict rainfall based on stars and found a relation between the poor visibility of the Pleiades and reduced rainfall in El Niño years. Similarly, many farmers who are members of either one of the 'new' religions still participate in the *hhoiru* ceremony.

3.5.4. Drought risk perception

The 'prison of experience' (Ferrier and Haque, 2003) or the 'curve of perception' (Heathcote, 1969) seem to be true in the Goima case. Farmers' threshold for what can be called drought is high. It could be argued that farmers underestimate drought risk because farmers do regularly face partial crop failure, however, farmers did not use the concept in its strict meaning. Even though drought perceptions were substantially the same for farmers, their actual drought vulnerability and with that their drought experience and risk differed.

Drought vulnerability not only depends on the external risk of exposure, but is also influenced by internal risk factors (Watts and Bohle, 1993). The perceived risk of drought has increased over time, which was felt more strongly among the female-headed and the younger households. Particularly the first group was less wealthy, while the younger farmers had a shorter memory for droughts. The past few seasons had been dry, which may also partially explain the general feeling regarding the increased drought trend. Farmers were more concerned about an increased severity than about an increased frequency of droughts.

Farmers have adapted their practices to the possibility of future droughts through their choices of land management practices. Possible choices depend on one's ability, attitude and opportunities. "Those who are unable to cope or adapt, are inevitably vulnerable and unlikely to achieve sustainable livelihoods" (Scoones, 1998: 6). This includes most female-headed households, and part of the older households. The older farmers were either among the poorest or among the richest households. Poorer households more often referred to the effects that the state of the land and land management practices have on drought vulnerability. The wealthier farmers have more possibilities for timely cultivation and improvement of soil quality, which makes these issues in relation to drought vulnerability less urgent for them.

3.*5.5. Challenges for further research*

Farmers recognized that human-induced environmental changes influence drought vulnerability and that one has to be an active farmer to be productive and to withstand drought conditions. This implies that farmers can distinguish drought conditions that are 'an act of God' from those that are human-induced (Roe et al., 1998). This insight creates possibilities for improved management to reduce drought vulnerability.

Farmers' drought perceptions can be related to a scientific concept of agricultural drought (Slegers and Stroosnijder, 2008). Biophysical factors other than rainfall deficiency

influence soil-water availability and can contribute to farmers' increased concerns about rainfall (Lindskog and Tengberg, 1994; Dahlberg and Blaikie, 1996). Meze-Hausken (2004) also found that farmers' perception of drought in her Ethiopian case relates to agricultural drought, but argues that caution is needed since this scientific concept does not take into account the influence of non-environmental conditions on farmers' perceptions. As also the Goima case shows, drought perceptions contains both biophysical and social components (Meze-Hausken, 2004).

Since the amount of rainfall cannot be influenced, the efficiency of the rains can be a focal point for addressing farmers' concerns about drought. Studies in the dryland areas of Africa show that only 10 to 30% of rainwater is actually productive, while the remaining rainwater evaporates or disappears through surface run-off or underground flow (Stroosnijder and Koné, 1982; Falkenmark and Rockström, 2004; Stroosnijder and Slegers, in press).

A focus on rainwater use efficiency is a challenging one. In semi-arid East Africa soils are generally poor; rainfall is erratic and when it falls, it often comes in highly erosive showers. Furthermore, the farmers in this region have generally a limited availability of resources. Any viable strategy to reduce farmers' vulnerability to drought and to improve productivity should be integrated into farmers' existing strategies to adapt to and cope with ecological insecurity (Scoones, 2004).

Insecurity not only has different impacts on individuals and social groups, it also changes over time (De Bruijn and Van Dijk, 1995). In the case of insecurities of the Sahelian rainy seasons, Mortimore and Adams (2001) argue for a closer focus on strategies by which farmers 'negotiate the rain' in every year. Deeper insight is needed into physical, social, economic and cultural contexts in which changes take place (Agnew and Warren, 1996) and how these influence farmers' adaptive strategies and opportunities to cope with drought.

Climate change is said to be occurring, however studies on long-term trends in rainfall patterns in different parts of sub-Saharan Africa have not confirmed ideas about general increase of drought frequencies (Chappel and Agnew, 1999; Nicholson, 2001; Conway et al., 2004; Scoones, 2004; Seleshi and Zanke, 2004; Seleshi and Camberlin, 2006; Amsalu et al., 2007; Stroosnijder, 2008). Deeper insight is needed into how farmers' drought risk perceptions relate to the actual rainfall trend in the area. The environmental history of Goima area and farmers' perceptions of environmental change deserve further exploration as these may partially explain farmers' growing concerns about drought.

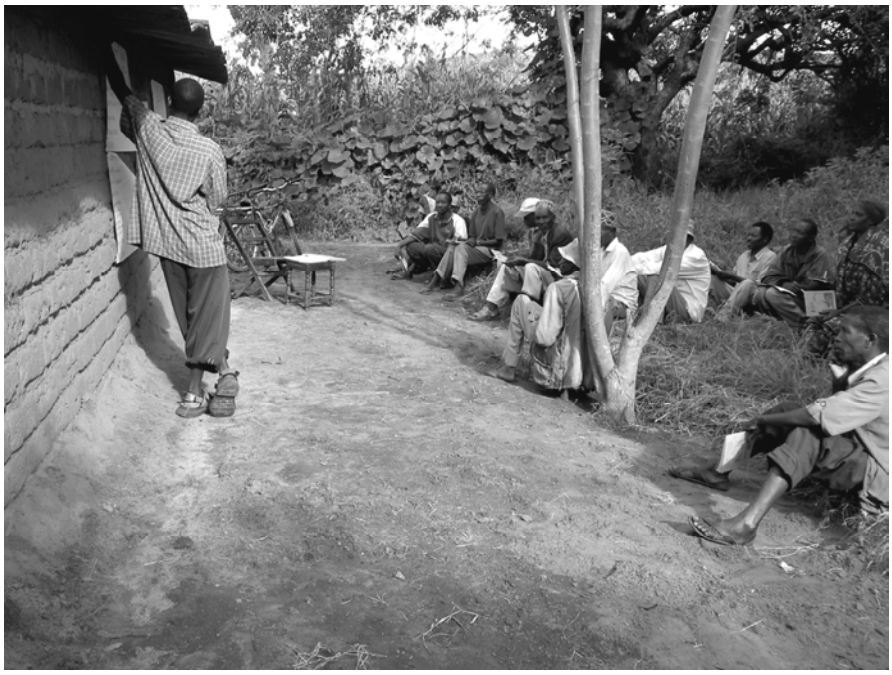

Figure 3.5. Group discussion with farmers in Mirambu.

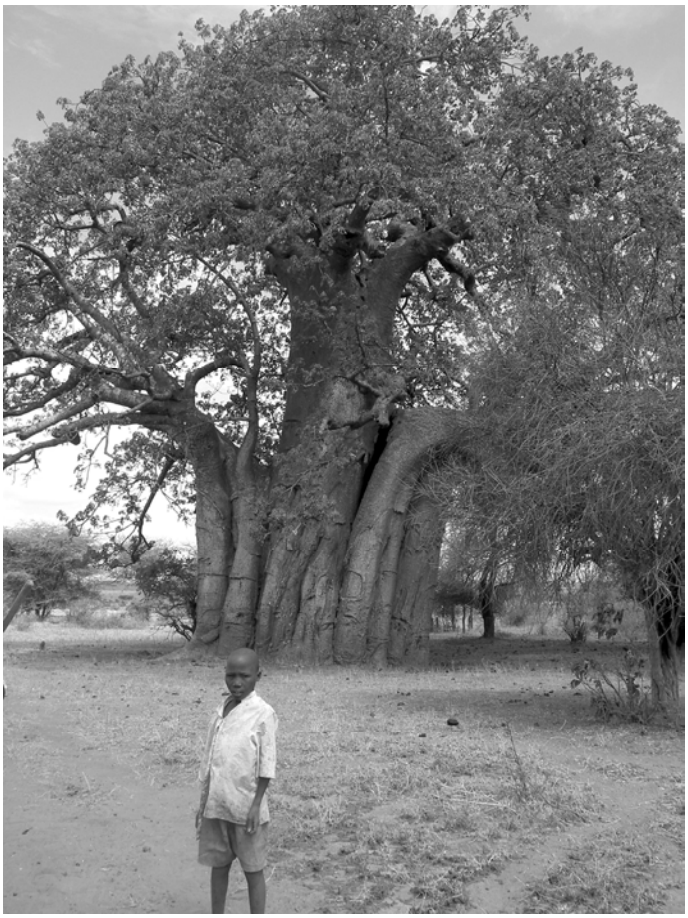

Figure 3.6. A big baobab tree in Goima, which harbours spirits of Burunge ancestors, showing signs of a good year.

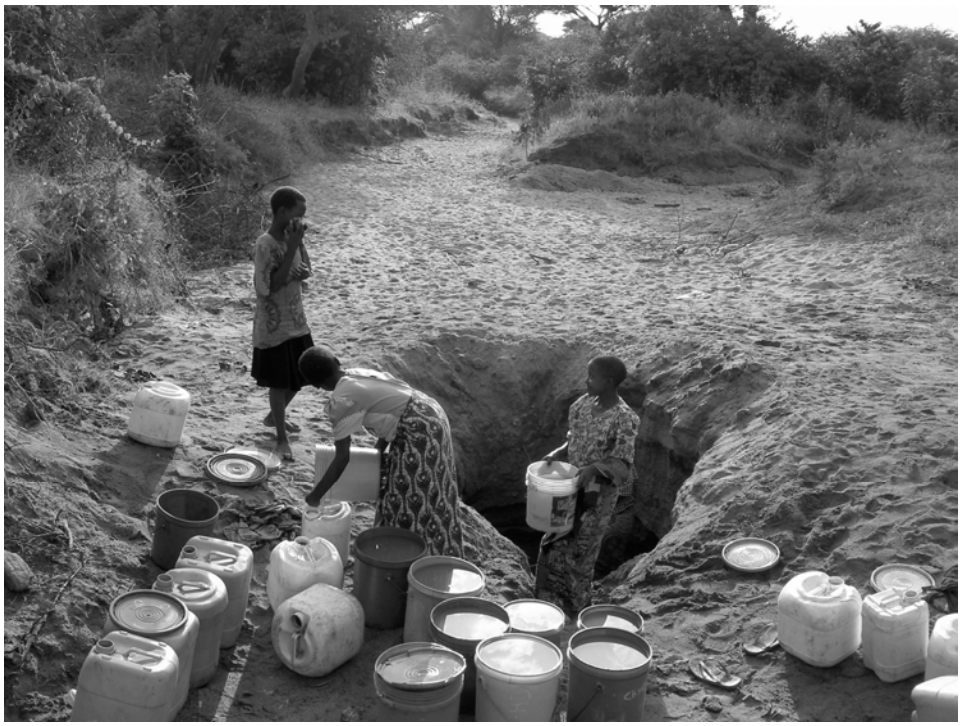

Figure 3.7. A shallow well in a dry river bed in Goima. Towards the end of the dry season, it takes up to half an hour to fill a bucket of water.

Figure 3.8. Farmers in Mirambu ploughing land using donkeys.

Chapter 4

Losing the rains: Farmers' perceptions of rainfall and drought in Asfachew area, Ethiopia

4. Losing the rains: Farmers' perceptions of rainfall and drought in Asfachew area, Ethiopia

Abstract

This chapter describes how farmers in Asfachew area, North Shoa Zone perceive rainfall and drought and how they relate recent changes in their environment to perceived changes in the distribution of rainfall. During the period from 2004 to 2006, a study was conducted in Asfachew Kebele, Ethiopia. The study included questionnaires with mainly open-ended questions (N=58), in-depth interviews, group discussions, field visits, informal talks and picture assignment. Drought perceptions related to weather conditions and the effects for the environment, people and livestock. Drought risk was perceived to have increased as rainfall has become more erratic. However drought severity and frequency was considered to have reduced since farmers did not experience any drought since 1984. Farmers recognized differences in drought vulnerability based on characteristics of the land, land management practices and farmers' characteristics. Farmers related changes in the rainfall to deforestation. It has been suggested that farmers have a fatalistic view on drought. However, this case study suggests otherwise; farmers recognized that one has to be an active farmer to be productive and to withstand drought conditions and that human-induced environmental changes influence drought vulnerability.

4.1. Introduction

In Ethiopia, there is a growing threat of land degradation that poses a serious problem for agricultural productivity and food security, particularly so in the Ethiopian Highlands (Haileselassie et al., 2006). In the highland areas (Haileselassie et al., 2006), soil erosion has been estimated at 42 tons per hectare per year on cultivated land. Ethiopia has one of the highest rates of soil nutrient depletion in sub-Saharan Africa (Pender et al., 2001). Reasons stated for this aggravating situation are population increase, decreasing landholding sizes, land tenure insecurity, increasing use of marginal land for agricultural purposes, deforestation, overgrazing and limited use of appropriate conservation practices (Hawando, 1997; Shiferaw and Holden, 1999; Shiferaw and Holden, 2001; Alemayehu et al., 2006; Amsalu et al., 2007). Up to 50% of the crop residues and animal dung is used to meet household energy needs, while crop residues are furthermore used to feed to livestock (Shiferaw and Holden, 1999). This limits farmers' options for soil fertility management.

Erratic rainfall patterns and recurrent droughts add to the food security problem (Hawando, 1997; Mersha and Boken, 2005). Ethiopia is well-known for its recurrent droughts and famines, especially those from the 1970s and 1980s. The majority of Ethiopia's population depends on rain-fed subsistence agriculture (Helldén and Eklundh, 1988). Ethiopia's population depends on rain-fed subsistence agriculture (Helldén and

Eklundh, 1988) and therefore, it is of utmost importance that farmers can trust and rely on the rains.

This chapter describes how farmers in Asfachew area, North Shoa Zone perceive rainfall and drought and how they relate recent changes in their environment to perceived changes in the distribution of rainfall.

4.2. Methodology

The case study took place in two villages in Asfachew *Kebele*. Asfachew and Chira Meda villages[1] are situated in North Shoa Zone, 200 km north-east of Addis Ababa along the tarmac road between the two small towns of Debre Sina and Shoa Robit. Asfachew and Chira Meda are two of ten villages within the administrative unit of Asfachew *Kebele*. The research took place in the period between November 2004 and September 2006, and was conducted in two phases: an exploratory phase of three months and a second three-months phase for more detailed research.

In the first phase, a baseline questionnaire (N=58) with mainly open-ended questions was used to get general information about the area and its population, their land, livelihoods, assets, farming practices, and problems perceived. The sampled households were selected using a stratified random sample from local officials' lists. Only the household heads were interviewed. Farmers' answers served as guidelines for further discussions with farmers.

The second phase took place in the 2005-2006 cropping season and was used to follow farmers during their agricultural practices, to get more insight into their livelihood strategies and opinions regarding the state of their land, weather conditions and drought. Information was gained through informal talks; field visits; in-depth interviews; a picture assignment, in which farmers described images; and a series of group discussions. This phase also included a biophysical study, the results of which will be discussed elsewhere.

The analysis of this case study was done using the drought perception model that was introduced and described by Slegers (2008b).

4.3. Asfachew area, the perceptual environment

4.3.1. Physical environment

Chira Meda is located 15 km downhill from the small town of Debre Sina (2800 m.a.s.l.), at an altitude of about 1850 m.a.s.l. The surroundings of Chira Meda are rugged. The village is constructed on a plateau, from where steep cliffs and ridges go down to different small terraces (Bekele-Tesemma, 1997). Asfachew is located 5 km further down along the road from Chira Meda at an altitude of about 1470 m.a.s.l. The small town of Shoa Robit (1275 m.a.s.l.) is 8 km further down the road. Asfachew is situated at the foot of the mountains where Chira Meda and Debre Sina are situated. Asfachew has areas with moderately steep

[1] When referring to both villages, "Asfachew area" will be used. To refer to Asfachew village, "Asfachew" will be used

and small slopes, covered with colluvial depositions. The remaining land is relatively flat towards the floodplain of the Tikurso River, where the wide river bed is covered with deposited stones. The river has a high peak discharge during and shortly after rainfall events, and turns into small braided streams soon after the rain stops.

The soils of the study area are mostly Cambisols and Vertisols. The first soil type is mainly found around Chira Meda, is brown or reddish-brown in colour, has a fine texture and is easy to till. Vertisols are mainly found in the flat areas and on the gentle slopes of Asfachew and are difficult to till. The soils, especially on the steep slopes around Chira Meda, contain many stones. Most of the area has been cleared from trees and shrubs to increase acreage for agriculture.

4.3.2. Rainfall and water availability

Both Asfachew and Chira Meda have a bi-modal rainfall pattern (Figure 4.1). The *belg* season starts at the end of January or in February and lasts for three months. The main *meher* season starts at the end of June or in July and lasts about three months. *Meher* rains are generally more predictable (Table 4.1), more intense and more frequent than the *belg* rains (Amsalu et al., 2007; Slegers, 2008a). Inter-seasonal rainfall variability is high. Because rainfall can be very intense, it can be highly erosive. The annual potential evapotranspiration in Shoa

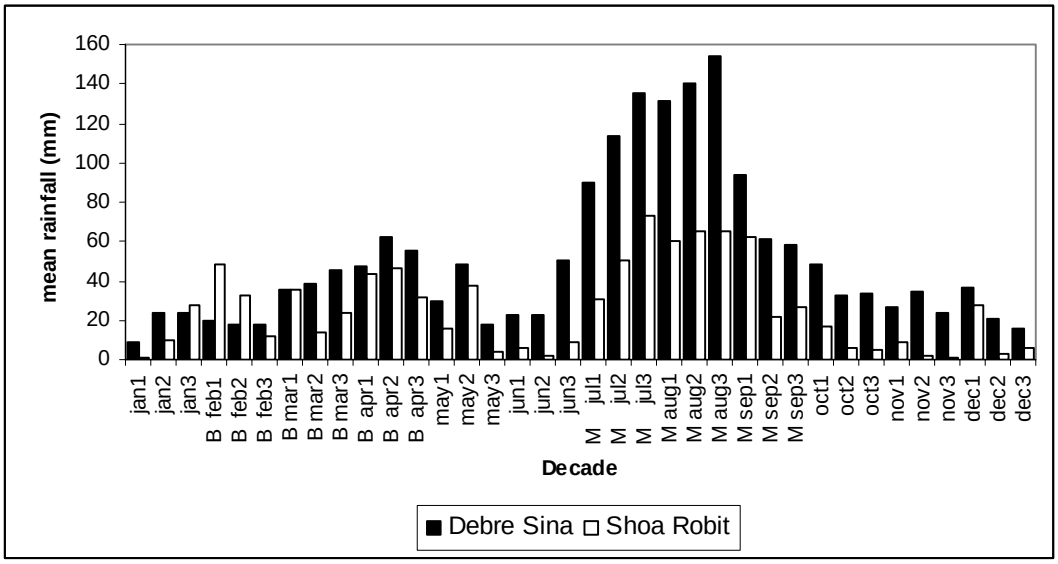

Figure 4.1. Mean rainfall per decade for Debre Sina and Shoa Robit, Ethiopia (B = belg, M = meher) (average of respectively 21 and 11 years).
Source: National Meteorological Services Agency of Ethiopia

Table 4.1. Rainfall characteristics of Debre Sina (21 years of data) and Shoa Robit (11 years of data).

	Debre Sina		Shoa Robit	
	Rainfall in mm (% of total rainfall)	**CV (%)**	**Rainfall in mm (% of total rainfall)**	**CV (%)**
Total	1839 (100)	28	1003 (100)	13
Meher	1348 (73)	40	581 (58)	31
Belg	491 (27)	40	422 (42)	38

Source: National Meteorological Services Agency of Ethiopia

Robit is 1517 mm (Bekele-Tesemma, 1997). *Meher* season accounts for 85-90% of annual agricultural production in Amhara region, while *belg* accounts for the remaining 10-15% (DPPC, 2006).

Water is available the whole year round. Chira Meda has three water taps. A natural spring is situated about 20 minutes walk from Asfachew and provides the villagers with clean water. In 2006 a hand pump was constructed at the border of the village. Livestock is taken down to the river for drinking.

4.3.3. Population

North Shoa zone is inhabited by the Amhara ethnic group. The average population density in Tarmaber Woreda, an administrative division between zonal and *Kebele* level, is 185 people per square kilometre (CSA, 2006). Asfachew *Kebele* as a whole has a total population of about 4500 people, 850 of which live in Asfachew (111 households) and Chira Meda villages (64 households). According to some old farmers, the villages in Asfachew *Kebele* used to be much smaller. In the mid-1980s the *Derg*, the socialist regime governing Ethiopia at that time, introduced a similar villagization policy to villagization of Tanzania in the 1970s (Slegers, 2008b). Farmers were forced to move to centralized villages in order to facilitate the formation of farmer cooperatives, marketing of inputs and outputs and distribution of resources.

The people in Asfachew are small-scale farmers who grow crops for home consumption, some for the market and who keep some livestock (Slegers, 2008a). Not all people in Chira Meda are subsistence farmers. When looking at the houses along the road, one will find many small businesses; tea houses, local beer houses, and a restaurant. Most importantly, there are small businesses where farmers from neighbouring villages come to sell their produce, mostly tef, a type of grain that is the staple food for most Ethiopians. These business men sell the grains to the traders who pass by with their trucks. Many people in the village earn money with handicraft such as weaving and basket making. Business is ‘booming’ in Chira Meda because the village has electricity. This focus away from farming, together with the finding that age of the household heads in the sample was generally higher in Chira Meda, explains why there are fewer farmers in Chira Meda than in Asfachew who cultivate their own land (Table 4.2).

Table 4.2. Usufruct rights in Asfachew area during the 2004 meher season in relation to village and gender of household head.

Land use rights	Total (N=161)	Asfachew (N=118)	Chira Meda (N=43)	MHH (N=121)	FHH (N=40)
Use of land distributed to farmer	55	64	30	65	25
Gifted land	2	1	5	0	7
Rent-out land	3	3	0	1	7
Shared out land	24	12	58	13	58
Rent-in land	9	12	2	12	3
Shared in land	7	8	5	9	0
Total	100	100	100	100	100

[a]MHH is male-headed household, [b]FHH is female-headed household

Village life and farming is dominated by religion. All farmers were active church members of the Orthodox Christian Church. Farmers respect Sundays and Christian holidays, on which days they will not work on their land. Besides the annual celebrations such as Christmas and Easter, farmers celebrate five monthly saint's days, such as St Michael and St George.

The *Kebele* is very active in organizing community work. Public buildings and soil and water conservation (SWC) structures are constructed through forced community labour. Farmers who do not show up are fined US$ 1.10 for each missed day. Agricultural extension is active and emphasis is put on fertility management, SWC and tree planting.

4.3.4. Land tenure

Land in Ethiopia is common property of the federal government and its people (Adal, 1999). The regional governments have the power to give farmers usufruct rights over land by way of redistributions (Tefera et al., 2002), which were organized through *Kebele* administrations. The rationale was to distribute land evenly among the rural population. The last redistribution in Amhara Region took place in 1997. Over time, more land on steep slopes has been cleared and distributed to farmers. In 2000, the regional government decided not to redistribute land in the future and to provide farmers with user rights certificates. Farmers are aware of this, but fear decisions of a future regime. Due to the redistributions, land has been fragmented and land holdings are small (Table 4.3).

Table 4.3: Mean land holding sizes in Asfachew area in relation to residence and gender of household head.

Land holding size (ha)	Total (N=58)	Asfachew (N=40)	Chira Meda (N=18)	MHH (N=39)	FHH (N=19)
≤ 0.5	29	28	33	21	47
0.5-1.0	59	7	61	69	37
>1.0	12	15	6	10	16
Total	100	100	100	100	100

[a]MHH is male-headed household, [b]FHH is female-headed household

When a farmer wants to increase his acreage, or when he cannot manage to cultivate his own land, he can rent-in or rent-out land or make sharecropping arrangements (Table 4.2). Contracts are made through the *Kebele* Office or through a group of respected elders, the *yager-shimagile*. Rarely farmers make agreements based on mutual trust. Renting and sharecropping arrangements are allowed for a maximum period of three years. Young farmers can apply for land at the *Kebele*. When land becomes available, it can be redistributed to them. Mostly young farmers inherit some land from their parents or grandparents, which is seldom enough for subsistence. These farmers rent-in land from or make sharecrop arrangements with elderly, poor, or female farmers who do not have the strength or the resources to cultivate their own land. Farmers living in one village often have usufruct rights over land or contracts to use land in other villages of the *Kebele*.

4.3.5. Land use

Land is used intensively because there are two growing seasons in a year. When the *belg* season starts on time, most of the land in Chira Meda and Asfachew is cultivated in both the *belg* and *meher* seasons. Mostly tef, mung bean, chickpea and maize are sown during *belg* season and during *meher* season. When the *belg* season starts late, many farmers decide not to use the season and to wait for the *belg* rains to stop, to sow sorghum immediately thereafter. For sorghum production both seasons are used. Residual soil moisture of the *belg* season is used for seed germination and initial plant growth, while the *meher* rains are used for further crop development.

The land is cultivated using ox-plough. Ploughing is done three to seven times before sowing depending on soil type and crop to be sown; i.e. tef requires a very fine seed bed. Ploughing is done by the men. Weeding is done two or three times per season. Crops are commonly rotated every season and are not commonly mixed in the field. The few farmers with a rainwater harvesting pit use a treadle pump to irrigate a small garden near their homestead. Farmers complain about the pits as the maintenance costs are high. The foil holding the water easily tears, while the water infiltrates fast, the soil can’t retain the water. Evaporation was also a problem commonly mentioned.

Soil erosion and intensive production have caused a fast decline of soil fertility, especially in the steep areas of Chira Meda. Traditionally, farmers maintained soil fertility through fallow, crop rotation, and farmyard manure application on fields nearby the home (Table 4.4). Fallow is no longer practiced. One farmer made this point very clear: “Our fathers used to have two or three plots, but we only have one. It is unthinkable to leave it uncultivated because what am I going to eat?” In Asfachew, green manure is used by spreading the fast-decaying leaves from the broad-leaved croton (*Croton macrostachyus*) on the field. The leaves come from a tree that only grows in the lower areas. Crop residues are used to feed livestock or as fuel for cooking. Contrary to other areas in Ethiopia, such as Debre Birhan (Amsalu, 2006), manure (dung-cakes) is not used as a fuel for cooking. According to one of the officials at the Rural Development Office, because farmers still have other options to meet their needs for fuel.

Table 4.4. Fertility management, SWC and irrigation practices in Asfachew Kebele.

Fertility management	Crop rotation 212 farmers in *Kebele* use farmyard manure 9 farmers in *Kebele* make/use compost In 2004-2006, 2750 kg of Urea and 850 kg of DAP was sold to farmers
SWC structures and irrigation	Contour ploughing and planting, cut-off drains in field and on border of field, stone rows, grass strips and shrubs at plot borders, stone bunds and terraces. 7 farmers have rainwater harvesting pit constructed through community work and a treadle pump. 2 farmers use irrigation from springs on/near field in mountains

An increasing number of farmers use fertilizers, which they can buy on credit. The credit has to be paid back after three months. Farmers explained that to be productive in Chira Meda, one has to use fertilizers. Farmers consider the land in Asfachew as fertile and as such there is no direct need to use fertilizers. However, some farmers have started fertilizers use after seeing differences in production on fields with and without fertilizers applied. The government keeps Diammonium Phopsphate (DAP) and urea[2] in stock in Asfachew *Kebele*. The urea is most popular among farmers because it is cheaper than DAP (urea is US$ 0.36 per kg; DAP is US$ 0.44 per kg) and because it only needs to be applied once in a season. DAP should be applied three times in a season. The advised amount of fertilizers (25 kg of DAP/ha and 49 kg of urea/ha) is not applied as farmers feel that the prices are too high, that its use increases a crop's water demand, and that its application makes land "lazy".

4.3.6. Livestock

Because farmers plough their land using oxen, it is important to own at least one pair (Table 4.5). Farmers consider ownership of draught animals as just as important as having usufruct rights over land through distribution or inheritance. Landless farmers can easily rent-in land or make sharecropping arrangements when they have their own draught animals and plough. These farmers can also hire out their labour and animals as a source of income. Cows can also be used as draught animals, but it is not preferred as these are not as strong as bulls or oxen. Farmers with only one draught animal can also make sharecropping arrangements or pair up their animal with another farmer. Farmers with land but without draught animals need to hire labour, rent-out their land, or sharecrop with other farmers, which is not favoured.

Besides the draught animals, it is good to have some goats, sheep and a donkey. Small livestock can easily be sold when necessary. To own a large herd of livestock is not highly valued by farmers because of feeding problems. Due to land pressure, communal grazing areas have become scarce. Parts of these grazing areas have been distributed to farmers for cultivation. During crop seasons, grazing is restricted to the communal grazing areas. Animals are fed with crop residues. After harvest, livestock is allowed on agricultural fields.

[2] DAP: 46% N, 18% P; Urea: 46% N

Table 4.5. Livestock owned in Asfachew area per household type and per village.

Livestock (%)	MHH[a]	FHH[b]	Asfachew	Chira Meda
≥ 2 draught animals	54	11	50	17
No draught animals	18	68	18	63
No livestock	10	37	13	39

[a] MHH is male-headed household, [b]FHH is female-headed household

4.4. Farmers' perceptions of rainfall

4.4.1. Expectation of rainfall

Like the farmers in Tanzania, the farmers in Asfachew area perceived their area to have medium rainfall. Of the farmers in the questionnaire, 17% agreed that the productivity of the land could get better only if the area received more rainfall. In general farmers did not complain about the amount of rainfall, rather they complained about the timing of the rains. Farmers considered the *belg* season as most unreliable and stated that the problem of unreliability has increased over the past ten years (Slegers, 2008a). Farming during the belg season has become "a matter of chance". Farmers do not expect a good harvest from *belg* season and those farming in Asfachew stated that since 2002, the *belg* has not been productive at all. During group discussions, farmers estimated that nowadays only one-fifth of the land in Asfachew is used during the *belg* season. Most farmers with land in Chira Meda produce crops twice a year.

Farmers who want to use the *belg* season prepare the land and wait for the rains to start. Based on the date of the first rain, they decide whether to sow the land. Farmers who do not use the *belg* season, or who experienced a bad *belg* season, may sow sorghum immediately after the last rains in April. The *meher* season is more reliable and is considered as the main cropping season. Survival of farmers depends on the production of this season. The *meher* season generally has more rainy days per month. Rains should continue until the end of September, otherwise the tef crop will fail. Rainfall in November and December is problematic for farmers as untimely rains can destroy the already matured crops that are drying on the field.

4.4.2. Prediction of rainfall

Farmers do not believe in ways to predict the rainy season. Rainfall comes from God and He decides when and how much it will rain. Their ancestors used to have certain beliefs based on the four evangelists of the Bible. Farmers could talk about it, but not in much detail. It has gone out of use because, according to them, the predictions were often not true. Only few of the predictions are still well-known and appear to be true most of the time[3].

[3] If a Luke year is very windy, it indicates that the next year will be a good year. A Matthew year is mostly a good year.

In general farmers only look ahead one day by sensing weather conditions. They look at the clouds to see whether it may rain that same day. Heavy clouds are a good indicator of rain. When the temperature gets very high, this is another sign that the rains are near. The direction from where the clouds come is another indicator. The rains start in Addis Ababa and from there rain clouds move towards the north. Therefore clouds that come from the south, Debre Sina, will bring rain, but clouds that come from the north, Shoa Robit, will not bring rain.

4.4.3. Influences on rainfall

Farmers believe that there is no way of influencing the rains; the only thing that could be done is to pray for rain and not to arouse the wrath of God. When people disrespect the Christian holy days, or when people fight or steal, God may punish the farmers by bringing them too much rainfall, not enough rainfall, or hailstones that destroy the crops on the field. Farmers have made agreements within their *idir*[4] group, of which almost every household is a member, that there is a penalty for disrespecting Sundays and Christian holy days.

Farmers see a link between deforestation and perceived increase in rainfall variability. The Rural Development Office has a tree nursery in the area and in cooperation with the extension officers provides farmers with eucalyptus trees, fruit trees, coffee plants and *geshu*[5] shrubs. The seedlings are sold at a low price and some varieties are offered for free. Farmers are planting trees mainly around their homesteads or along SWC structures.

4.5. Farmers' perceptions of drought

4.5.1. Descriptions and indicators of drought

As the farmers in Tanzania (Slegers, 2008b), the farmers in Asfachew area mainly define drought (*dirk*) based on weather conditions (Table 4.6). The balance between rainfall and sunshine is considered by the farmers as most important for good crop production. A scorching sun is one of the causes of reduced crop production. Whenever agricultural production is below expectations, farmers refer to their situation as *chigir*, meaning problem. Commonly, problems that farmers mentioned were erratic rainfall, insect pests, weeds, sickness of farmer, and laziness of farmer. From the baseline questionnaire and from later interviews and group discussions it appeared that farmers consider drought as a *chigir*. To some farmers any *chigir* is drought when it results in reduced food availability and sometimes even hunger. A few farmers did not want to discuss drought for too long as they were afraid to provoke it.

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[4] *Idir* is a group of households that contribute a monthly fee. These households help each other when necessary, especially during funerals.
[5] A shrub of which the leaves and branches are dried and used for making local beer and liquor.

Table 4.6. Drought descriptions and indicators for Asfachew area (in percentages).

	What is drought? (N=96)	**How to recognize drought? (N=141)**
Shortage of rainfall	43	3
Shortage of food/animal feed/hunger	16	23
Very strong sunshine	13	18
Chigir (problem)	9	2
Crops/plants damaged and dried/low or no production	8	22
No rainfall	7	8
No rains when expected	1	1
S*edat* (migration)	1	-
Chenefer (bad thing)	1	-
Land is dry/infertile	-	6
Increased death rates of animals/people	-	6
No water in spring/dry river	-	5
Availability of aid	-	1
High price of grain	-	1
Radio broadcasts drought	-	1
Wind erosion	-	1
No clouds	-	1
Total	100	100

The timing of the rains is very important to the farmers. The unpredictable *belg* season is not used by all farmers. Annual production depends on *meher* season. *Meher* rainfall is more predictable and higher in amount.

Not only is there a temporal variety in rainfall, there is also a spatial variety. In Asfachew, annual rainfall is lower and the number of rainy days is fewer compared to Chira Meda. Moreover, days are sunnier and temperatures are higher in Asfachew.

Drought indicators mentioned by farmers relate to weather conditions, its effects on the natural environment, and its effects on food and feed availability. Almost a quarter of the farmers related drought to famine and death of livestock, as happened last time in 1984.

4.5.2. Drought expectation and experiences

Anyone who experienced the severest drought, in 1984, knows real drought and according to these farmers, what they commonly experience is not drought, but rather a diminished production. A year can be called drought when both *meher* and *belg* seasons fail. It will cause famine for both humans and livestock. However, it rarely happens that both seasons fail. *Belg* is not the season that farmers count on. Anything the *belg* season produces in Asfachew, is considered a bonus. Farmers with land in Chira Meda expect more from the *belg* season. When only the *belg* season fails, at least there will be harvest from *meher* season. When *meher* production is good, the year is considered a good year. The failed crop plants from *belg* season will be fed to the livestock.

Farmers' expectation of a year is based on a 'normal' year, although the standard of what is normal seems to be changing since they have started to lose the *belg* season. Of all answers (N=87) in the questionnaire about the years remembered as years with crop failure, more than 80% were related to drought, the remaining were related to insects or untimely cultivation. From the years remembered as years with crop failure, 2% was due to failure of *belg* season, 29% was due to failure of *meher* season, and 69% was due to failure of both seasons. The years remembered were extreme years. The in-depth interviews and group discussions gave more detailed information about extreme years. Farmers have a communal memory for a small set of years, each of which has been given a name. Both farmers who had personally experienced these years and farmers who had not, recalled the following years:

1. 1949, the year which is referred to as *Dubale*, meaning unexpected or suddenly. The season started well, but suddenly the rains stopped, causing a complete crop failure;'
2. 1959, the year which is referred to as *Shenkute*, meaning 'kick in the society'. It was a year of hunger that hit the people;
3. 1980, the year which is referred to as *Zuriaw zendo*, meaning 'all over dragon'. It was a drought that occurred all over Ethiopia;
4. 1984, the year which is referred to as *Chenefer* or *Kifuken*, meaning 'bad day'. This was the most severe drought according to the farmers.

Almost all farmers personally experienced the drought of 1984, which had deep impacts on everybody's life. Many stories were told about how people tried to survive within the area, how people and livestock died of hunger, and how people migrated. One survival strategy, which was told by several people, shows the destitution of that period and the despair that people felt. Some husbands brought their wives to areas where the situation was better and gave their pretended 'sister' away for marriage in return for a bride price. The first husband would then go back home to take care of the children and other relatives. From time to time he would visit his 'sister', who would give her 'brother' some food for her relatives. After the drought had passed, some women returned to their first husbands, while others stayed with their second husband. One very old farmer told that the experience of 1984 had changed his perception of drought. He had thought that drought would only hit the poorer people. The 1984 drought left all people "naked": it was not possible to distinguish rich from poor. Farmers fear ending up in a similar situation again and make sure they have food in stock.

The year 2002 has officially been recorded as a drought year with food shortage but was only mentioned by a few farmers as such. The government had organised food-for-work for 300 farmers in Asfachew *Kebele*. These farmers received maize in return for their participation in the construction of rainwater harvesting pits.

4.6. Farmers' perceptions of drought risk

With the big drought of 1984 in memory, all production losses due to shortage of rainfall since that time have been comparatively minor. Almost all farmers perceived a reduced drought frequency (67%) and severity (68%) or an unchanged drought frequency (31%) and severity (28%). Only the farmers younger than 20 years, the first generation that has not personally experienced the 1984 drought, unanimously agreed that there had been no changes. The problem that farmers experience is a reduced reliability of the rains over the past ten to twenty years. An explanation given for this change in reliability is deforestation. Land has been cleared to increase agricultural acreage. The poorest farmers cut trees illegally for charcoal burning as a way to make some income. The bush land that still remains, mostly on the steepest slopes, is used for firewood collection.

Deforestation has resulted in increased soil erosion; soils have lost depth and fertility. Through extension, farmers have learned that deforestation reduces rainfall amount and predictability. Farmers see proof of this within their surroundings. The lowland areas, from Asfachew towards Shoa Robit have only few trees and have low and erratic rainfall, while the area surrounding Debre Sina is rich in trees and has a better rainfall pattern.

Farmers are aware that land gradually has become less productive due to continuous cultivation and soil erosion and that this has increased drought vulnerability. Gradually, farmers are investing in trees, fertilizers, SWC and in rain water harvesting structures. Not every household experiences a similar loss of harvest in case of a dry season. Farmers identified differences in drought vulnerability based on characteristics of the land, land management practices and farmers' characteristics (Table 4.7).

Table 4.7: Differences in drought vulnerability as perceived by farmers in Asfachew area.

Differences in drought vulnerability based on:		**Most vulnerable to drought:**
Land characteristics	Location of land	Steep slopes
		Asfachew more sunny, hot and less rainfall
	Soil type	Red *Merere* soils
		Borabor soils
	Soil depth	Shallow soils
	Soil fertility	Unfertile soils
	Stones	Many and big stones
	Erosion sensitivity	Land on steep slopes
Land management practices	Investments	Those who do not use SWC
		Those who do not apply fertilizers
	Crop type	Maize
Farmers	Ability	Female-headed households
		Households who lack oxen and/or labour
		Households who have no access to credit
		Households without land
		Households with drought-vulnerable land
	Attitude	Lazy farmers

4.6.1. Characteristics of the land

Farmers in Asfachew generally identified drought-vulnerable areas based on soil type, while Chira Meda farmers mainly referred to the quality of the land. Soil types that farmers distinguish (Table 4.8) can be classified according to soil texture: from soils with high clay content (Vertisols) to soils with high sand content (Cambisols) and to soils mainly consisting of gravel and stones. For each soil type, farmers identified soil properties that influence its drought vulnerability. Soil depth and soil fertility positively influence water holding capacity. Soils that are rich in clay require a lot of water before it is possible to cultivate them.

Farmers refer to the black merere soils as initially "deaf" for water, as this soil type does not react immediately to the first rainfall of the season. The sandy soils are "easily satisfied" when there is rainfall, but require regular rains, as these soils do not hold the moisture for a long period. An area's drought vulnerability is not only dependent on natural characteristics of a soil, also on the state of the soil and location of the land. Of the sampled farmers, 64% agreed that soil degradation can cause drought.

Table 4.8: Soil types, location and properties as perceived by farmers in Asfachew area.

Texture	**Soil type**	**Location**	**Characteristics**	**Productivity** 1=most productive 5=least productive
Clay ↓	Black *Merere*	Flat areas Asfachew	Black, sticky, heavy to plough, low water infiltration capacity, deep soil, fertile	Bad rainfall: 4 Good rainfall: 2
	Boda	Mainly flat areas Asfachew	Dark, slightly sticky, high water demand, good water holding capacity, deep soil, more fertile than black *Merere* soil	Bad rainfall: 1 Good rainfall: 1
↓ Sand	Red *Merere* *Borabor*	Flat land and steep areas, Chira Meda	Red in colour, slightly sticky, low water infiltration and water holding capacity, low fertility	Bad rainfall: 5 Good rainfall: 5
↓	*Seteafer*	Slopes, Asfachew and Chira Meda	Brown soil, sandy, thin topsoil, stony underground, requires good rainfall, low water holding capacity, low fertility	Bad rainfall: 2 Good rainfall: 3
↓ Gravel and stones	*Ajara*	Steep and gentle slopes Chira Meda and Asfachew	Gravel and stones on the surface, shallow soil, medium water holding capacity, some soils more stone than soil, low fertility	Bad rainfall: 3 Good rainfall: 4

The location of the land influences whether land is vulnerable to soil erosion. Chira Meda has more land with steep slopes. The steep areas are highly vulnerable to erosion; after an intensive rain shower early in the 2006 *meher* season, rills were visible. These locations contain much gravel and many stones. Small stones and gravel are not necessarily considered as negative. On the contrary, these reduce a soil's vulnerability to soil erosion, increase water infiltration and reduce evaporation. However, plots where almost all the soil has been washed away contain too many and too big stones, are very shallow and lack nutrients. The seeds cannot easily germinate, and roots cannot penetrate. Without fertilizers, these plots will not be productive. Not only the soil and nutrients are washed away, but farmers downhill complain about the big stones that cover their land after such high-intensity rainfall events.

The deep, sticky soils are found around Asfachew. The most productive soil types are *boda* soils, and secondly black *Merere* soils. The black *Merere* soils were considered to be most vulnerable to drought. Even though the most drought-vulnerable soils are found in Asfachew, farmers said that it is impossible to infer that the farmers living in Asfachew are more vulnerable to drought as farmers can have land anywhere in the *Kebele*.

4.6.2. Land management practices

Since every plot has its own difficulties and benefits, each soil type and location requires different management practices. Farmers generally agreed that the soils in Chira Meda require more work than the land in Asfachew. Land in Chira Meda requires SWC measures and fertilizers because these soils are often on steep slopes. The most commonly used SWC measures are contour ploughing and planting, stone rows and grass strips at the border of the field, and cut-off drains to divert water from uphill and within the field. Of the SWC measures that are used, stone bunds, terraces and rainwater harvesting structures are least common and are often constructed as part of community work. Rills are ploughed after harvest or are covered with branches for stabilization. Fertilizer use is increasing rapidly and most farmers in Chira Meda mentioned that they could not be productive without fertilizers.

Farmers also recognized that some crops like maize have higher water requirements than other crops like sorghum and chickpea. Farmers have a strict agricultural calendar with exact sowing periods for each crop. Which crop to be sown is partially determined by the start of the rains.

4.6.3. Farmers' characteristics

Farmers agreed that the diverse characteristics of the land have made farmers with land in Chira Meda active and the farmers in Asfachew lazy. Lazy farmers could gain higher production if they would only be more active; if they would use fertilizers, practice SWC and make efforts to get rent contracts to cultivate more land. However this does not only involves the activeness of the farmer, it also concerns a household's ability in terms of resources. Farmers who lack labour will face difficulties making SWC structures, those who

lack draught animals cannot plough their own land, those without financial means cannot rent-in land and the ones without access to credit may not be able to buy fertilizers (Slegers, 2008a).

Farmers with land in Chira Meda do also have benefits. Their land is located at higher altitudes where rainfall amount is higher and potential evaporation is lower. Farmers with land at higher altitudes have a higher chance of getting harvest from *belg* season.

Farmers with good quality land are less vulnerable to the effects of a bad season in terms of rainfall because they may still get a reasonable harvest. In good rainfall seasons, farmers will be able to get a good produce, enough to enlarge grain reserves.

Another drought-vulnerable group were the landless farmers. They can rent-in land or make sharecropping arrangements. However, they have to invest money or part of the produce to get access to land. When the harvest (partial) fails, they may get nothing or very little in return for their investments. One of the young male farmers with whom this issue was raised, stated that even though they preferred to have their own land, things will work out as long as they are active. Being an active farmer gives a good reputation and enables them to get new contracts on land of good quality. However, another landless farmer stated that he was not able to make the initial investment for making a renting contract. He had to do day labour on other farmers' land to get some income.

Another group that was identified as drought-vulnerable were female-headed households. This group lacks opportunities. For a male it is easy to temporarily move out of the area for wage labour. Females have to take care of their household. Traditionally, ploughing is a typical male job. Females are not to plough the land. It is a heavy work, especially on the *Merere* soils. Farmers said that nowadays females can plough the land, but it is not commonly done.

Fifty five percent of all households and 74% of the female-headed households were not self-sufficient in a normal year. Generated cash is used to buy food (Slegers, 2008a). Major reasons for not being self-sufficient were: "shortage of land" (50%), "unproductive land" (27%) and "have to make sharecropping arrangements" (15%). These reasons reflect farmers' thoughts about drought vulnerability.

4.7. Perceptions explained using the perception model

4.7.1. Elements shaping perception of drought

Asfachew farmers have experienced diminished harvests due to unfavourable weather conditions (Figure 4.2). The duration of a rainy season, together with its timing, and periods of strong sunshine were the most crucial weather conditions. Farmers have experienced drought before. The most recent drought of 1984 had devastating consequences and is carved in peoples' memories. This event left everyone destitute and one farmer explained how the 1984 experience had changed his opinion about drought; i.e. that it not only affects the poorer households, but even the rich ones.

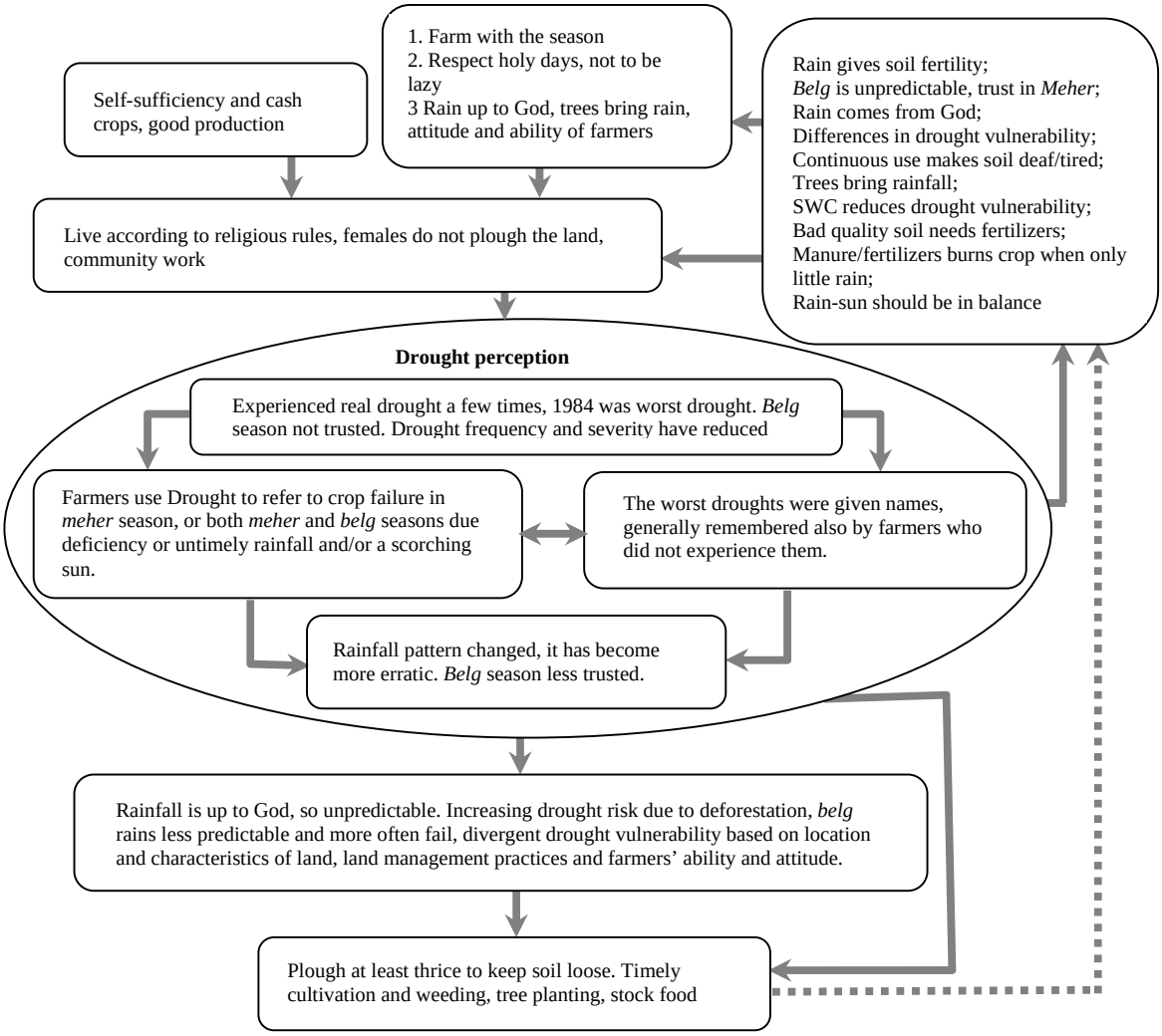

Figure 4.2. Influences on and elements shaping drought perception in Asfachew area.

Farmers remember extreme drought years with reduced productivity (Saarinen, 1966; Ferrier and Haque, 2003). With experience of the devastating drought and subsequent famine of 1984 in their memories, farmers agreed that no droughts have occurred since. This case demonstrates the influence of experience on drought perception, as was described by Taylor et al. (1988).

Heathcote (1969) argued that one's perception depends on one's environment and its characteristics. Asfachew farmers adhere to the principle of drought being a complete crop failure during *meher* and possibly also *belg* season due to deficient or untimely rainfall, resulting in famine. Farmers depend on *meher* for food production and are used to failures of the *belg* season. Farmers use "*chigir*" (problem) or reduced production in less severe situations to refer to a year with reduced crop production due to deficient rainfall or imbalance between rainy days and sunny days.

Droughts may be expected in the future, but no prediction can be made. Farmers believe that it is up to God to decide the timing and amount of rainfall. However, it is not possible to state that farmers have a fatalistic attitude (Park, 1999). Farmers felt that the variability of rainfall, especially during *belg*, has increased over the past decade or two. However, they generally felt that frequency and severity of droughts have decreased because according to their definition no droughts have occurred since 1984. Asfachew farmers experience other productivity-reducing problems. Land pressure has increased land use intensity. Marginal land has been distributed to farmers. It has resulted in deforestation, increased grazing pressure on communal grazing areas and loss of soil and soil nutrients. Loss of productivity is becoming a continuous threat for farmers, while erratic rainfall represents only an occasional threat to them. This was for one group of farmers a reason to state that the degradation of their land was their major threat. Other farmers felt that the occasional rainfall deficiency was their priority problem. In a normal year they are still productive, whereas a dry year can cause even complete crop failure.

4.7.2. Perceptional environment

Farmers do not consider drought in strictly meteorological terms. Farmers have area-specific knowledge about how soil properties, location of land, land management practices, and changes in their physical environment, create differences in drought vulnerability. Studies about drought perceptions of farmers in Burkina Faso (Slegers et al., 2005) and Tanzania (Slegers, 2008b) showed similar results. Klintenberg et al. (2007), who studied farmers' perceptions of environmental change in Namibia, also observed that farmers' views were based on knowledge about area-specific situations, changes and agricultural practices.

Bekele-Tessema (1997: 96), who has performed an environmental assessment in Tikurso catchment where Asfachew *Kebele* is part of, reported how old farmers remembered the area from their childhood. Trees and the number of tree species were abundant and harboured wildlife such as lions, leopards and occasionally elephants. Agricultural lands were fertile and gave good harvests and there was ample grazing land available to feed the livestock.

According to farmers in this study, land availability has been a problem since the 1980s. Each farmer has been given usufruct rights over a very small piece of land, while young farmers are landless. Anyone without land or who wants to expand his acreage has to make sharecropping arrangements or has to rent-in land. Competition over land is high. Land is cultivated once or twice every year, which will have negative consequences for soil quality when no soil fertility enhancing measures are taken. One 88-year old farmer compared changes in the quality of the land to himself: "I used to be beautiful, like the land was. I have become ugly over the years, just like the land has after years of use". Farmers have small land holdings and therefore, it is very important to cultivate good quality land to reach self-sufficiency. However, soil quality is reducing and has made good-quality land valuable. A farmer sharing out his land can get half of the produce when the land is fertile, while he or she will only get one-third of the produce when the land is of poor quality.

Differences in soil quality are considerable. Bekele-Tessema (1997) has identified that the majority of the land had a poor or even extremely poor soil fertility. Soil depths in Tikurso catchment were rather shallow: 38% of the soils had a maximum depth of 30 cm and 80% of the soils had a maximum depth up to 70 cm. Most hills have been deforested and bush vegetation remains on the very steep slopes. Land with slopes in excess of 60% has been put into cultivation using hand hoe. The soils on such steep slopes are washed down in a few years time and in has left some parts of Tikurso catchment with extremely shallow soils of less than 10 cm in depth (Bekele-Tesemma, 1997).

4.7.3. The influence of values, beliefs, knowledge and culture on perception

Religion plays a role in agriculture. Farmers pray to God to ask for rains. The farmers of Asfachew area do not work on Chirstian holy days. Anyone who breaks this rule, trespasses against God (Strauss and Orlove, 2003) and may arouse His wrath. This may result in unfavourable weather conditions.

Farmers want to be self-sufficient and to be able to have some extra produce to sell. Farmers place a high value on keeping reserves, either in cash, food, or livestock. This will help them to survive a bad year. However, as described by Ajzen (2002), farmers are or feel restricted due to internal and external locus of control. Timely cultivation and weeding is very important. Ploughing has to be done several times before one can sow and weeding is a tedious job done by hand. When one has land but no draught animals, a farmer has to rent-out the land or to make sharecropping arrangements. Females are not supposed to handle the ox-plough. Farmers in Asfachew area face another constraint, which especially in Chira Meda is gaining importance. Loss of soil fertility has reduced productivity to the extent that farmers with land in Chira Meda have to use fertilizers to be productive. Therefore, farmers who lack resources or who are weak are more vulnerable to drought as they lack control (Ajzen, 2002).

Farmers related the perceived increase in rainfall variability to deforestation. Farmers' reactions to the pictures shown in the picture assignment confirmed information gained through interviews and group discussions; pictures that showed areas with many trees and bushes were considered as areas receiving more rainfall than their own area. Other studies have also reported a perceived link between diminished rainfall and deforestation (Meze-Hausken, 2004; Slegers et al., 2005; Slegers, 2008b).

Most knowledge about agriculture was knowledge learnt from parents and grandparents or was based on experience; they have developed certain farming styles (Van der Ploeg, 1991). Timely cultivation or farming with the rains is one of the most important elements therein. An example of this is the strict agricultural calendar that farmers use with for each crop a precise period for sowing.

Farmers had detailed knowledge about their environment and their soils. Each soil type distinguished had its own characteristics and drought vulnerability. Farmers were also aware of how agricultural practices influence drought vulnerability. Timing of cultivation

and weeding, crop type and variety sown and use of SWC measures, all were mentioned to influence drought vulnerability.

The active extension service and forced community labour on SWC structures and the diminishing productivity levels of the soil has speeded up the use of fertilizers and SWC measures. Maintaining soil quality is crucial, especially since farmers only have very small amounts of land to cultivate.

4.7.4. Drought risk perception

Farmers recognized differences in drought vulnerability, both of land and of people. Farmers who lack resources or who are lazy are more at risk. This includes most female-headed households since they more often lack resources and possibilities. Farmers who have no land, who have land only at lower altitudes of the *Kebele*, or who have land of low quality are at higher risk of crop failure due to poor rains. Insecurity not only has different impacts on individuals and social groups, it also changes over time (De Bruijn and Van Dijk, 1995).

Climate change is said to be occurring, however studies on long-term trends in rainfall patterns in eastern Africa have not confirmed ideas about general increase of drought frequencies (Nicholson, 2001; Conway et al., 2004; Scoones, 2004; Seleshi and Zanke, 2004; Seleshi and Camberlin, 2006; Amsalu et al., 2007; Stroosnijder, 2008). Insight is needed into how farmers' drought risk perceptions relate to the actual rainfall trend in the area.

In general, farmers perceived drought as complete crop failure, or absence of rainfall. This may imply that farmers underestimate drought risk, as farmers do regularly face partial crop failures. The 'prison of experience' (Ferrier and Haque, 2003) or the 'curve of perception' (Heathcote, 1969) seem to be true in the case study area. Farmers' threshold for what can be called drought is high. The majority of farmers believed that the frequency and the severity of droughts had reduced or had not changed, especially the youngest generation of farmers felt that the drought trend had not changed.

Nationwide, the area with stable rainfall has decreased while the area with highly variable rainfall has increased, which results in higher drought frequencies (Mersha and Boken, 2005). The National Meteorological Services Agency of Ethiopia (NMSA, 1996) applied the decile technique (Gibbs and Maher, 1967) to rate droughts. They identified three drought intensities: mild, moderate and severe. In the case of a mild drought, negative anomaly from the mean seasonal rainfall is 19% or more, but below 21%. In the case of a moderate drought, negative anomaly from the mean seasonal rainfall is between 21 and 25%. When anomaly from the mean seasonal rainfall is more than 25%, a drought is considered as severe. When using these criteria on the data from Debre Sina, it follows that 2002 had a severe drought for both individual seasons and for the year as a whole. However, this year was not generally considered by farmers as "drought", even though there was food-for-work.

Farmers depend on *meher* season. In Debre Sina, six out of seven *meher* season droughts occurred in the period between 1984 and 1992, while six out of eight *belg* season

droughts occurred in the period between 1993 and 2005. These figures can explain farmers' feelings that the drought trend has reduced but that they are "losing" *belg*.

4.8. Conclusion

Farmers in Asfachew area rely on the *meher* season for their food production. Whatever the *belg* produces is considered a bonus, especially by farmers who use land at the lower altitudes. Farmers' general feeling was that they have "lost" the *belg* season. The *belg* rainfall pattern has increased its variability. Farmers believed that the *meher* rainfall pattern had not been affected. Rainfall data from Debre Sina indeed shows many *belg* drought incidences over the past fifteen years compared to the previous decade, while for the *meher* drought incidences the opposite was true. Since 1984, there has not been a drought according to farmers' definition. However, the year 2002 has officially been recorded as a severe drought. Not so in farmers' minds. They still have a vivid recollection of the destitution of the 1984 famine: the drought that did not differentiate between rich and poor and that left everyone "naked".

It has been suggested that farmers have a fatalistic view on drought. However, this case study suggests otherwise; farmers recognize that one has to be an active farmer to be productive and to withstand drought conditions and that human-induced environmental changes influence drought vulnerability. Farmers have started using fertilizers and gradually see the beneficial effects in their production.

Farmers related the increased variability of the rains to the ongoing deforestation in the area. Besides this direct link, there was also an indirect link between deforestation and the rains. Asfachew farmers agreed that deforestation has increased soil erosion rates. Soil and soil nutrients have washed down, with the result that land especially in Chira Meda has lost productivity and most of its depth. Some farmers are merely cultivating stones. Continuous cultivation furthermore depletes the land. All of these soil degradation processes were considered by farmers as processes that make their land more vulnerable for drought. Crops on degraded soils cannot resist long dry spells such as can be expected during the unreliable *belg* season. Further study of the area's rainfall pattern should reveal whether there actually is a trend visible in the rainfall patterns, or if farmers' perceived changes in the rainfall pattern can be explained by ongoing soil degradation processes.

Figure 4.3. Rill erosion on sloping land covered with stones.

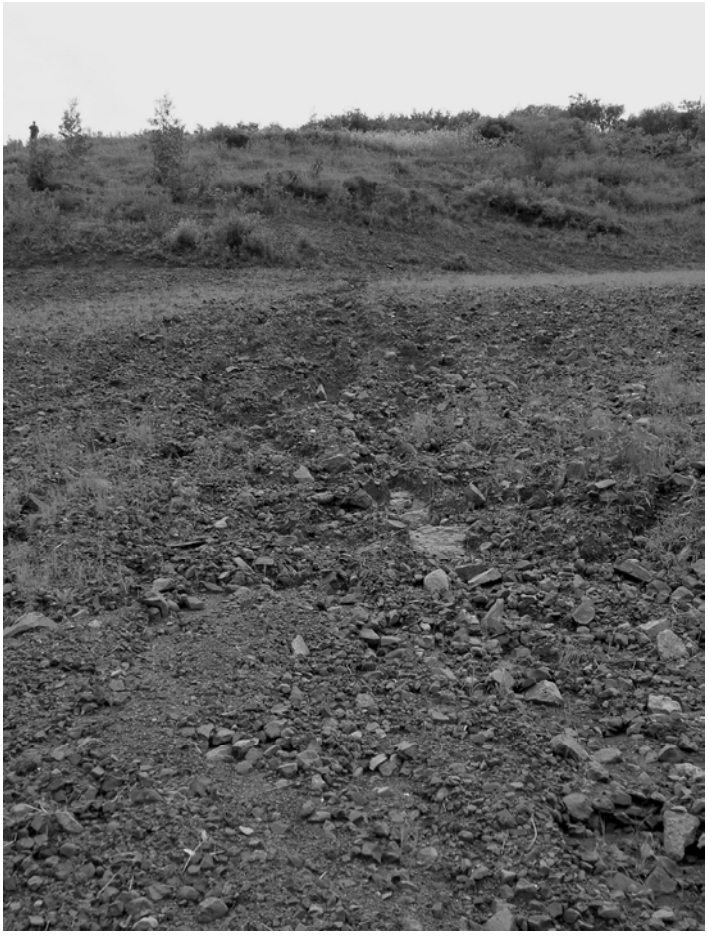

Figure 4.4. Culivating stones. The field is sparsely covered with tef.

Figure 4.5. Boys grazing livestock.

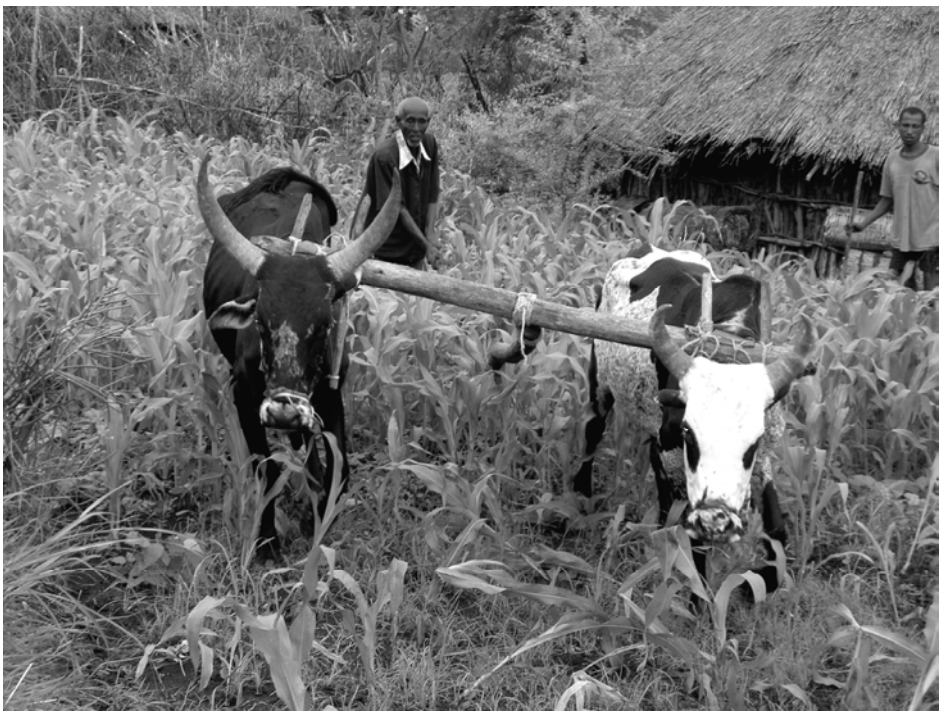

Figure 4.6. A farmer thinning his sorghum crop in his homestead field.

Chapter 5

Rainfall and dry spells in Tanzania and Ethiopia and farmers' perceptions about recent changes

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Submitted to Climate Research

5. Rainfall and dry spells in Tanzania and Ethiopia and farmers' perceptions about recent changes

Abstract

Studies in Kondoa District, Tanzania, and North Shoa Zone, Ethiopia, have focussed on the factors behind farmers' preoccupation with 'drought'. In both places, the prevailing feeling is that the rains have become less reliable over the past ten to twenty years. The farmers in Tanzania were mainly concerned about increasingly severe droughts, whereas those in Ethiopia believed that they had been "losing" the short rainy season. Rainfall data was analyzed for its annual and intra-seasonal patterns, the number of rainy days, the maximum daily rainfall, the mean rain per rainy day, and the lengths of dry spells. The results were compared to the farmers' knowledge and their perceptions. These analyses did, however, indicate some changes in rainfall and dry spells which accorded with the farmers' perceptions, although most of these were not significant enough to provide them with scientific proof. The Tanzanian data revealed one significant change in the period 1970-1971-2005-2006: a negative trend in the length of December dry spells. The Ethiopian data showed no significant change (1984-2005). Perceived changes in rainfall may be a result of changes in other physical parameters. The farmers in both areas believed that deforestation had contributed to the rainfall problems, and that different soil properties also influence a plant's ability to withstand dry conditions. Greater insight into the local biophysical processes which interact with soil-water properties is required, because such information would contribute to a better understanding of farmers' concerns about the rains.

5.1. Introduction

Scientists working on sustainable land use in Eastern Africa have not always succeeded in changing farmers' agricultural practices towards a more productive and sustainable use of natural resources (Kiome and Stocking, 1995; Ringrose et al., 1996; Bekele-Tesemma, 1997; Cartier and De Graaff, 1998; Tenge, 2005; Van den Bosch and Sterk, 2005). Local subsistence farmers were more concerned about drought than about land degradation (Östberg, 1995; Beshah, 2003; Biamah, 2005; Hella and Slegers, 2006; Stroosnijder, 2008). To overcome productivity problems in a sustainable way, it is important to reconcile the difference between the difficulties perceived by the scientists and those perceived by the actual users of the environment (Slegers and Stroosnijder, 2008).

Drought is a recurrent and normal feature of a climate, a natural hazard (UNCCD, 1994; Kassas, 1995), which causes temporal changes in productivity (Slegers and Stroosnijder, 2008). Most farming systems in Eastern Africa are rain-fed and labour-intensive, and food security is directly affected by climate variability (Ziervogel et al., 2008). Judgments about a drought's severity are culturally defined and should be taken into consideration (Slegers and Stroosnijder, 2008; Stroosnijder, 2008).

Unlike in Sahelian West Africa (Hulme et al., 2001; Nicholson, 2001; West et al., 2008), studies of long-term trends in rainfall patterns in different areas of East Africa have not provided definite proof of an increased drought problem (Chappel and Agnew, 1999; Nicholson, 2001; Conway et al., 2004; Seleshi and Zanke, 2004; Seleshi and Camberlin, 2006; Adosi, 2007; Amsalu et al., 2007; Stroosnijder, 2008). Rainfall variability in Eastern Africa occurs over short periods of time and is more influenced by the El Niño-Southern Oscillation (ENSO) phenomenon (Nicholson, 2001).

Within a year, the total amount of rainfall may be accord with the long-term average, yet extended dry spells within the rainy season can cause total or partial crop failure (Barron, 2004). The timing of a dry spell within a cropping season is crucial to later crop development, or even crop survival.

Studies in the Kondoa District, Tanzania and the North Shoa Zone, Ethiopia focussed on understanding local drought perceptions and the factors behind farmers' preoccupation with 'drought' (Slegers, 2008a). In both areas farmers believe that the rains have become less reliability over the past ten to twenty years. The farmers in Tanzania were most concerned about an increased severity of droughts, whereas the farmers in Ethiopia felt that they had been "losing" one of the two annual cropping seasons.

This paper explores these issues further by analysing rainfall data from the two areas. Seasonal characteristics and possible trends were compared to farmers' knowledge about the rainy seasons and perceived changes thereto.

5.2. Study areas and methodology

5.2.1. Goima area, Tanzania

Goima area lies at the foot of the Burunge Hills, at an altitude of between 1,300 and 1,400 m.a.s.l. It is situated in the northern part of semi-arid central Tanzania, 40 km south-east of Kondoa town. The area is characterized by an undulating landscape of plains and scattered small hills and has sandy soil.

The upper slopes of the hills consist of bare rocks and forests. More and more areas are being cleared, both legally and illegally. Goima's farmers traditionally practiced rotational bush fallow, during which long fallow periods of about twenty years were common. The use of fallow has decreased in recent decades, due to a shortage of vacant land (Östberg, 1995).

Goima has a uni-modal rainfall pattern and rain can be expected between November and May. The variability of inter and intra-seasonal rainfall is high. No reliable data exist on the rainfall of Goima area, but annual figures estimate that it is less than 550 mm (Östberg, 1995: 32). The mean seasonal rainfall, measured at the meteorological station at Kondoa town, 40 km north-west from Goima, is 668 mm[1]. Potential evapotranspiration in the area is

[1] Analysis of daily rainfall data further on in this article, data for 1970-2006

about 1,700 mm year^{-1} (Östberg, 1995: 31). Rivers are ephemeral and have high peak discharges both during and shortly after rainfall events.

5.2.2. Asfachew area, Ethiopia

Asfachew area is situated in North Shoa Zone, some 200 km north-east of Addis Ababa, along the tarmac road which runs between the two small towns of Debre Sina and Shoa Robit. There is a difference in altitude between these two towns, which are 25 kilometres apart, of about 1500 metres. The altitudes within Asfachew area range from about 1470 to 1850 m.a.s.l. The terrain at higher altitudes is rugged. One village is constructed on a plateau, from where steep cliffs and ridges lead down to a number of small terraces (Bekele-Tesemma, 1997). At lower altitudes, the landscape has fairly steep slopes, covered with colluvial depositions. The land is relatively flat towards the floodplain of the braiding Tikurso River. The wide river bed is covered with deposited stones. The river has high peak discharges both during and soon after rainfall events, and turns into small braided streams shortly after the rain stops.

Asfachew area has a bi-modal rainfall pattern. The short rainy season, which is called the *belg* locally, commences at the end of January or early February, and lasts for three months. The main rainy season, which is called the *meher*, starts at the end of June or in July and also lasts for three months. *Meher* rains are generally more predictable, more intense and more frequent than those in the *belg*. The sometimes intense rain showers can be highly erosive, particularly when they fall early in the season when the soil is not covered with plants. The mean annual rainfall, measured at the meteorological stations at Debre Sina and Shoa Robit, is 1839 and 1003 mm respectively[2].The annual potential evapotranspiration in Shoa Robit is 1517 mm (Bekele-Tesemma, 1997).

5.2.3. Methodology

Sociological field studies have been conducted in both Tanzania and Ethiopia in the period from December 2004 to October 2006. The central issue was how farmers perceive their environment in terms of rainfall and drought. Consideration was also given to related topics such as rainfall predictions, drought vulnerability, and the adapting and coping strategies used to deal with a dry year.

The studies included baseline questionnaires, in-depth interviews, a series of group discussions, visits to farmers' fields, and, in Tanzania, a one-day multi-stakeholder platform during which local farmers, scientists, and local, district and regional level government officials were brought together to discuss drought problems. This article will only refer to the farmer's knowledge of the rainy seasons, and their perceptions of drought and the

[2] Analysis of daily rainfall data further on in this article, data for 1984-1994 and 1996-2005 (Debre Sina) and 1984-1994 (Shoa Robit)

changes thereto, and will compare this information to the outcomes of analyses of rainfall data. In both countries, farmers were concerned about the rains, and perceived that the rainfall pattern had changed.

In Tanzania, data from Kondoa Meteorological Station (Kondoa) were used. Daily rainfall data over a period of 37 years (1970-2006) were rearranged into 36 cropping years, running from October to September the following year. Spatial and temporal rainfall variability is high, and therefore, in Goima area, daily rainfall was measured during the 2005-2006 cropping season with two tipping bucket rain gauges with a WatchDog data logger. The 2005-2006 daily rainfall data from both Goima and Kondoa were tested for their correlations with each other and with the Kondoa data in the period between 1970-1971 and 2005-2006 seasons. Since the data for the majority of the cropping years had no normal distribution, we used Spearman's rho correlation.

In the case of Ethiopia, daily rainfall data were obtained from two nearby towns that represent the differences in altitude found within the study area. Debre Sina meteorological station (Debre Sina) is located at an altitude of 2800 m.a.s.l. and that of Shoa Robit at 1275 m.a.s.l. Daily rainfall data were available for a total period of 21 years (1984-1994 and 1996-2005) from the former, and for an 11-year period (1984-1994) from the latter. These data were not reorganised because the cropping year corresponds with the calendar-year. The daily rainfall data from both stations over the period 1984 to 1994 were tested for correlations using Spearman's rho correlation.

The data representing both study areas were analyzed for annual and intra-seasonal rainfall patterns, the number of rainy days, the maximum daily rainfall, the mean rain per rainy day and the length of dry spells and for possible trends therein. For the intra-seasonal analyses in Tanzania only data from the period between November and June were used because rainfall in the remaining months was either nil or extraneous.

Instat + 3.033 software was used to perform a two-state Markov analysis of the first order on the meteorological data from Kondoa, Debre Sina and Shoa Robit to determine both unconditional and conditional probabilities of rainfall on any given day of the year and to determine the probability of dry spells of predetermined lengths within the next 30 days.

In a two-state Markov chain, each day of the year (d_j) is classified into one of two possible states, rainy or dry (Coe and Stern, 1982). A day is classified as rainy when rainfall is at least 0.85 mm. First order means that the probability of any day (d_j) within a year (Y_i) being rainy P(r) is a stochastic event, which only depends on the state of the previous day, either rainy (P(rr)) or dry (P(rd)) (Coe and Stern, 1982; Barron et al., 2003).The probability of a rainy day after a rainy day (Barron et al., 2003) can be estimated as:

$$P(rr) = \text{Prob}(d_j = 1, d_{j-1} = 1) = \frac{\sum_{Y=1}^{Y=i}(d_j = 1, d_{j-1} = 1)}{\sum_{Y=1}^{Y=i}(d_{j-1} = 1)} \qquad (1)$$

The probability of a rainy day after a dry day (Barron et al., 2003) can be estimated as:

$$P(rd) = Prob(d_j = 1, d_{j-1} = 0) = \frac{\sum_{Y=1}^{Y=i}(d_j = 1, d_{j-1} = 0)}{\sum_{Y=1}^{Y=i}(d_{j-1} = 0)} \quad (2)$$

A Fourier analysis was done to fit a function to the estimated probabilities. The best fitting function (according to F-test) is determined by changing the number of terms (harmonics) in the model (Coe and Stern, 1982; Barron et al., 2003). Sites with a uni-modal rainfall pattern usually require a function with two or three harmonics, and those with a bi-modal rainfall pattern usually require a function with four harmonics (Coe and Stern, 1982). The fitted models are used to estimate probabilities of rainfall and dry spells of different lengths (Barron et al., 2003).

5.3. Results

5.3.1. Rainfall and dry spells in Goima area

Rainfall

The 2005-2006 rainfall data from Kondoa and Goima had a significant correlation (r_s = 0.658, $p < 0.01$). Of the earlier seasons measured at Kondoa, 17% had a significant correlation with the area's 2005-2006 seasonal rainfall ($p < 0.05$). This figure was 8% when

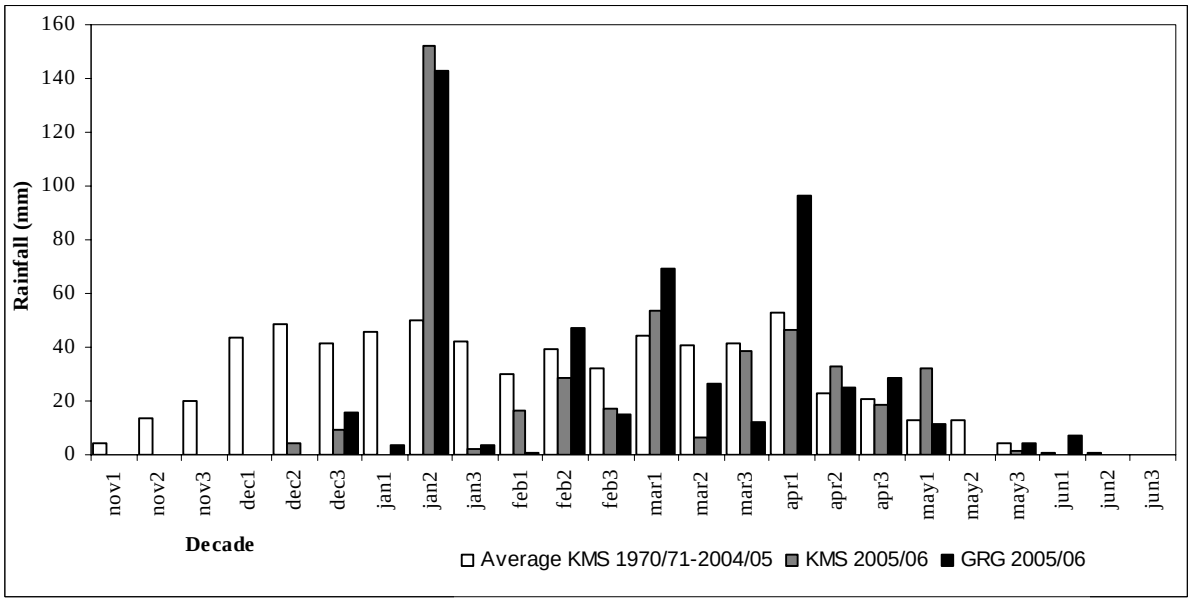

Figure 5.1. Mean rainfall per decade (from November to June) at Kondoa Meteorological Station (KMS) (1970-1971- 2004/05), and rainfall distribution during 2005-2006 season at KMS and Goima Rain Gauge (GRG), Tanzania.

Table 5.1. Long-term seasonal means of different climatic indices (data for 36 seasons; from November to June) compared to 2005-2006 season and the trend over all 36 seasons; data from Kondoa Meteorological Station (KMS), Tanzania.

	cropping season			
	2005-06	**Mean of 1970-71/2005-06**	**CV (%)**	**Trend 1970-71/2005-06**
Seasonal rainfall (mm)	461	659	27	- 0.26
Number of rainy days (days)	43	55	20	-0.01
Maximum daily rainfall (mm)	66	77	49	- 0.45
Mean rain per rain day (mm)	11	12	18	-0.02

it comes to the correlation between previous seasons in Kondoa and the Goima 2005-2006 seasonal rainfall ($p < 0.05$). The 2005-2006 rainfall distributions at both Kondoa and Goima deviated from the long-term mean at the former (Figure 5.1). All climatic indices for Kondoa (Table 5.1) reveal below-mean figures for the 2005-2006 season, when compared to the long-term mean for the period between 1970-1971 and 2005-2006.

Mean rainfall over the cropping years (October to September) from 1970-1971 to 2005-2006 was 668 mm (Figure 5.2), but variability is high. More seasons had below than above mean rainfall. The wetter seasons had greater deviations from the mean than the drier ones. This is notable when looking at extreme dry and wet seasons. An extreme dry season was defined as being a below-mean rainy season, with a 10% or less chance of occurrence, while an extreme wet year was defined as an above-mean rainy season with a 10% or less chance of occurrence. In this dataset an extreme dry season had at most 433 mm of rainfall and an extreme wet year had at least 903 mm.

Least squares linear fitting for trend analysis of the long-term meteorological data highlighted that none of the climatic indices had significantly changed (Table 5.1). All of these climatic indices indicate slight decreases.

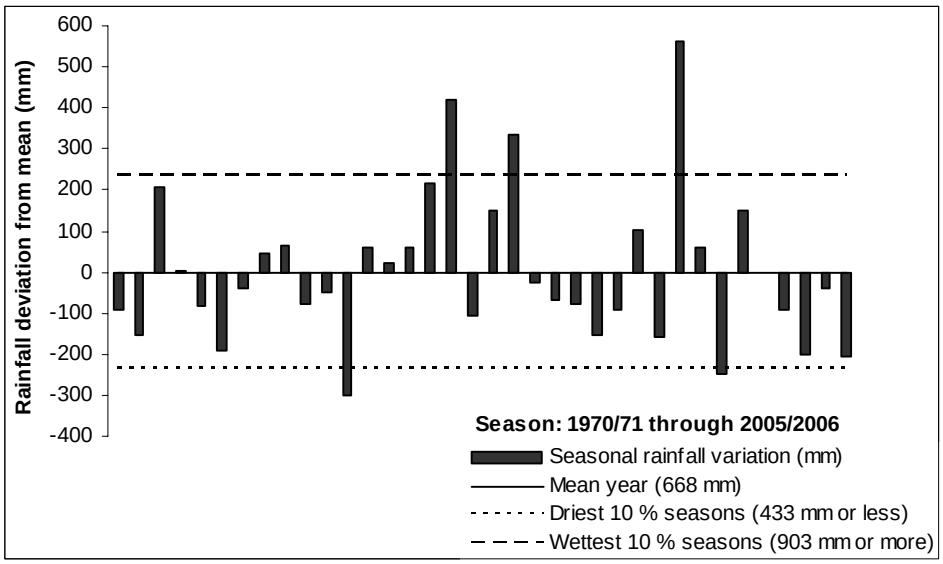

Figure 5.2. Rainfall deviation from the mean (36 seasons, from October to September) and occurrences of extreme dry and wet years at Kondoa, Tanzania.

Table5.2. Long-term monthly means of different climatic indices and the trends over 36 seasons; data from Kondoa Meteorological Station (KMS), Tanzania.

	Rainfall (mm)			Rainy days (days)			Dry spell length (days)		
	Mean	CV (%)	Trend	Mean	CV (%)	Trend	Mean	CV (%)	Trend
November	37	122	-0.49	3	97	-0.08	41[a]	41	+0.25
December	131	80	-0.55	10	51	- 0.03	24	94	+0.95**
January	138	51	+0.65	11	47	-0.05	11	46	-0.03
February	100	60	+ 0.10	9	44	- 0011	13	52	-0.12
March	126	67	+ 0.94	9	43	+ 0.06	13	43	-0.02
April	96	61	-0.04	9	32	+ 0.04	12	48	-0.07
May	30	136	-0.84	4	74	+ 0.02	20	49	+0.05
June	1	386	-0.04	0	362	0.00	46	28	+0.14

** Significant at $p < 0.01$

[a] Figures are based on total dry spell lengths and therefore, runs do not restart with every new month

Trend analysis of the monthly data from Kondoa (Table 5.2) shows a decline in total rainfall and the number of rainy days in the season's first two months. The intermediate months show a positive change in rainfall amounts and rainy days. Only February had a decrease in the number of rainy days. The last three months of the season reveal a reduction of monthly rainfall, while the number of rainy days has increased. Results from seasonal and monthly analyses imply that there is no univocal trend visible that could indicate either an improvement or a deterioration of rainfall.

Dry spells

For agricultural purposes, the intra-seasonal distribution of the rains is crucial. Within a growing period, crops can only withstand a certain length of dry spell without stress, depending on available soil moisture, crop type, and development stage of the crop plant.

Short dry spells can be expected at any time in the season (Figure 5.3). The probability that a dry spell of 5 days will occur within the next month is at least 80 % throughout most of the season. February has the highest risk of dry spells within the cropping season. The probability that a dry spell of 10 days will occur within the coming month is less than 20% between mid December and mid January and throughout March. The probability that a dry spell of 15 days will occur within the next month is less than 20% from December to mid-April. At the initial crop stage, in the first weeks after germination, a plant is highly vulnerable to drought. Therefore a dry spell of 15 days would certainly be too long. Once a crop has passed the grain filling stage, water requirements diminish and it could tolerate a dry spell that length.

Based on this data, it can be stated that the cropping season in Kondoa starts in the third decade in December and lasts until the second decade in April. During this period, the overall chance of rainfall is at its height (Figure 5.4). The likelihood of rainfall depends on whether the previous day was dry or rainy. The likelihood of rainfall is greater when the previous day was wet.

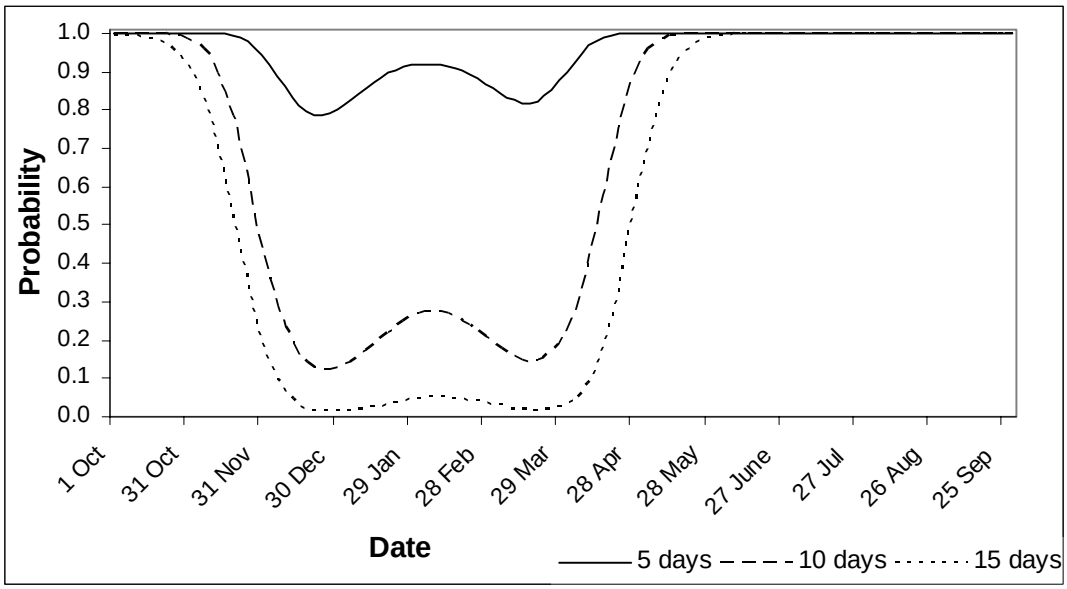

Figure 5.3. Probability of a dry spell of 5, 10 or 15 days occurring in the next 30 days for Kondoa, Tanzania (based on data of 36 seasons, from October to September).

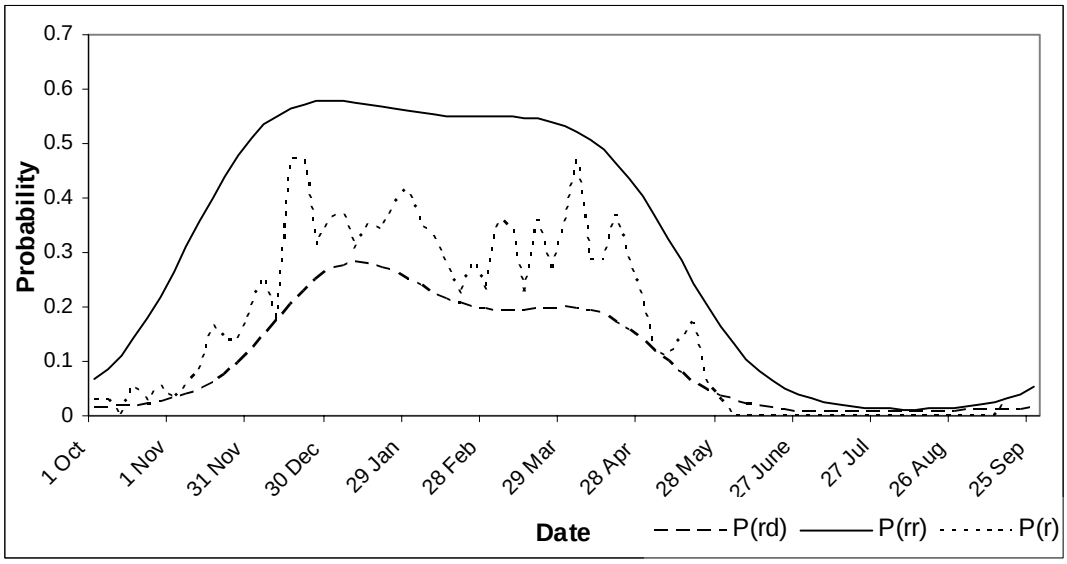

Figure 5.4. Unconditional probability of rain (P(r)) and the probability of rain under the condition that the previous day was dry (P(rd)) or rainy (P(rr)) for Kondoa, Tanzania (based on data of 36 seasons, from October to September).

Trend analysis shows that the average length of dry spell has increased in the first two months of the rainy season (Table 5.2), but only the duration of the December dry spell shows a significant increase. The mid-season months reveal a decline in mean dry spell lengths, whereas the final two months show a slight increase. This implies that crops sown early in the season will be exposed to longer dry spells in December, and are, therefore,

more likely to suffer from water stress than thirty years ago. In the other months, there was no univocal trend visible that would indicate changes in the lengths of dry spells.

5.3.2. Rainfall and dry spells in Asfachew area

Rainfall

The rainfall in Asfachew area comes in two seasons: *meher* season, which is the main cropping season for farmers and *belg* season, which is considered to be the short season. Daily rainfall data for both Debre Sina and Shoa Robit revealed significant correlations ($p < 0.01$) for all of the common years (1984-1994). Debre Sina, which lies at a higher altitude, receives more rainfall and has a slightly different rainfall distribution over the two seasons (Figure 5.5). There, 73% of the total rainfall falls in the *meher* season, and 27% falls in the *belg*. For Shoa Robit, these figures are 58% for *meher* and 42% for *belg*. Nearly half of the years considered in Debre Sina, and three-quarters of those in Shoa Robit showed opposite anomalies from mean rainfall for both seasons (Figure 5.6); i.e. when *belg* had below-mean rainfall, the *meher* had above-mean rainfall and vice versa.

Extreme *belg* seasons in Debre Sina, i.e. seasons with below-mean or above-mean rains with a 10% or less chance of occurrence, deviated by 250 mm or more from mean rainfall. Extreme *meher* seasons in Debre Sina, with below or above-mean rains with a 10% or less chance of occurrence had a deviance of 694 mm or more. For Shoa Robit, these figures deviated at least 206 mm for *belg* season and at least 215 mm for *meher* season. In Debre Sina, none of the years had extreme dry *belg* or *meher* seasons, whereas in Shoa Robit, there was one extreme dry *meher* and one extreme dry *belg* season (Figure 5.6).

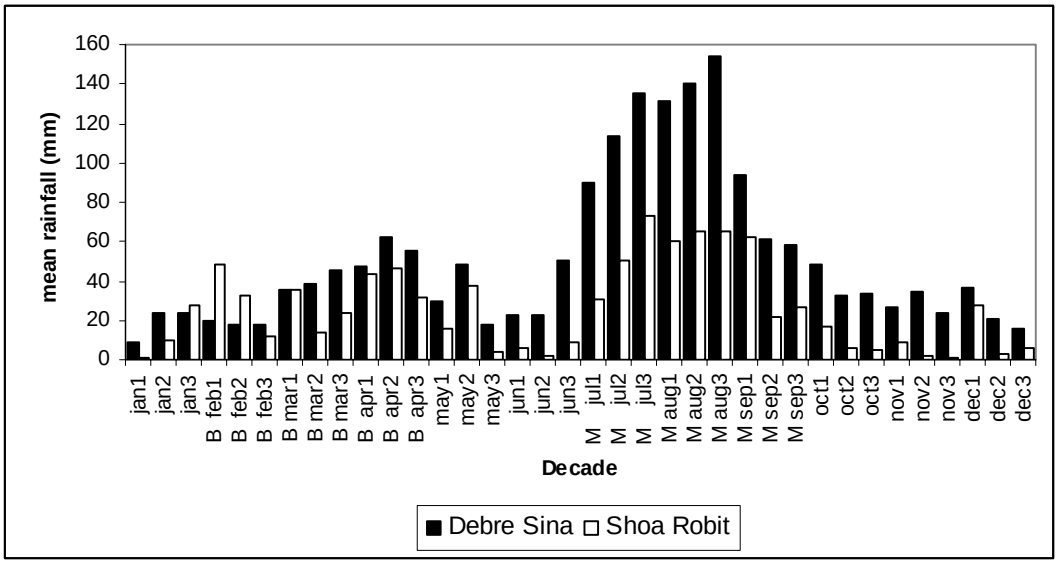

Figure 5.5. Mean rainfall per decade for Debre Sina and Shoa Robit, Ethiopia (B = belg, M = meher) (average of respectively 21 and 11 years).

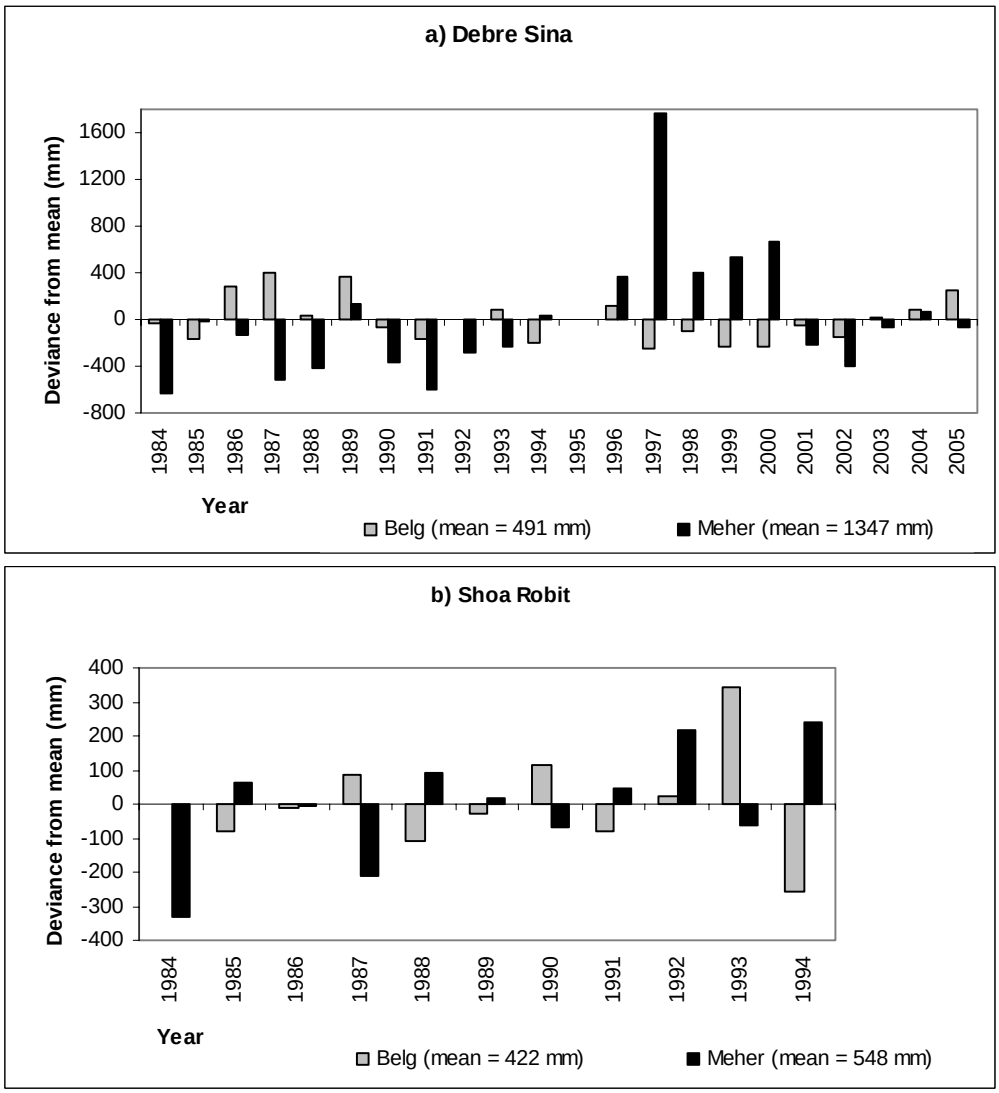

Figure 5.6. Deviance from mean rainfall per season for Debre Sina (a) and Shoa Robit (b), Ethiopia (average of respectively 21 and 11 years).

The rainfall in Debre Sina revealed a greater inter-annual variability than in Shoa Robit rainfall (Table 5.3). Trend analysis of the Debre Sina data showed that even though rainfall and mean rain per rainy day during *meher* season have declined significantly over the period from 1996 to 2005, the long-term trend over 21 years shows no significant changes. *Meher* season, on the other hand, showed positive but insignificant changes for all climatic indices over the past 21 years. The source of this sharp downward trend in *meher* rainfall during the 1996-2005 period is clearly visible in Figure 5.6a. The first half of this period received well above-average rainfall. *Belg* rainfall shows positive but insignificant changes for all climatic indices over the past ten years, but also reveals negative but insignificant changes for all climatic indices over the period from 1984 to 2005. The 1984-1994 trend analysis for Shoa Robit shows no significant changes for any of the climatic indices. Most indices show a slightly upward change for both seasons.

Table 5.3. Long-term seasonal means and trends for different climatic indices for annual and seasonal meteorological data from Debre Sina and Shoa Robit, Ethiopia (average of respectively 21 and 11 years).

		Debre Sina			Shoa Robit		
Period		**Total**	***Meher***	***Belg***	**Total**	***Meher***	***Belg***
Rainfall (mm)							
1984-1994	Mean	1613	1072	541	1003[a]	548	422
	CV%	22	24	39	13	31	38
	Trend	-0.6	+16.8	-17.3	+23.9	+19.0	+4.8
1996-2005	Mean	2088	1651.7	436.86			
	CV%	26	37	38			
	Trend	-104.3	-131.8*	+27.5			
1984-2005	Mean	1839	1348	491			
	CV%	28	40	40			
	Trend	-30.2	+29.7	-7.0			
Number of rainy days							
1984-1994	Mean	112	70	42	106	66	39
	CV%	24	23	48	13	12	25
	Trend	+1.45	-0.1	+1.6	-0.4	+0.2	-0.6
1996-2005	Mean	127	91	36			
	CV%	21	17	42			
	Trend	-1.4	-2.8	+1.5			
1984-2005	Mean	119	80	39			
	CV%	20	26	41			
	Trend	+1.06	+1.2	-0.1			
Max. daily rainfall (mm)							
1984-1994	Mean	102	86	74	69	52	67
	CV%	42	46	54	33	32	38
	Trend	+4.7	+6.5	-2.2	+1.0	-0.6	+1.7
1996-2005	Mean	81	77	54			
	CV%	21	17	42			
	Trend	+2.6	+0.9	+3.7			
1984-2005	Mean	92	82	64			
	CV%	37	36	52			
	Trend	0.0	+0.4	-1.3			
Rain per rainy day (mm)							
1984-1994	Mean	15	16	14	10	8	11
	CV%	28	27	38	16	30	21
	Trend	-0.1	-0.3	-0.8	+0.3	+0.3	+0.2
1996-2005	Mean	16	18	12			
	CV%	18	20	22			
	Trend	-0.6	-0.8*	+0.2			
1984-2005	Mean	16	17	13			
	CV%	23	24	33			
	Trend	-0.6	+0.1	-0.24			

*significant at $p < 0.05$

[a]No data available for 1984 *belg* season in Shoa Robit. Therefore, analysis of *belg* and annual data only includes data for 1985-1994

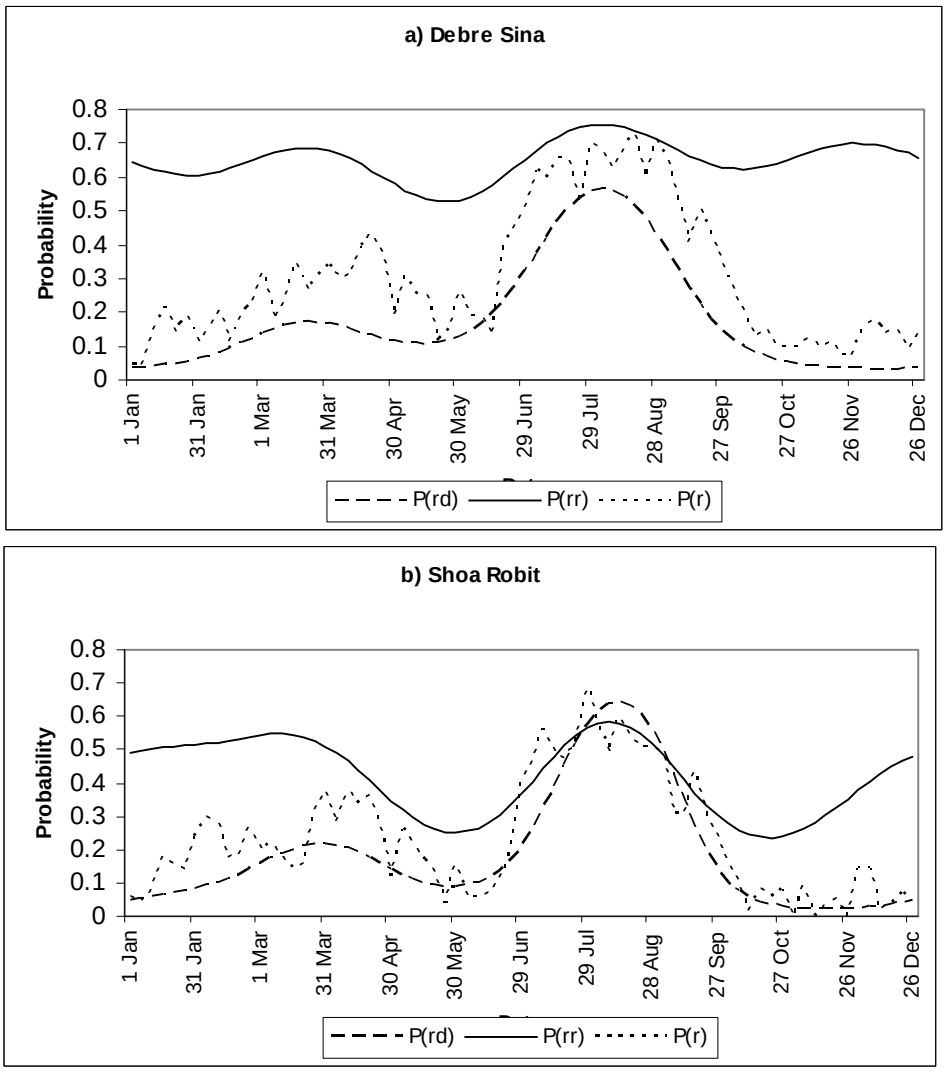

Figure 5.7. Probability of a dry spell of 5, 10 or 15 days occurring in the next 30 days for Debre Sina (a) and Shoa Robit (b), Ethiopia (average of respectively 21 and 11 years).

Trend analysis of rainfall and climatic indices indicated no significant changes in the rainfall and its pattern. The different directions of change for each of the two periods in Debre Sina can be explained by the first year of the 1984-1884 period showing rather low values (the big drought of 1984), while the first few years of the 1994-2005 period, which included the 1997 El Niño year, showed above mean figures.

Dry spells

Short dry spells can be expected at any time during both seasons, but in *meher* season, dry spells were shorter than in *belg* season. Variability was high. The probability of dry spells in both Debre Sina and Shoa Robit is similar in *meher* season (Figure 5.7). However, figures for *belg* season differ. Even though total rainfall in Debre Sina is slightly higher, rainfall for the last decade in January and the first two in February was greatest in Shoa Robit (Figure 5.5). This may explain the lower figures for lengths of dry spells in Shoa

Robit compared to Debre Sina. Rainfall figures for Shoa Robit are well below those of Debre Sina during the last two decades of March.

The probability that a dry spell of 5 days will occur within the next month is at least 90 % throughout the *belg* season in both locations (Figure 5.7). Indeed, there is only a very short period when the probability of a 10-day dry spell drops below 50%. The probability that a dry spell of 15 days will occur within the coming month is less than 20% between mid March and early April. Based on this data, it can be stated that crop production in *belg* season is highly unpredictable, due to the continuously high dry spell probability. During the period from early February to the end of April, the chance of rainfall is at its height (Figure 5.8).

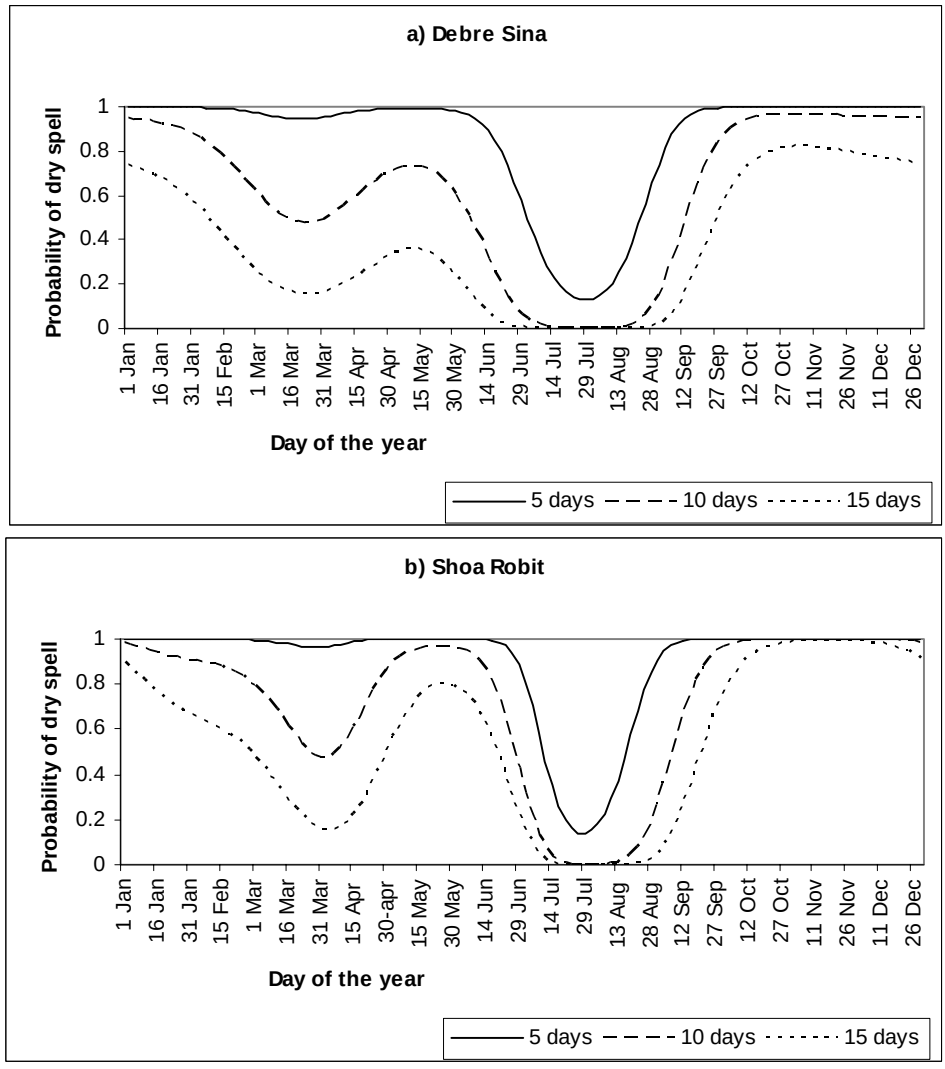

Figure 5.8. Unconditional probability of rain (P(r)) and the probability of rain under the condition that the previous day was dry (P(rd)) or rainy (P(rr)) for Debre Sina (a) and Shoa Robit (b), Ethiopia (average of respectively 21 and 11 years).

The likelihood of rainfall depends on whether the previous day was dry or rainy. The likelihood of rainfall is considerably greater when the previous day was wet.

The probability of dry spells drops to its lowest level during *meher* season. The chance that a dry spell of 5 days will occur within the next month is less than 50% between mid July and early august in both areas, and the probability that a dry spell of 15 days will occur within the coming month is less than 20% from early July to mid September. During the period between early July and the end of September the overall chance of rainfall is at its height. The likelihood of rainfall depends on whether the previous day was dry or rainy. The likelihood of rainfall is considerably greater when the
previous day was wet. However, in Shoa Robit the likelihood of rainfall after a dry day is greater than after a rainy day in *meher* mid-season.

Dry spells during *belg* season seem to have increased in length over the past two decades (Table 5.4), albeit not significantly, whereas dry spells during *meher* season have decreased in length over the same period. Again the changes were insignificant. The only significant changes, both decreases in dry spell lengths, were between 1984 and 1994, and occurred during the dry season, when rainfall is unwanted.

Analyses of dry spells and the likelihood thereof confirm the unreliability of *belg* season. In particular, there is a very short period of reduced dry spell probabilities in this season. No significant trends were visible in the occurrence of dry spells, even though
belg dry spells seem to have become prolonged and *meher* dry spells seem to have shortened over the past two decades.

Table 5.4. Long-term monthly means and trends for length of dry spells in Debre Sina and in Shoa Robit, Ethiopia (average of respectively 21 and 11 years).

	Dry spell length in Debre Sina (days)					**Dry spell length in Shoa Robit (days)**		
	Mean	CV (%)	Trend 1984-94	Trend 1996-05	Trend 1984-05	Mean	CV (%)	Trend 1984–94
January	44 [a]	67	-4.1	-3.9	-1.6	45[b]	74	-0.6
February	50	73	-3.3	-0.2	+1.0	34	65	-0.8
March	29	94	-0.6	-2.3	+0.6	25	78	+2.9
April	16	57	-0.8	+0.3	+0.1	15	67	+0.8
May	16	39	-0.1	+0.9	+0.3	16	32	-0.9
June	19	62	-0.6	+1.5	-0.3	27	45	-0.4
July	6	127	-0.4	+0.1	-0.6	11	118	-0.1
August	4	87	-0.4	0.0	-0.1	4	37	-0.1
September	6	40	+0.4	-0.2	-0.2	8	21	0.0
October	21	42	-0.2	-0.7	+0.4	25	39	-1.9*
November	37	43	-3.4*	+1.7	+0.1	43	36	-2.5
December	42	54	-2.8	-0.9	-0.8	53	45	-2.7

*Significant at $p<0.05$

[a]Figures are based on total dry spell lengths and therefore, runs do not restart with every new month

[b]No data available for 1984 *belg* season in Shoa Robit. Therefore, analysis from January to June only includes data for 1985-1994

5.4. Rainfall and dry spells and changes perceived by farmers

5.4.1. Farmers' perspectives in Goima area

The farmers in Goima expect a rain shower by the end of October. This first rain is not considered to be the start of the cropping season because its purpose is to enable the grass, bushes and trees to sprout. Rains are unpredictable, particularly this early in the season, and it may be another month until the next rain shower. The farmers expect the rains to really start between the end of November and the end of December. When rainfall is sufficient to wet the soil in this period, farmers will start to prepare and sow their fields. In February, farmers expect a two-week dry spell, after which the rains resume. The farmers have mentioned that dry spells of two weeks are common in February. The rains then decrease in magnitude and frequency by the middle or the end of April. Starting from mid May, farmers expect that light rain will only fall in the hills. This is an indication to the farmers that the rainy season is at an end.

The farmers believe that rainfall has become less predictable over the past ten to twenty years, especially early in the season. The farmers perceive that agricultural production is good when seasonal rains come as expected. Farmers explained drought in terms of anomalous weather conditions. The amount of rainfall, its intra-seasonal distribution and the hours of sunshine were most crucial weather conditions. Rainfall and sunshine should be balanced.

Farmers believe that it is up to God to decide the timing and amount of rainfall; droughts may be expected in the future, but no prediction can be made. They were more concerned about an increased severity rather than an increased frequency of droughts. Farmers believe that trees bring rainfall (Östberg, 1995; Slegers, 2008b) and accordingly, are of the view that that ongoing deforestation has increased the problem of drought over the past two decades (cf. Meze-Hausken, 2004; Slegers et al., 2005).

5.4.2. Farmers' perspectives in Asfachew area

The farmers in Asfachew area expect the *belg* rains to start towards the end of January or early in February, and to continue to the end of April. They characterized this season as erratic. Dry spells of one or two weeks are common. Rain in May and June is not welcome, since these are the months for harvesting, and rain will spoil the crops that are drying in the fields.

The *Meher* rains start in early July, and should continue until the end of September. Short dry spells occur, but farmers expect rain every day. Rains in October and November would again spoil the crops drying in the fields.

Farmers depend on the *meher* season. Rainfall during this season is more predictable than in *belg, which* is highly unpredictable, and therefore not farmed by all of them. The farmers believe that the problem of the unreliability of the seasons has increased over the past ten years: "farming during *belg* has become a matter of chance". Those farming at

lower altitudes stated that since 2002, the *belg* has not been productive at all. Farmers estimated that only one-fifth of the land there is used during the *belg* season, and stated that they have "lost the *belg*". Most farmers with land at higher altitudes still produced crops twice a year. Farmers argued that this was not only because of the higher rainfall figures, but also because temperatures are lower and cloud cover is more extensive, meaning that moisture remains in the soil for longer.

In general, the farmers did not complain about the amount of rainfall, instead expressing concern about the timing of the rains, i.e. their increased unreliability, especially during *belg*. The farmers believe that there is no way to influencing the rains; the only thing that can be done is to pray for rain and ensure that you do not arouse the wrath of God. When people disrespect holy days, or fight or steal, God may punish the farmers by bringing them too much or not enough rainfall, or hailstones that will destroy the crops.

Like the farmers in Goima, those in Asfachew area define drought on the basis of weather conditions. The balance between rainfall and sunshine is considered to be the most important factor for good crop production. A year can be called dry when both *meher* and *belg* seasons fail or when the *meher* season fails. Anything that the *belg* season produces in Asfachew is considered a bonus. None of the farmers with land at lower altitudes rely on *belg* production, and like their counterparts in Goima area, farmers in Asfachew area believe that there is a link between deforestation and the perceived increase in rainfall variability (Slegers, 2008a).

5.5. Integrating scientific rainfall data with farmers' perspectives

5.5.1. Goima area

The probability of intra-seasonal rainfall and dry spells (Figure 5.3 and 5.4) confirm the farmers' expectations of the rainy season. The figures show a reduction in the average rainfall and an increase in the probability of dry spells during February. However, the probability of a two-week dry spell is less than 10 % and does not accord with the farmers' beliefs about the frequency at which long dry spells occur.

Basalirwa et al. (1999) revealed a similar rainfall pattern for the climatic zone of which Kondoa is part. Data from Dodoma, Singida, and Iringa meteorological stations show that the rains start around the third decade in November and end around the first decade in May (Basalirwa et al., 1999). The meteorological data and the farmers both indicate that the start of the rains cannot be seen as the start of the cropping season. Even though rainfall can be expected in November, the risk of discontinuity is still too high at that time. The farmers will not start sowing in then because of the high risk of crop failure, both because germinated seeds may dry out and because the crop's water requirements would reach high levels during the expected dry-spell period in February.

The seasonal and monthly rainfall data from the past 36 seasons, along with the climatic indices, indicate some minor changes in the rainfall pattern. All seasonal climatic indices show a decreasing tendency, which could explain the farmers' concerns. However,

none of these were significant. Rainfall in January, February and March has slightly increased, while rainfall early and late in the season seem to have decreased. The lengths of dry spells, both early and late in the season, have increased, and the one in December significantly so, which may explain the farmers' concerns about the diminished reliability of the rains early in the season. The February dry spell showed no trend.

Different rainfall trends presented by Adosi (2007), show the great temporal and spatial variability of rainfall within semi-arid Tanzania. According to the Goima farmers, the 2005-2006 season was different to previous years, which is confirmed by KMS and GRG data. The 2005-2006 season did partially demonstrate the direction of changes in the monthly rainfall characteristics: a delayed start of the season and no long dry spell in February.

5.5.2. Asfachew area

Rainfall and dry spell expectations as described by the farmers for both seasons, are visible in both Debre Sina and Shoa Robit's meteorological data (Figures 5.7 and 5.8). The data obtained from both meteorological stations show a very high probability of dry spells for *belg* and a low probability for *meher* season. Amsalu et al. (2007) found that *belg* rainfall in Debre Birhan area is less frequent than *meher* rainfall. Farmers there, like the Asfachew farmers, characterized the *belg* as being unreliable.

The National Meteorological Services Agency of Ethiopia (NMSA, 1996) applied the decile technique (Gibbs and Maher, 1967) to rate droughts. They identified three drought intensities: mild, moderate and severe. In the case of a mild drought, the negative anomaly from the mean seasonal rainfall is 19% or more, but below 21%. In the case of a moderate drought, the negative anomaly from the mean seasonal rainfall is between 21 and 25%. When the anomaly from the mean seasonal rainfall is more than 25%, a drought is considered to be severe.

In Debre Sina, six out of seven *meher* season droughts occurred in the period between 1984 and 1992, while six out of eight *belg* season droughts occurred in the period between 1993 and 2005. These figures can explain farmers' perceptions that the drought trend has reduced but that they are "losing" *belg*.

The trend analyses of rainfall and dry spells presented in this article revealed only minor and insignificant changes. The 1996-2005 period showed a significant decline in the rainfall pattern during the *meher* season in Debre Sina, which was not visible over the whole 21-year period. Instead, the rainfall figures show an insignificant increase. The lengths of dry spells in *Belg* season seem to have increased over the past two decades, which would confirm the farmers' beliefs. However, these changes were insignificant.

Amsalu et al. (2007) found that annual rainfall had increased and variability had reduced in the period between 1985 and 2003, whereas local farmers experienced the opposite. Farmers in the Eastern Highlands of Kenya which also has a bi-modal rainfall pattern, also perceived that the short season had become less reliable (Ovuka and Lindqvist, 2000). Annual rainfall data of that area did not show any trend, however the intra-seasonal

rainfall distribution showed decreased rainfall at times when the farmers' major crop, maize, was most vulnerable to drought.

The farmers in Asfachew area have different sowing periods for each crop depending on their individual growing periods. Tef, the staple crop, is sown between February 14th and March 14th, and dry spells during the first month can be devastating (Rosell and Holmer, 2007). Starting in mid-February, the probability of dry spells decreases and in the month after the latest sowing date the probability thereof has reached its lowest level. In *meher* season, farmers sow tef between July 9th and August 8th. In the first two months after the earliest date, the probability of rain is at its height and reveals how the agricultural calendar, which is based on the experiences of generations of farmers, is well-adapted to local circumstances.

5.6. A need for greater insight

These analyses did show some changes in rainfall and dry spells which accorded with farmers' perceptions, although most of these were not significant enough to provide the farmers with scientific proof thereof. Several studies, wherein there was no clear evidence in rainfall patterns to support the farmers' concerns, explained these perceived changes in rainfall as being the result of changes in other physical parameters (Dahlberg and Blaikie, 1996; Kinlund, 1996; Ovuka and Lindqvist, 2000; Stroosnijder, 2007). Biophysical factors other than rainfall deficiency influence water availability for a crop and can contribute to farmers' increased concerns about rainfall (Lindskog and Tengberg, 1994; Dahlberg and Blaikie, 1996; Amsalu et al., 2007; Slegers and Stroosnijder, 2008). In both study areas, the farmers believed that deforestation had contributed to their problems (cf. Meze-Hausken, 2004) and that different properties of a soil influence a plant's ability to withstand dry conditions. Deeper insight is needed into local biophysical processes which interact with soil-water properties, since this will contribute to a better understanding of farmers' concerns about the rains.

Chapter 6

Comparison of farmers' perceptions of drought with moisture and nutrient availability to maize in semi-arid central Tanzania

6. Comparison of farmers' perceptions of drought with moisture and nutrient availability to maize in semi-arid central Tanzania

Abstract

Since there is no unequivocal proof of an increased problem of meteorological drought, this chapter looked beyond meteorological data by comparing farmers' knowledge about spatial differences in drought susceptibility of crops with moisture and nutrient availability to maize during the 2005/06 cropping season. With help of farmers suitable fields were selected of the three soil types distinguished by farmers, Dark, Red and Pale. Farmers were provided with the same maize variety, Kilima. The experimental design was a 2^2 factorial with manure and water conservation as factors, each at two levels (with or without). The fields studied were managed by the farmers themselves and according to their usual practice. Rainfall, soil moisture, soil, and crop data were analyzed using a water balance model and QUEFTS, a model to evaluate soil fertility. Yield assessments of both analyses and by farmers were compared. The plots where manure was applied showed better crop growth than the other plots of the same soil type. Effects of the ridges, however, were limited, but might have been significant if a period of more severe moisture stress would have occurred during this particular cropping season. Farmers' knowledge about spatial differences in drought susceptibility of crops generally agreed with the outcomes of the analyzed data. Farmers perceived that in good rainfall years, the less sandy soils perform relatively best due higher fertility status, while in a bad rainfall year lighter soils are relatively most productive because of easier water infiltration and lower water demands. Chemical and physical properties of the Dark soil were best, and those of the Red soil were poorest. Yield assessments by farmers were low compared to QUEFTS calculated yields and yield estimates based on the water balance model. These deviances might be attributed to moisture stress during periods when soil moisture is near permanent wilting point and is not readily available to the crop. Farmers distinguished meteorological drought from local manifestations of soil nutrient deficiency, or moisture deficiency and recognized that natural conditions of a soil as well as their activities influence nutrient and soil moisture availabilities.

6.1. Introduction

6.1.1. Perceptions of drought

A Goal set by the 1996 World Food Summit was to reduce by half the number of malnourished people by 2015 (FAO, 2006). The biggest challenge is to achieve this goal in

sub-Saharan Africa (SSA), where a third of the fast-growing population is food insecure (FAO, 2006). Over the past 40 years, average food production per capita has declined (Love et al., 2006). Since most people in SSA live in rural areas where subsistence agriculture is the major economic activity, development approaches should prioritize improvement of agricultural productivity in a sustainable manner.

One limitation for the achievement of sustainable agriculture in semi-arid East Africa is the existing mismatch between problem perceptions of scientists and local land users. Scientists consider soil degradation as major limitation for sustainable production, while farmers mostly relate reduced productivity to drought. From the perspective of the conservation of natural resources in Africa it is of importance that the production-reducing obstacle 'drought' is taken into serious consideration.

Causes of drought can be more complex than shortage of rainfall (Rockström, 2003b). Biophysical factors other than lack of rain influence soil-water availability and can contribute to farmers' increased concerns about rainfall (Lindskog and Tengberg, 1994; Dahlberg and Blaikie, 1996). Amsalu (2007) found a discrepancy between farmers, who perceived that rainfall had become more unreliable, and the rainfall data, which showed an improvement in terms of amount and distribution. Amsalu suggests that water loss due to soil erosion and increased water needs due to population growth could possibly explain this discrepancy. Thurrow and Taylor (1999) refer to this "drought paradox" as some form of agricultural drought and attribute it to degradation of vegetation and to processes of soil erosion and soil crusting. Others have drawn similar conclusions (Rietkerk and Van de Koppel, 1997; Stocking and Murnaghan, 2001; Stroosnijder, 2008).

Rietkerk (1998) claims that soil-water and nutrient availability are decreasing through soil degradation processes. Such processes increase the susceptibility of crops to drought. Farmers relate these processes rarely directly to soil degradation, but may perceive adverse effects on crop yield as the result of meteorological drought (Stocking and Murnaghan, 2001).

Slegers and Stroosnijder (2008) developed an agricultural drought framework (ADF)[1] that takes into account soil moisture deficiency as well as nutrient deficiency as possible factors influencing farmers' growing concerns about drought and that therewith accommodates scientists' as well as farmers' concerns about major agricultural productivity-reducing problems (Slegers and Stroosnijder, 2008).

[1] The ADF and its drought components were developed based on empirical insights into the inter-relation between drought, land degradation and biological productivity from the perspectives of farmers. These drought components are termed: "meteorological drought", "soil water drought" and "soil nutrient drought" to refer to rainfall deficiency, soil moisture deficiency and nutrient deficiency, respectively. Since these drought components were developed from the perspective of farmers, they do not necessarily reflect the views or concepts applied by physical scientists.

6.1.2. Drought in Goima, Tanzania

In the period from mid December 2005 to June 2006, a study was performed in two villages, Goima and Mirambu villages[2], located within Goima Ward. A sociological study had preceded the biophysical study, in which the central question was how farmers perceive drought (Slegers, 2008a).

A general statement among farmers in Goima is that "if only it would rain, our harvests will be good". Farmers firmly stated that they had never personally experienced a drought, which may appear as a paradox in this drought-stricken region. The reason is that they adhere to the principle that drought would imply complete crop failure due to absence of rainfall, the land being bare and dry. In less severe situations, in a year with reduced crop production due to deficient rainfall or when "rainfall and sunshine are out of balance" farmers prefer to talk about a bad year (*mwaka mbaya*) or about a scorching sun (*jua kali*) instead of drought (*ukame*) (Slegers, 2008b). However, they often hear the word drought being used on the radio and by local agricultural services during what they refer to as bad years.

The farmers in Goima feel that rainfall has become less predictable during the past ten to twenty years, especially early in the season. They are concerned about increased frequency, but even more so about increased severity of bad years. Farmers believe that trees bring rainfall and that the ongoing deforestation has increased the drought problem over the past two decades (cf. Meze-Hausken, 2004; Slegers et al., 2005).

The seasonal and monthly rainfall of the past 36 seasons (1970/71-2005/06), the mean rainfall per rainy day, the number of rainy days in a season, the maximum daily rainfall and length of dry spells were analyzed for possible trends (Slegers, 2008a). These analyses did only show some changes which accorded with farmers' perception. Only the mean dry spell length in December, which is at the start of the cropping season, indicated a significant increase ($P < 0.01$). Other changes were insignificant and could not provide farmers with further scientific proof of perceived changes.

Farmers understand that their vulnerability to drought is diverse and depends on characteristics and state of their land and on their land management practices (Slegers, 2008b). Based on this knowledge, an experiment was set up on the three soil types that farmers distinguish. Meteorological, soil, manure and crop data were used to assess the vulnerability of maize to water and nutrient stress. Maize (*Zea Mays*) was used as test crop since it is most commonly grown by farmers because of its marketability. The outcomes of the analyses were compared with farmers' knowledge about their soils and effects of land management practices on the crop's performance.

This chapter looks beyond meteorological data to address the 'drought' problem as perceived by farmers in Goima Ward. The objective was to understand the source of farmers' growing concerns about the rains by comparing their knowledge about spatial differences in drought vulnerability of crops with moisture and nutrient availability to maize during the 2005/06 cropping season.

[2] When referring to both villages, Goima will be mentioned

6.2. Study area and methods

6.2.1. Geography of the study area

Goima Ward is situated in the northern part of semi-arid central Tanzania, 40 km south-east of Kondoa town. The area is characterized by an undulating landscape of plains and scattered small hills and has sandy soils. Goima and Mirambu villages lie on the foot of the Burunge Hills, at an altitude between 1,300 and 1,400 m.a.s.l. The upper slopes of the Hills consist of bare rocks and forests.

Goima has a uni-modal rainfall pattern; rain can be expected from November through May. Inter-seasonal and intra-seasonal rainfall variability is very high. The mean seasonal rainfall measured at the meteorological station of Kondoa town is 650 mm[3]. Evapotranspiration in this area is about 1,700 mm $year^{-1}$ (Östberg, 1995: 31). Rivers are ephemeral and have high peak discharges during and shortly after rainfall events, but the water flows mostly disappear within a day after a rainfall event.

Increasing parts of the Burunge Hills are being cleared, both legally and illegally, as a result of population growth. Goima farmers traditionally practiced rotational bush fallow in which long periods of fallow were common. The use of fallow has diminished in the past few decades due to increased population pressure.

6.2.2. Farmers' classification of soils and their agricultural practices

Farmers classify soil types mainly on the basis of colour, but also distinguish between texture and fertility (cf. Schechambo et al., 1999). The three major soil types distinguished are Black, Red and White. Since these colours do not correspond to scientific soil classifications, we will denote these soil types as Dark, Red and Pale, respectively. Soils can also be a mixture of two colours. Soil textures distinguished are light and heavy. Soil fertility is referred to as good or bad. The Dark soil was considered to be heavy, the Red soil could be both heavy and light and the Pale soil was considered to be light. The fertility of heavy soil was considered as naturally good and that of light soil as naturally bad.

Crop residues are most commonly left on the field for off season grazing. Before the onset of the rains, farmers clean their land by scraping together plant residues in lines in the direction of the wind which then are burnt. It is also common to plough under the residues. Most farmers till their land with hand hoe. Some farmers can afford to use ox-plough and even fewer farmers are able to hire a tractor. Many farmers fear that mechanized cultivation for consecutive years will damage their land due to its deeper tillage compared to other techniques. Deep tillage is perceived to exhaust the soil as it brings infertile subsoil to the surface.

Most common soil and water conservation (SWC) techniques used are diversion ditches at the border of the field and ridge cultivation. Only a small number of farmers apply

[3] Data for 1970-2006

manure on their fields, partially because of transport costs, lack of livestock and thus manure, but also because of the fear that the manure will burn their crop during a bad year. Farmers do not apply fresh manure, but two or three-year old manure. Old manure has already "cooled down" and is less strong than the fresh manure. Other farmers felt that their land was productive enough, or used short fallow periods to maintain soil fertility.

6.2.3. Methodology

Field selection, experimental design and crop management

With help of farmers different zones were identified with predominant presence of one of the three soil types distinguished by farmers. Thereafter, meetings and field visits with farmers were held to find suitable fields. Plots were selected with similar relief and similar period of continuous cultivation to limit diversity of environmental factors as much as possible. Farmers were provided with the same improved maize variety, Kilima, with a growth period of 4.5-5 months. It is preferred by farmers because of its good yield potential, drought resistance and resistance to storage pests. Its yield potential is 4.5-6.25 tons ha^{-1} (Kaliba et al., 1998).

On each soil type, a field with four sample plots of five by five meters each was demarcated. The experimental design was a 2^2 factorial with manure and water conservation as factors, each at two levels (with or without). Water conservation comprised the formation of ridges. Ridge construction and manure application as well as sowing and weeding were done by the farmers themselves and according to their usual practice.

Ridges were made with hand hoe by scraping together surface soil, ashes and plant residues. Seeds were put in small holes. Manure was applied in the seeding holes below the seeds, at rates of 0.5 tons ha^{-1} on the Dark and Pale soils and of 0.6 tons ha^{-1} on the Red soil. At the end of the season, farmers were asked to predict their grain yield. Due to the delayed start of the rainy season by a month, and thus of the harvest period, the author could not be present at that time, and the actual yield has not been measured.

Meteorological data

Since spatial and temporal rainfall variability is high, we measured the daily rainfall near to the plots in Goima and Mirambu villages during the 2005/06 cropping season. Rainfall was measured with two tipping bucket rain gauges with a WatchDog data logger that registered rainfall amounts every ten minutes. The loggers were read out regularly, the data were compared and amounts were checked on the basis of observations by researcher, field assistant and farmers. On a few occasions one or the other rain gauge showed failures. For these occasions the other rain gauge served as a back-up. Data from the two rain gauges were averaged, and this data set will further on be referred to as Goima Rain Gauge (GRG).

Soil moisture

Volumetric ring samples (100 cm^3) were taken at 5 and 27.5 cm depth in each sample plot to determine its field capacity (FC), permanent wilting point (PWP), maximum

available moisture (MAM) and pF curve. FC was determined using undisturbed samples and PWP was determined using disturbed samples on 1.6 MPa pressure plates. Total porosity was determined based on moisture content of saturated soil samples. The texture of each sample was determined using a laser particle size analyzer. Soil profiles were studied using auger samples up to 1.20 meters.

Two different methods were used to measure soil moisture during the experimental period of 24 weeks. One method consisted of weekly measurements on all twelve sample plots with a mobile ThetaProbe soil moisture sensor, at 15-21 cm (15 cm) and 45-51 (45 cm) cm in the first five weeks and after the start of the rainy season, at 30-36 cm (30 cm) as well. The second method comprised continuous soil moisture measurements with six E+ soil MCT (moisture, conductivity, temperature) sensors, two per soil type. They were buried in the sample plots without manure. The sensors were installed in a horizontal position at 30 cm depth. Data loggers recorded soil moisture content at a 30 minutes interval. Due to problems with both sensors in the Dark soil and one sensor in the Pale soil, no complete data set is available for the whole period.

Data were used to characterize the three soil types in terms of infiltration and water holding capacity and to study soil moisture fluctuations over time in different soil layers. Data were tested using an analysis of variance (ANOVA) in which the main effects of soils, ridges and manure were compared to the sum of the interaction terms with soils.

A water balance model (Stroosnijder, personal communication) was used to estimate available moisture (AM) in the 60 cm root zone, soil evaporation (E), plant transpiration (T) of Kilima Maize and water loss (L) during the 2005/06 growing season. Sources of input and calculation procedures are summarized in Table 6.1. Deep percolation below the root zone at 60 cm and runoff are both comprised in the term loss (L). Daily rainfall in Goima, soil moisture data, plant development and a number of soil physical properties were used as input data. Due to the great variability in soil moisture data between the sample plots, it was decided to use work with the aggregated figures for each soil type.

Soil, crop and manure nutrients

Mixed soil samples (from 0-15 cm and 15-45 cm soil layers) and four leaf samples (the leave opposite the cob) were taken at each sample plot 60 days after sowing. A manure sample was taken of the manure applied on each soil type. Soil and manure samples were air-dried, and crop samples were cleaned and air-dried before laboratory analyses.

The soil and manure samples were analyzed for nitrogen (N), phosphorus (P; P-Olsen), exchangeable potassium (K), pH (H_2O), and soil organic carbon content (org. C). Leaves were analyzed for N, P and K. The results were compared with values found in literature (Beaufils, 1973; Jones and Eck, 1977).

For interpretation of the chemical soil data, the system QUEFTS (QUantitative Evaluation of the Fertility of Tropical Soils) was used (Janssen et al., 1990). In this system, soil fertility is interpreted as: “the capacity of a soil to provide plants with nutrients”. Yields

Table 6.1. Type and source of input data and brief description of calculation procedures for the daily water balance model used to estimate evaporation (E), transpiration (T) and loss (L) of soil moisture for Dark, Red and Pale soils of Goima, Tanzania (2006 season).

Input	Code	Calculation procedure
Days after planting	DAP	Planting of Kilima maize on the Pale soil at 17.01.2006 (DAP =0) with 40 000 hills per ha, mature at 12.06.2006 (DAP = 147).
Rainfall (mm d^{-1})	P	Measured in field (average two gauges)
Potential evapotranspiration (mm d^{-1})	ET-pot	CLIMWAT database (FAO, 2003) for Kondoa, 40 km from Goima.
Weekly measured available moisture in 60 cm root zone (mm)	AM-m	[200*(measured moisture content 15 cm depth (MC-15) + MC-30 + MC 45)] – [200*(Moisture content at permanent wilting point at 15 cm depth (PWP-15) + PWP-30 + PWP-45)]
Leaf area index (-)	LAI	Estimation based on pictures taken during crop season
Daily dry matter accumulation (kg ha^{-1} d^{-1})	ΔDM	Calculation using estimates of total dry matter (∑DM in t ha^{-1}), derived from LAI values and data for Kilima maize (Vesterager et al, 2007).
Daily plant transpiration (mm d^{-1})	T	T = (ΔDM * TC) / 10.000 TC = transpiration coefficient : set at 225 kg H_2O per kg DM
Potential soil evaporation (mm d^{-1})	E-pot	Epot = (ETpot – T)* exp(-0.5 * LAI) (Stroosnijder, 1982)
Number of days since last rain	DSLR	Calculated using daily rainfall
Actual soil evaporation (mm d^{-1})	E-act	On day with P > Epot: Eact = Epot On day with P < Epot: Eact = P On dry day: Eact = minimum of Epot or 3.3 * [SQRT(DSLR) – SQRT(DSLR - 1)] (Stroosnijder, 1982)
Daily calculated AM in 60 cm root zone (mm) for each day after planting	AM-c	AM-c = AM (DAP-1) + P (DAP) – T (DAP) –E (DAP)
Weekly rainfall (mm)	∑P	Sum of daily rainfall over a week
Weekly transpiration (mm)	∑T	Sum of daily transpiration over a week
Weekly evaporation (mm)	∑E	Sum of daily evaporation over a week
Weekly loss (mm)	∑L	∑L = AM (DAP-1) + P (DAP) – T (DAP) –E (DAP) – AM-m

are calculated as a function of some selected soil parameters and the quantities and properties of applied fertilizers. Other limiting factors such as pests and water deficiency are not taken into account.

The values of soil parameters in the original QUEFTS version had to be within certain boundaries. Our samples were within the boundaries set by QUEFTS. An exception was that pH (H_2O) in some samples of the Dark and Pale soils were above the upper boundary of 7. Therefore we used the modified version of QUEFTS (Smaling and Janssen, 1993), which has been calibrated for pH(H_2O) between 4.8 and 8. Another reason was that in Kenya this modified version gave a better fit to measured data than the original version.

The required soil data for the modified version of QUEFTS are organic carbon, organic nitrogen, Total P, exchangeable K, pH(H_2O), clay percentage and average temperature. All data were available except Total P. Using data of sandy soils in the study by Smaling and Janssen, we could relate Total P to organic C: Total P (mg kg^{-1}) = 26 * Organic C (g kg^{-1}). The factor 26 is very close to the value of 25 which was used in the original version of QUEFTS (Janssen et al., 1990).

QUEFTS has been calibrated on the basis of soil data from 0-20 cm. Because our soil samples had been taken from 0-15 cm and 15-45 cm, representing the topsoil and subsoil layers that farmers distinguish, the parameter value (PV) of the 0-20 cm soil layer was calculated with Eq. 1:

$$PV(0\text{-}20cm) = 0.75 * PV(0\text{-}15\ cm) + 0.25 * PV(15\text{-}45\ cm) \quad (1)$$

Input of nutrients to the soil increases the quantity of available nutrients, but part of the added nutrients is not available as it is lost by leaching, microbial immobilisation, chemical immobilisation (fixation), or volatilization. Therefore the recovery by the crop of added nutrients is always less than 1. Default values for the maximum recovery fraction (MRF) are set at 0.5 for N and K, and at 0.1 for P (Smaling and Janssen, 1993).

Since the availability of one nutrient influences the uptake of other nutrients, the available quantities of N, P and K must be well-balanced to get optimum nutrient use efficiency. When a situation of balanced nutrition exists, the uptake of 1 kg of N increases maize grain yield by 50 kg. The same yield effect can be reached when 0.143 kg of P or 0.769 kg of K is taken up (Janssen and De Willigen, 2006). These quantities of N, P and K are indicated by kPNE, standing for (kilo) plant nutrient equivalent (Janssen, 2008). Plant nutrition is in balance when available N, P and K quantities, expressed in PNE, are equal.

The analysis of variance (ANOVA) for nutrient related data implied a comparison of the main affects of soils, ridges and manure to the sum of the interaction terms with soils.

6.3. Results and discussion

6.3.1. Soil characteristics

The A horizon of the Dark soil was 24 cm thick and consisted of very fine sand, and was sticky. The B horizon, from 25 to 90 cm depth, showed a gradual change towards a reddish soil. The C horizon, beyond 90 cm depth, was very dry, red sand and contained white stones. It was impossible to get soil up with the auger from deeper than 112 cm.

The Red soil showed an A horizon (12 cm) of red, sandy soil containing some dark spots. The B horizon up to 24 cm was sandy, while the remaining part of the profile up to a depth of 121 cm was uniform, red and sticky. No stones were found.

The A horizon of the Pale soil profile (12 cm) was brown-greyish in colour. The B horizon, up to 90 cm depth, showed a gradual change towards a yellow, sandy soil. The C horizon, from 90 up to 118 cm, contained many red and yellow stones.

Table 6.2 shows soil texture of the 5-10 and 27.5 - 32.5 cm layers. All samples indicate sandy soils. On average, clay and silt contents of the Dark soils are higher than those of the other two soil types.

Table 6.2. Soil texture (%) of 5-10 and 27.5-32.5 cm layers of the Dark, Red and Pale soils. Codes for treatments: first digit no (0) or with (1) ridges, second digit no (0) or with (1) manure.

Soil	Soil layer (cm)	Size class (µ)	Treatment 1 (00)	2 (01)	3 (10)	4 (11)	Average
Dark	5-10	< 2	4.2	3.6	3.8	3.3	3.7
		2-50	7.5	6.3	6.6	5.7	6.5
		> 50	88.3	90.2	89.7	91.0	89.8
	27.5-32.5	< 2	4.8	7.2	8.7	5.0	6.4
		2-50	6.2	8.6	9.2	7.2	7.8
		> 50	89.0	84.2	82.1	87.9	85.8
Red	5-10	< 2	3.2	2.8	3.2	3.4	3.2
		2-50	3.2	1.7	2.3	3.0	2.6
		> 50	93.6	95.5	94.5	93.6	94.3
	27.5-32.5	< 2	4.1	4.5	5.3	4.4	4.6
		2-50	2.3	2.3	5.0	2.7	3.1
		> 50	93.6	93.2	89.7	92.9	92.4
Pale	5-10	< 2	1.7	3.1	2.7	2.7	2.6
		2-50	1.9	3.3	3.4	4.4	3.3
		> 50	96.4	93.6	93.9	92.9	94.2
	27.5-32.5	< 2	3.0	3.6	3.9	3.5	3.5
		2-50	3.6	2.9	3.4	3.7	3.4
		> 50	93.4	93.5	92.7	92.8	93.1

In Table 6.3, the moisture characteristics of the topsoils (0-20 cm) and subsoils (20-60 cm) are shown. Data for each soil are averages of the four sample plots. No significant difference among the individual plots of the soil types was found.

Porosity of the Dark topsoil is higher than the Dark subsoil. This is due to the organic matter content of the topsoil that allows more aggregation. In the Red soil it is the opposite situation indicating that the topsoil is somewhat compacted. In the Pale soil there is little differentiation between top and subsoil.

Table 6.3. Soil moisture (SM) characteristics for the Dark, Red and Pale soils of Goima, Tanzania. FC = Field Capacity (at 0.1 kPa), PWP = Permanent Wilting Point (at 1.6 MPa), MAM = Maximum Available Moisture in a specified soil layer (in mm). Values in the same row followed by the same letter do not differ significantly (P < 0.05).

Soil layer (cm)	SM characteristic	Soil Dark	Red	Pale
0-20	Porosity (%)	38.0 a	33.0 a	38.0 a
	FC (mm)	41.2 a	36.3 ab	32.9 b
	PWP (mm)	9.9 a	12.1 a	6.7 b
	MAM (mm)	31.3 a	24.2 b	26.2 b
20-60	Porosity (%)	31.0 a	38.0 b	34.0 ab
	FC (mm)	79.8 b	91.8 a	68.8 c
	PWP (mm)	33.4 b	42.0 a	24.9 c
	MAM (mm)	46.4 b	49.8 a	43.9 b
0-60	MAM (mm)	78.0 a	74.0 a	70.0 a

Table 6.4. Chemical characteristics (0-20 cm) of the Dark, Red and Pale soils. Values in the same row followed by the same letter do not differ significantly (P < 0.05). Note: for soils letters abc are used, for ridges letters q and r, for manure v and w.

Chemical characteristic	Soil			Ridge		Manure		Average
	Dark	Red	Pale	0	1	0	1	1
Org. C (g kg^{-1})	13.8 a	9.2 b	8.7 b	8.2 r	13.0 q	9.7 v	11.4 v	10.6
N (g kg^{-1})	1.25 a	0.90 b	0.78 b	1.12 q	0.83 r	1.00 v	0.95 v	0.98
P-Olsen (mg kg^{-1})	7.6 b	8.0 b	15.2 a	9.3 q	11.3 q	9.2 v	11.3 v	10.3
Exch. K (mmol kg^{-1})	7.0 a	3.7 b	6.2 a	4.8 r	6.4 q	5.5 v	5.8 v	5.6
pH(H2O)	7.5 a	5.7 b	7.1 a	6.5 r	7.0 q	6.7 v	6.8 v	6.7

All soils differ in their FC and PWP values. FC in Dark soil is homogeneous over the whole rooting depth. FC of Red subsoil is significantly higher than the FC of the topsoil. Pale soil shows the smallest FC values with little differentiation. Subsoils show high values of PWP due to the presence of a lot of fine sand. This implies that quite some soil moisture is not available for plants.

Maximum available moisture (MAM) of the 0-20 cm layer was significantly higher for the Dark soils than for the other two soils. Also when the whole 60 cm root zone is considered the MAM of the Dark soil scores highest. Topsoil MAM was lowest on the Red soil where plots showed signs of runoff damage and sand deposition, which negatively influences soil properties and water use efficiency. This confirms the compacted nature of the Red topsoil. The Pale soils showed lowest level of MAM over the root zone.

Table 6.4 presents chemical soil data for the 0-20 cm layer as calculated with Equation 1 from the data of the 0-15 and 15-45 cm soil layers. The Dark soil was higher in all characteristics except P-Olsen. The high P-Olsen and rather high Exchangeable K on the Pale soil may be a residual effect of a kraal which had been located on this site as the farmers told (after the trial had been finished).

Ridges had a significant negative effect on organic N, and a significant positive effect on all other characteristics. This is likely the result of the method the ridges were made, scraping together surface soil, crop residues and ashes. During the burn N is volatilized while ash contains much P and K and has a high pH (compare e.g. Van Reuler and Janssen, 1996).

The effects of manure were similar as those of ridges but not significant. As manure was placed in the plant holes it was practically not included in the soil samples taken.

6.3.2. Soil moisture

Temporal and spatial fluctuations in soil moisture

Generally, the Dark soils had most moisture available for the crop throughout the 2005/06 rainy season (Figure 6.1), which is also visible from the average moisture availability over the 18-weeks period between sowing and maturation of the maize crop (Table 6.5). The figures for the 0-20 cm layer in Table 6.5 showed significant differences

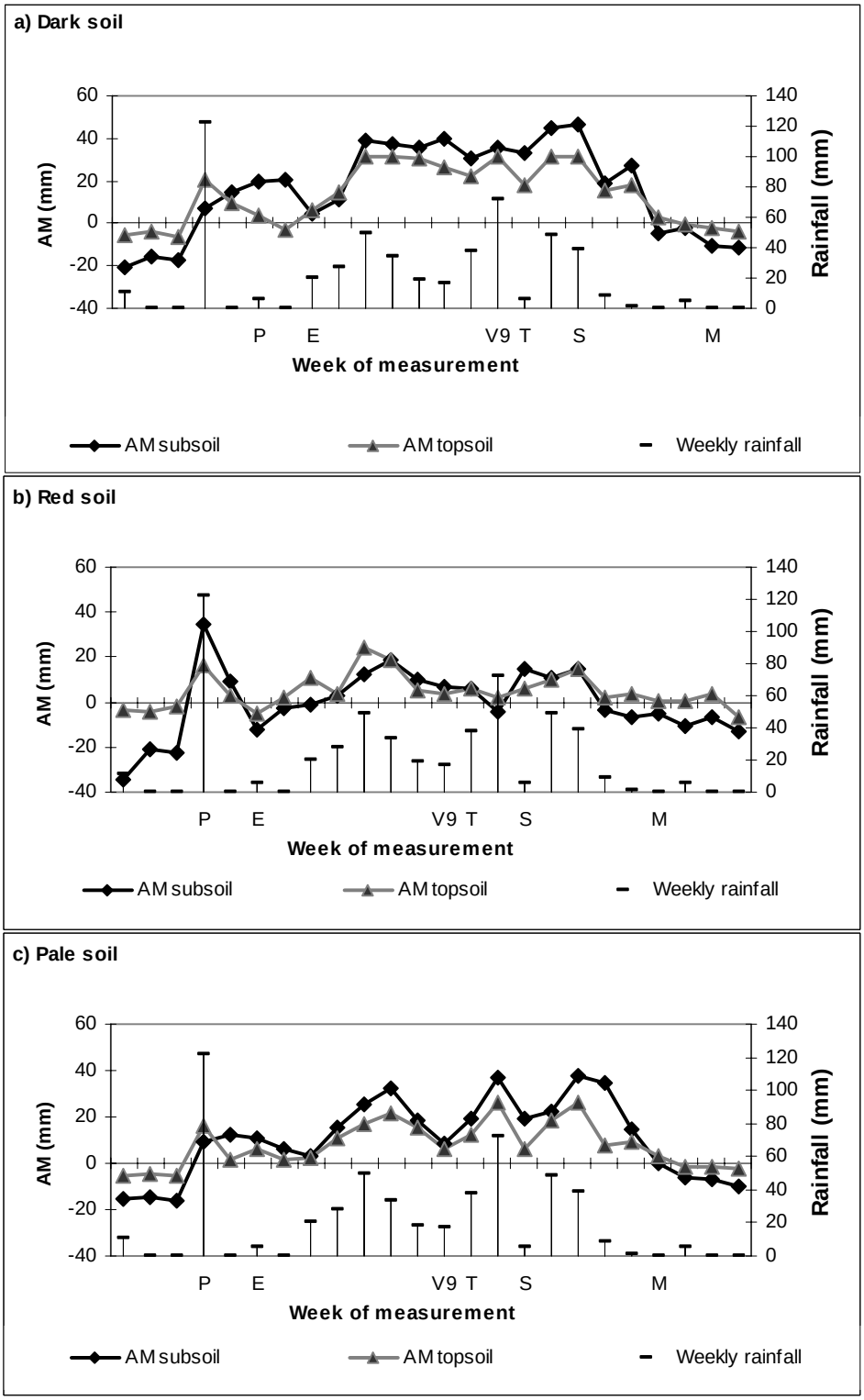

Figure 6.1a-c. Weekly rainfall (mm), available moisture (AM) (mm) for the maize crop during 2005/06 rainy season, for 0-20 and 20-60 cm soil layers on three soil types (Dark (a), Red (b) and Pale (c)) and maize crop development stages: P = Planting; E = emergence; V9 = development ninth leave; T = tasseling; S = silkening; M = maturation.

Table 6.5. Seasonal mean of moisture available (AM) in mm per layer in the Dark, Red and Pale soils over the cropping season, between sowing and maturation of the Kilima maize crop. Values in the same rows followed by the same letter do not differ significantly (P < 0.05).

Seasonal mean AM (mm) in soil layer	Soil		
	Dark	**Red**	**Pale**
0-20 cm			
	9.2 b	7.3 c	13.3 a
20-60 cm	25.0 a	12.0 b	17.9 ab

between all soil types. The Red soils had the least moisture available for the plant during the crop season.

For the 20-60 cm layer, average moisture availability for the maize plants was significantly higher on the Dark compared to the Red soils. For both layers there were no significant differences between the treatments of ridges and manure. ANOVA of each separate week showed no differences in AM for the treatments.

Moisture stress and water balance

Whether soil water stress occurs depends on the development stage of the crop. Figure 6.1 includes for each soil type, the development stage of the maize crop. On the Dark soil, there was some water stress immediately after sowing. The maize crop developed well and showed no signs of water stress. On all soils, AM has been depleted till zero by the time the maize reached maturation. The Red soil showed negative values also at a critical stage of crop development: i.e. in the first weeks after emergence. The small plants had curled leaves towards the end of that period. Almost throughout the crop development period, AM was low and may not have been readily available, which implies that yield was water stress limited. The maize crop on the Pale soil did not suffer water stress during the 2005/06 crop season.

Daily data for transpiration (T), evaporation (E) and loss (L), calculated as described in Table 6.1, were joined into seasonal figures and expressed as percentages of total seasonal rainfall (Figure 6.2). Red soil lost more than 40% of rain mostly in runoff due to the compacted nature of the topsoil. As expected this caused less vigorous maize growth, visible from the low percentage of T. Subsequently with low vegetation cover, the soil E is highest. Pair-wise comparisons of weekly figures for T, E and L (Table 6.6) showed that T was significantly higher on the Dark and the Pale soils compared to the Red soils. Dark and Pale soils showed no significant differences. E was significantly higher on the Red soil compared to the Pale soil. Loss (L) estimates showed no differences between the soil types.

Rainfall partitioning as was displayed in Figure 6.2, shows similar figures as presented in literature (Falkenmark and Rockström, 2004; Stroosnijder and Slegers, in press). Of the total rainfall, 30 to 50% evaporates and 20 to 55% is lost through runoff and deep percolation. Only 10 to 30% is actually used by plants. In our data, about 30% of the rainfall is ‘productive’.

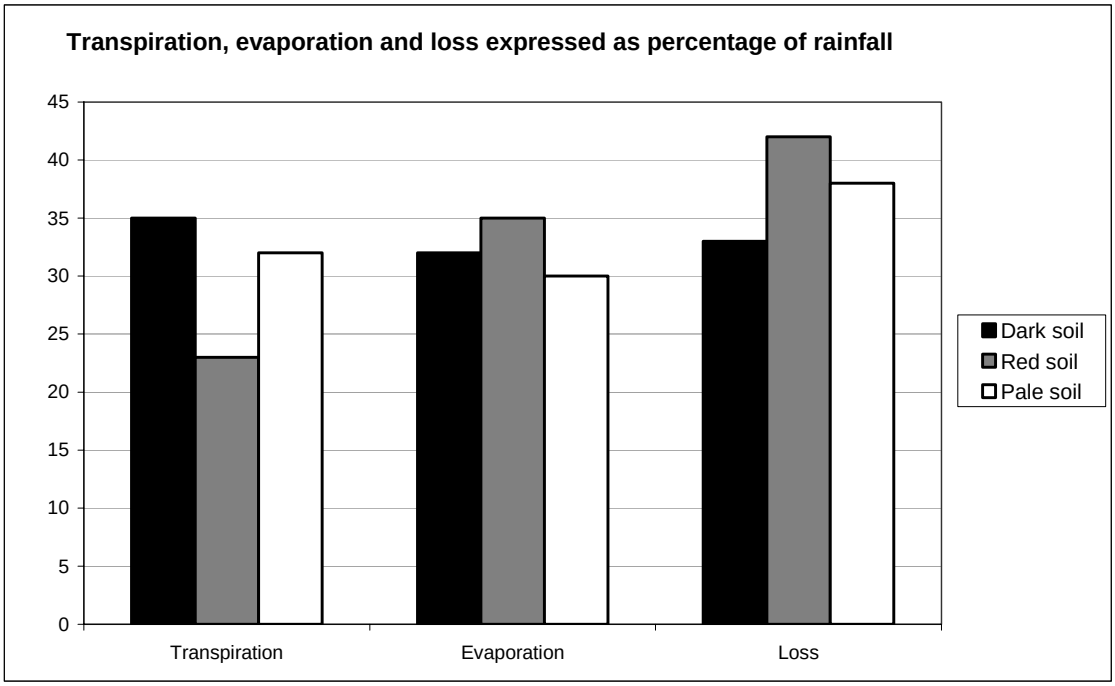

Figure 6.2. Water balance for 2005/06 season for the Dark, Red and Pale soils.

Table 6.6. Pairewise comparisons of Dark, Red and Pale soils for mean weekly transpiration (T), evaporation (E) and loss (L) during the cropping season (in mm). Values in the same row followed by the same letter do not differ significantly (P < 0.05).

Variable	Pairwise comparisons of means		t
Transpiration	Dark – Red	8.0 a – 5.3 b	2.63
	Dark – Pale	8.0 a – 7.3 a	0.51
	Red – Pale	5.3 b– 7.3 a	-3.35
Evaporation	Dark – Red	7.3 a – 8.0 a	-1.51
	Dark – Pale	7.3 a – 7.0 a	0.93
	Red – Pale	8.0 a – 7.0 b	2.88
Loss	Dark – Red	7.7 a – 9.9 a	-0.46
	Dark – Pale	7.7 a – 8.7 a	0.28
	Red – Pale	9.9 a – 8.7 a	0.24

6.3.3. Nutrients

Leaf analysis

The maize on Red soil had the lowest mass fractions for all three nutrients (Table 6.7) which may indicate that the Red soil is more nutrient deficient (Jones, 1983) than the Dark and Pale soils. The standard deviations of the three nutrients were so high that only in one case significant differences among the soils were found: leaf N was higher on the Pale soil

Table 6.7. Leaf analysis of maize grown at the Dark, Red and Pale soil. Leaf opposite the cob was taken. Values in the same row followed by the same letter do not differ significantly (P < 0.10). Note: for soils letters abc are used, for ridges letters q and r, for manure v and w.

Nutrient	Soil			Ridge		Manure		Average
	Dark	Red	Pale	0	1	0	1	
Leaf N (mg g^{-1})	21 b	20 b	26 a	21 q	23 q	20 w	24 v	22
Leaf P (mg g^{-1})	4.6 a	3.9 a	6.1 a	4.2 q	5.6 q	4.0 v	5.8 v	4.9
Leaf K (mg g^{-1})	23 a	17 a	18 a	19 q	19 q	19 v	20 v	19

than on the Dark and Red soils. Leaf K and Leaf P on the three soils did not differ significantly. Manure increased the leaf mass fractions of all three nutrients, but only the effect on leaf N was significant.

The criteria by Jones and Eck (1977) indicate that N was the deficient nutrient, K was sufficient, and P was high. According to DRIS system (Beaufils, 1973), N/P and K/P ratios were low pointing to high P. The ratio N/K varied from low (Dark soil) via sufficient (Red soil) to high (Pale soil), but the difference between Dark and Red soils was too small to be significant.

QUEFTS calculated available nutrients, nutrient uptake and yield

Soil supplies of available N and P (Table 6.8), as calculated with the QUEFTS program, were highest for the Dark soil, and equal for the Red and Pale soils. The supply of available K was lowest for the Red soil. Also QUEFTS-estimated yields were highest for the Dark soil; they were lowest for the Red soil, in accordance with the results of leaf analysis (Table 6.7), but the difference with the Pale soil was not significant. In these calculations the possible effect of manure could not show up as the soil samples were not taken in the place where the manure was placed. The effects of ridges were negligible, except that the ridges were lower in available N and higher in available P than the surrounding soil. The higher P in the ridges apparently could not compensate for the lower N, as N was the limiting nutrient. This is easily seen in Table 6.9, where the quantities of available soil nutrients are expressed in kilo plant nutrient equivalents (kPNE), and as fraction of the sum of kPNE.

Table 6.8. Soil supplies of available N, P, K, and expected yield on non-fertilized Dark, Red and Pale soils, as calculated with the QUEFTS program (modified version by Smaling and Janssen, 1993). Values in the same row followed by the same letter do not differ significantly (P < 0.10). Note: for soils letters abc are used, for ridges letters q and r, for manure v and w.

Nutrient supply and yield estimate (kg ha^{-1})	Soil			Ridge		Manure		Average
	Dark	Red	Pale	0	1	0	1	
Available N	85 a	64 b	60 b	80 r	59 q	72 v	67 v	70
Available P,	15.8 a	9.6b	10.7 b	10.3 q	13.8 r	10.7 v	13.4 w	12.0
Available K,	128 a	91 b	134 a	112 q	123 q	118 v	118 v	118
Yield estimate	3675 a	2372 b	2486 b	2881 q	2807 q	2772 v	2916 v	2844

Table 6.9. QUEFTS calculated soil supplies of available N, P and K, expressed in kilo plant nutrient equivalents (kPNE) per ha, and as fraction (%) of the kPNE-sum of N, P and K, on non-fertilized Dark, Red and Pale soils. For relative imbalance see text.

Nutrient	Dark		Red		Pale	
	kPNE	%	kPNE	%	kPNE	%
N	85	23	64	26	60	19
P	111	31	67	27	75	24
K	167	46	118	47	174	56
SUM	363	100	249	100	308	100
Relative imbalance		28		30		49

N is at most 26%, and K is at least 46% of the NPK-sum. For the calculation of relative imbalance, the deviations of the N, P and K fractions from 33.3% were squared. Next, the square root of the mean square (SQRT MS) was calculated. Relative imbalance is found as 100 * SQRT MS/33.3. It is obvious that the soil supplies of N, P and K were not well balanced, certainly not those of the Pale soil.

Table 6.10 shows the analytical data of manure, and the quantities of N, P and K applied. The calculated responses are surprisingly strong. This is explained by the increased uptake efficiency of N, the most limiting nutrient. The values for uptake efficiency for N, P and K, as calculated with QUEFTS, were 77, 88, and 51 %, respectively, on unfertilized soil, and 81, 87 and 42%, respectively, on the soils receiving manure.

Table 6.10. Chemical characteristics of manure (based on dry matter), quantities of manure applied and QUEFTS calculated response to the manure at the Dark, Red and Pale soils. Quantities of N, P and K applied, based on 10% moisture in applied manure.

Chemical characteristics of manure and yield response	Soil		
	Dark	Red	Pale
Org. C (g kg^{-1})	63.2	69.8	75.9
N (g kg^{-1})	8.9	7.0	8.4
P-Olsen (g kg^{-1})	29.4	26.4	35.7
Exch. K (mmol kg^{-1})	3.5	6.0	5.5
pH(H_2O)	9.8	8.8	9.4
Applied manure (t ha^{-1})	0.5	0.6	0.5
Applied N (kg ha^{-1})	4.0	3.8	3.8
Applied P (kg ha^{-1})	13.2	14.3	16.1
Applied K (kg ha^{-1})	61.4	126.4	96.5
Yield response (kg ha^{-1})	293	379	298

6.3.4. Yield estimates by farmers

Towards the end of the season farmers estimated the yield on their land. Table 6.11 compares the yield estimates by the farmers with QUEFTS calculated yields, and with dry matter accumulation (∑DM) estimates at the end of the season. The maize on the Dark soils developed well, as did the weeds. No additional sowing was necessary. Yield estimates were highest for the fields with manure treatment. This response to manure was even higher than calculated with QUEFTS in Tables 6.10 and 6.11. Farmers did not see yield differences between the fields with and without ridges.

The yield estimate for the Red soil was rather low. The major reason mentioned was that the soil was exhausted and had lost its strength to produce maize. Another reason was that the plots suffered from runoff water and sand deposition. The ridges to a certain extent had reduced runoff damage. The chemical analyses did not show such an exhaustion of the soil, and the QUEFTS calculated yields, although lower than on the other fields, neither were extremely low. Here, yield can be water stress limited.

The plots on the Pale soil showed some unexpected results. The farmers living in the Pale soils' area mentioned that their soils are not good for growing maize. The plant would show stunted growth at the time when crop development should start due to the lack of fertility. At that time of the season maize plants stop growing and fade colour to a yellowish green. Plants would finally dry out without bearing cobs. This held true for the plot without ridges and manure application. The fields where manure had been applied did very well. Plants were tall and maize cobs were big. The plot without manure and with ridges did even

Table 6.11. Comparison of yield estimates by farmers with QUEFTS calculated yields and with estimates of dry matter accumulation (∑DM) at the end of the season.

Ridge	**Manure**	**Soils**			***Average***	
		Dark	**Red**	**Pale**	**Ridge**	**Manure**
		Farmer				
0	0	750	75	250	*704*	*650*
	1	2000	150	1000		*1108*
1	0	750	75	2000 [a]	*1054*	
	1	2000	500	1000		
	Average	*1375*	*200*	*1063*	***879***	
		QUEFTS				
0	0	3496	2366	3102	*3049*	*2772*
	1	4020	3018	2295		*3079*
1	0	3470	2094	2105	*2936*	
	1	4359	2715	2874		
	Average	*3836*	*2548*	*2594*	***2993***	
		0.4 * ∑DM[b]				
	Average	*3013*	*1960*	*2729*	***2567***	

[a] Former kraal.

[b] Estimated 40% of ∑DM is grain.

better. This unexpected high yield was attributed to the fact that long time before, that site used to be a kraal.

Grain yield was also calculated as 40% of ∑DM, used for the calculation of transpiration (as explained in Table 6.1). The results are in between the farmers' estimates and the QUEFTS calculated yields, and again lowest for the Red soil.

6.4. Farmers' knowledge about crop performance

6.4.1. The effects of soil characteristics in good and bad years

The sociological study on farmers' perceptions of drought in Goima (Slegers, 2006; Slegers, 2008b) revealed that farmers have site-specific knowledge about how soil characteristics influence crop performance during dry and wet conditions (cf. Schechambo et al., 1999). Farmers believe that water adds fertility to the land; when there is no moisture in the soil, the land is "empty". A common statement is: "If only it rains, we will harvest". However, farmers know that a soil cannot give good production when it is infertile, no matter the amount of rainfall. This was clearly explained by some farmers who stated that in a wet year the major limiting factor is soil fertility, while the major limiting factor in a dry year is soil moisture.

The first big rainfall event of the 2005/06 season was very intense. Within a period of twelve hours, 120 mm of rainfall with a highest intensity of 41 mm $hour^{-1}$ was recorded. After this downpour, farmers with heavy soils were not yet able to cultivate their land, while farmers on the light soils had started working their land that same day. The big rain was followed by a four-week period of very little rainfall. Some fields needed re-sowing after big rains had resumed, while plants on other fields had survived this dry spell. Again, on other fields, it was just the start of the season, like on our Dark soil.

Farmers mentioned that heavy soils contain more clay and organic matter than light soils, and are generally considered as most fertile, which also appeared from the texture and chemical analyses. The QUEFTS and kPNE data showed that the Dark soil not only had the highest nutrient contents, but also that on these soils N, P and K were in the most balanced situation. The crops grown on this soil least suffer from nutrient deficiency. Farmers also mentioned that the Dark soil was the most fertile soil.

The analyses showed that all three soil types are sandy soils and that the Dark soil had highest clay, silt and organic C contents and water holding capacity. Farmers considered crops on the Dark soil and on heavy soils in general, to be most susceptible to drought because such soil is hard when it is dry. Farmers felt that this limits water infiltration early in the season. A farmer who cultivates a heavy soil generally cannot start cultivation immediately after the first big rain. Their land needs a lot of water before it is workable, which reduces the length of the cropping season on these soils. This can be problematic in years when the rains stop early. Tillage with animal traction or tractor were options mentioned by farmers to overcome these constraints for the Dark soil as it speeds up the work and allows water to infiltrate easier and deeper compared to hand hoe tillage. The data

showed that the Dark soil had the highest potential and actual moisture availability compared to the other soils and that soil moisture after the first big rainfall event was sufficient to start sowing, contrary to farmers' practices. The effect of late sowing was also visible (Figure 6.1) as moisture had reached PWP before maturation.

The Pale soil was described as sandy and infertile and, therefore, unsuitable for growing maize. Maize plants would show stunted growth, even when rainfall is not limiting plant growth. However, farmers consider crops grown on Pale soils to be the least susceptible in a dry year. Water infiltrates easily and deeply into the sandy or light soils, which makes it very easy for farmers to start cultivation immediately after the first big rain. It is important for farmers not to miss any rain because rainfall is erratic. The analyses of the Pale soil samples showed that PWP was lowest, which implies that the Pale soil requires the least amount of rainfall before farmers can start cultivation. Barron et al. (2003) found that crops on light-coloured sandy soils least suffered during dry spell periods compared to soils that were more rich in clay. Chemical characteristics as well as crop performance were not as poor as would be expected from farmers' description of the soil, which later appeared to be the effect of a kraal that used to be located on part of that land. This can explain the high levels of P and K.

Farmers in general judged the Red soil's susceptibility to drought to lie in between that of the Pale and the Dark soils, depending on whether the soil is heavy or light. The darker red the soil, the heavier it is. Heavy Red soils mostly resemble the Dark soils' characteristics, while light Red soils mostly resemble the Pale soils in terms of their characteristics. The Red soil used in our study was characterized by farmers as a light soil, exhausted due to continuous cultivation, sheet erosion and sand depositions. The owner of the land had predicted that maize on his land will not perform well; it stunts before the plant starts to develop, resulting in poor cob formation. Indeed the data showed that the Red soil was poorest in terms of nutrient status, had a compacted topsoil, and the highest evaporation (E) and loss (L), resulting in the lowest transpiration (T).

6.4.2. The effects of land management practices in good and bad years

Farmers not only identified natural factors that create spatial differences in crop performance in dry conditions, they also identified anthropogenic factors. Soil fertility is not an intrinsic permanent characteristic of a soil; it changes over time. After a consecutive number of years of cultivation the soil gets exhausted. According to the farmers the soil becomes "tired" and loses its productivity and capacity to retain water. Farmers also recognized the effects of soil erosion on the land. Farmers believe that the soil layer up to a depth of 30 cm is good soil as it has been enriched by decaying grass, leaves and crop residues. Analyses of soil samples showed that the topsoil layers had higher nutrient levels than the subsoil layers.

Soil erosion was generally known as a process whereby the fertile topsoil is washed away and deposited in other places. Eroded areas are less productive and crops on these soils

more easily suffer from water stress. Farmers complained about the loss of fertile topsoil by runoff water, especially on sloping land and land where livestock and people pass regularly.

Farmers agreed that sedimentation can have both positive and negative effects. Where sand is deposited, the land loses productivity, and where fertile soil particles are deposited the land gains productivity. According to the farmers, the Dark soil in our study showed the beneficial result of soil deposition, whereas our Red soil was exhausted and suffered from sheet erosion and sand depositions, both of which are visible in the soil profiles.

Soil fertility can be enhanced when fertilizers or (green) manure is applied, or when land is fallowed. Increased pressure on the land has limited fallow practices and is, according to the farmers, exhausting the land. Chemical fertilizers are not easily available and are too expensive for most farmers. Only one-third of the farmers own livestock. Transportation and application of manure require transportation means, labour and/or capital, which many farmers lack. In the 2004-05 crop season, less than 10 % of questioned farmers (N=120) had applied manure. Some farmers have experienced that crops 'burn' on fields where manure had been applied in bad rainfall years and are reluctant to apply manure, while others felt that their land was still productive.

Ridge cultivation is a common practice, particularly since most farmers work their land with hand hoe. Farmers agreed that ridges prevent the soil from washing away and help to retain water in the depressions, which makes plants to grow stronger and faster. Farmers felt that fewer weeds come up on the ridges, which makes their job of weeding easier. Some farmers believed that the ridges increased the fertility of the soil because it increases the depth of the fertile topsoil layer; however, most farmers believed that the ridges only had beneficial effects on the moisture availability in the soil. The chemical soil data (Table 6.4) showed a nutrient accumulation effect in the ridges, whereas there was no significant difference in the available moisture availability. AM was generally sufficient throughout the season, the difference between plots with and without ridges might, however, show significant differences during an extended dry spell period.

6.4.3. Estimated yields

Farmers' yield estimates showed low figures. Farmers indeed found it difficult to estimate yield due to the small sizes of the sample plots, which might have resulted in these low figures. Yields estimates through dry matter production ranked the soils in the same order as the QUEFTS calculated yields and with the average yield estimates of the farmers. Average yield estimates were highest for the Dark soil and lowest for the Red soil. However yield estimates of farmers showed a large absolute difference compared to the other estimates, particularly to the QUEFTS calculated yields. QUEFTS takes no other limitations into account for yield production besides nutrient deficiency. Even though no extreme moisture deficiency was visible during the 2005/06 cropping season, Figure 6.1 does show AM close to zero, which is not always readily available. The yield estimates based on the ∑DM accumulation is also rather high. The 40% mass fraction for some plots on the Red and Pale soil was too high because of poor cob formation and growth. Since there was no moisture

stress throughout the cropping season, with the exception of a short period early in the season, the differences in LAI and yield must be ascribed to differences in nutrient availability.

The QUEFTS analyses confirmed outcomes of previous studies in Tanzania that soils are mostly N deficient (Table 6.9), and that P is the one but most deficient nutrient (Vesterager et al., 2008). In general terms, it can be stated that the nutrient levels and the productivity of the different soils in Goima were quite good compared to FAO's maize production estimates of 905 kg ha^{-1} (Kaihura et al., 2001).

6.5. Conclusions

The objective of this study was to understand the source of farmers' growing concerns about the rains. Since there is no unequivocal proof of an increased problem of meteorological drought, this chapter looked beyond meteorological data by comparing farmers' knowledge about spatial differences in drought susceptibility of crops with moisture and nutrient availability to maize during the 2005/06 cropping season.

Farmers believe that water adds fertility to the land; when there is no moisture in the soil, the land is "empty". However, farmers know that a soil cannot give good production when it is infertile, no matter the amount of rainfall. Such soils are not suitable for crops. Maize will not grow well on Pale and light Red soils, even in a good rainfall year. According to farmers, the relative productivity of each soil differed between wet and dry years. Farmers perceived that in good rainfall years, the less sandy soils perform relatively best due higher fertility status, while in a bad rainfall year lighter soils are relatively most productive because of easier water infiltration and lower water demands. Crops on soils that are exhausted, or that have been affected by erosion are more susceptible for moisture deficiency and less productive in a good year.

Nutrient deficiency and water deficiency are problems that occur alternately in areas such as Goima, where rainfall is erratic, the soils are sandy and not very fertile. This is especially visible on the soils that contain least clay and organic material.

Adequate land management practices are required to maintain productivity and ensure food security. Farmers agreed that the land management practices used influence farmers' production levels and crop performance in a bad year. The plots where manure was applied showed better crop growth than the other plots of the same soil type. Effects of the ridges, however, were limited, but might have been significant if a period of more severe moisture stress would have occurred during this particular cropping season.

It can be stated that farmers' knowledge about spatial differences in drought susceptibility of crops generally agreed with the outcomes of the analyzed data. Chemical and physical properties of the Dark soil were best, and those of the Red soil were poorest. Yield assessments by farmers were low compared to QUEFTS calculated yields and yield estimates based on DM accumulation. These deviances might be attributed to moisture stress during periods when soil moisture is near PWP and is not readily available to the crop.

Farmers distinguished meteorological drought from local manifestations of soil nutrient deficiency, or moisture deficiency. Farmers recognized that natural conditions of a soil as well as their activities influence nutrient and soil moisture availabilities and by that the crops' susceptibility to dry conditions.

Figure 6.3. We got assistance from farmers to put the rain gauge in position.

Figure 6.4. Digging in a E+ soil MCT sensor.

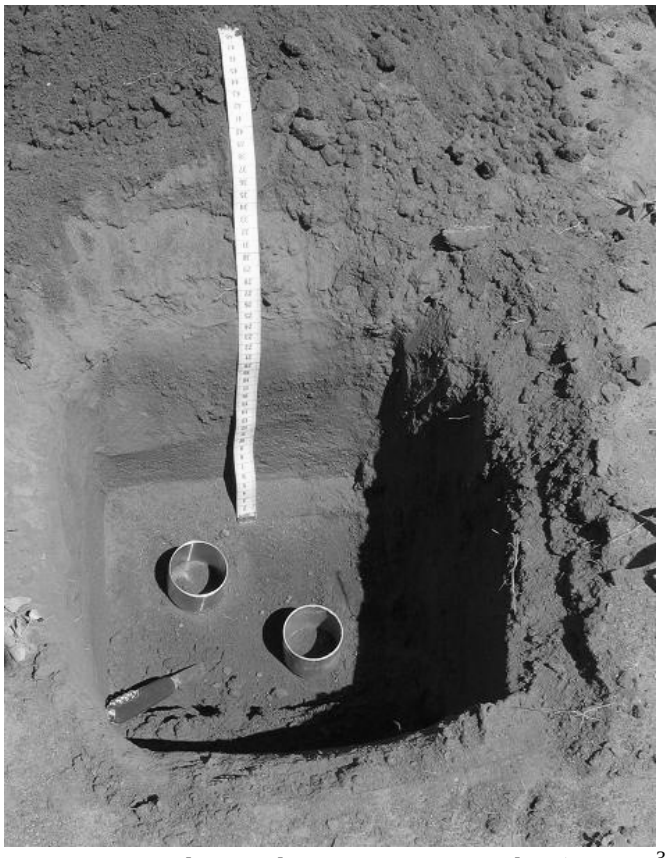

Figure 6.5. Taking volumetric ring samples (100 cm^3).

Figure 6.6. Crop leave samples.

Chapter 7

The strength of the land and the missing rains. Environmental change in Goima, Tanzania, and farmers' growing concerns

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7. The strength of the land and the missing rains. Environmental change in Goima, Tanzania, and farmers' growing concerns

Abstract

Two studies among Burunge farmers disclosed a striking difference in their perception of environmental stress over a period of fifteen years. Environmental history of the region helps to explain how a Burunge mode of relating to natural resources evolved. Dramatic changes in official land policies in the 1970s did not in essence change this. However, the accumulative effects of rapid immigration to their area and liberalised land use made Burunge farmers to move from an essentially trustful relationship to their environment to become deeply concerned over increased drought, diminishing soil fertility and accelerated soil erosion. The increased concerns over these issues emerged over the past ten to fifteen years and coincide with the period over which farmers perceive an increased rainfall variability and drought severity. Drought was not just understood in meteorological terms but also as a function of disappearing forests and declining conditions of the land.

7.1. Introduction

Many small-scale farmers in semi-arid East Africa see drought as the major factor reducing the productivity of their fields. By contrast, natural resource specialists tend to identify land degradation as the main cause of poor harvests. In popular thinking declining harvests are often blamed on reduced rainfall but studies of long-term trends do not necessarily confirm that assumption.

A study in a local area of semi-arid, central Tanzania in 2005-2006 attempted to understand what factors lie behind many farmers' current preoccupation with drought (Slegers, 2008b). Goima and Mirambu villages of Kondoa District are situated along the Western foot slopes of the Burunge Hills. A previous study in the same area had found that farmers there related reduced production to erratic rainfall rather than to soil erosion or reduced soil fertility (Östberg, 1995). The last two processes were at the time not considered as serious problems. Ten years later this was no longer the case; soil erosion and loss of soil fertility had become serious concerns for many farmers (Slegers, 2008b). However, farmers still perceived rain as their major problem and held that rainfall had become more erratic during the past ten to twenty years.

Analysis of rainfall data (1970-2006) from the nearby Kondoa meteorological station showed no other significant trend in annual rainfall, or in intra-seasonal rainfall distributions than an increase in mean length of dry spells in December (Slegers, 2008a). However, biophysical factors other than rainfall deficiency influence soil-water availability and can

contribute to farmers' increased concerns about rainfall (Lindskog and Tengberg, 1994; Dahlberg and Blaikie, 1996; Amsalu, 2006; Slegers and Stroosnijder, 2008). Slegers found that farmers considered that land management, soil type, soil quality and the location of the land influence drought vulnerability, implying that soil degradation processes were included in farmers' perceptions of drought.

An account of the environmental history of the area and a comparative look at the studies by Slegers and Östberg respectively, carried out with a bit more than a decade's latitude, provide an opportunity to explain more in-depth how environmental changes have had their effect on the environmental perceptions among a group of East African small-scale farmers. Environmental change is analysed in historical, cultural, socio-economic as well as in biophysical context to understand how farmers' environmental perceptions evolved over time and to explain why they until recently remained relatively indifferent in relation to land degradation. The increased concerns over these issues emerged over the past ten to fifteen years and coincide with the period over which farmers perceive an increased rainfall variability and drought severity.

7.2. Population and physical environment

Goima village is both the administrative seat of Goima Ward in Kondoa District, comprising eight villages, and of Goima Division, which includes 29 villages. This is the home area of the Cushitic speaking Burunge people who today remain in majority in Chambalo, Goima, Kambi ya Nyasa and Mirambu villages. In all other villages the Rangi, Bantu-speakers who originate from the central parts of the district, are in majority. This study is focused on the two villages Goima and Mirambu (Figure 7.1). Their population nearly doubled in the period from 1978 through 2005 (Table 7.1). During the same period, population growth in Kondoa District was just over a third. Immigration by Rangi from the central parts of the District contributed to the rapid population increase of Goima and Mirambu.

Goima area has a semi-arid climate with an average annual precipitation of below 550 mm. The rain falls irregularly between November and May, the rest of the year being very dry. The rivers are ephemeral and it is difficult to find surface water for most of the year.

Miombo woodland (*Brachystegia* sp.) and montane forests form the natural vegetation of the Hills. Where settlements and fields have been abandoned for longer or shorter periods of time, acacia species dominate as they quickly colonise cleared areas. The plains are characterised by bushed grassland with scattered trees, often acacia. Baobab trees provide a landmark here and there.

On the plains surrounding the Burunge Hills the soils are sandy with low water-storage capacity. On flat depressions in the landscape, *mbuga*[1], soils are clayey, prone to seasonal water logging, and in the absence of tractors, difficult to work. They are commonly used for dry season grazing.

[1] Italics indicate words in Latin or, as here, in Swahili, or Burungaiso.

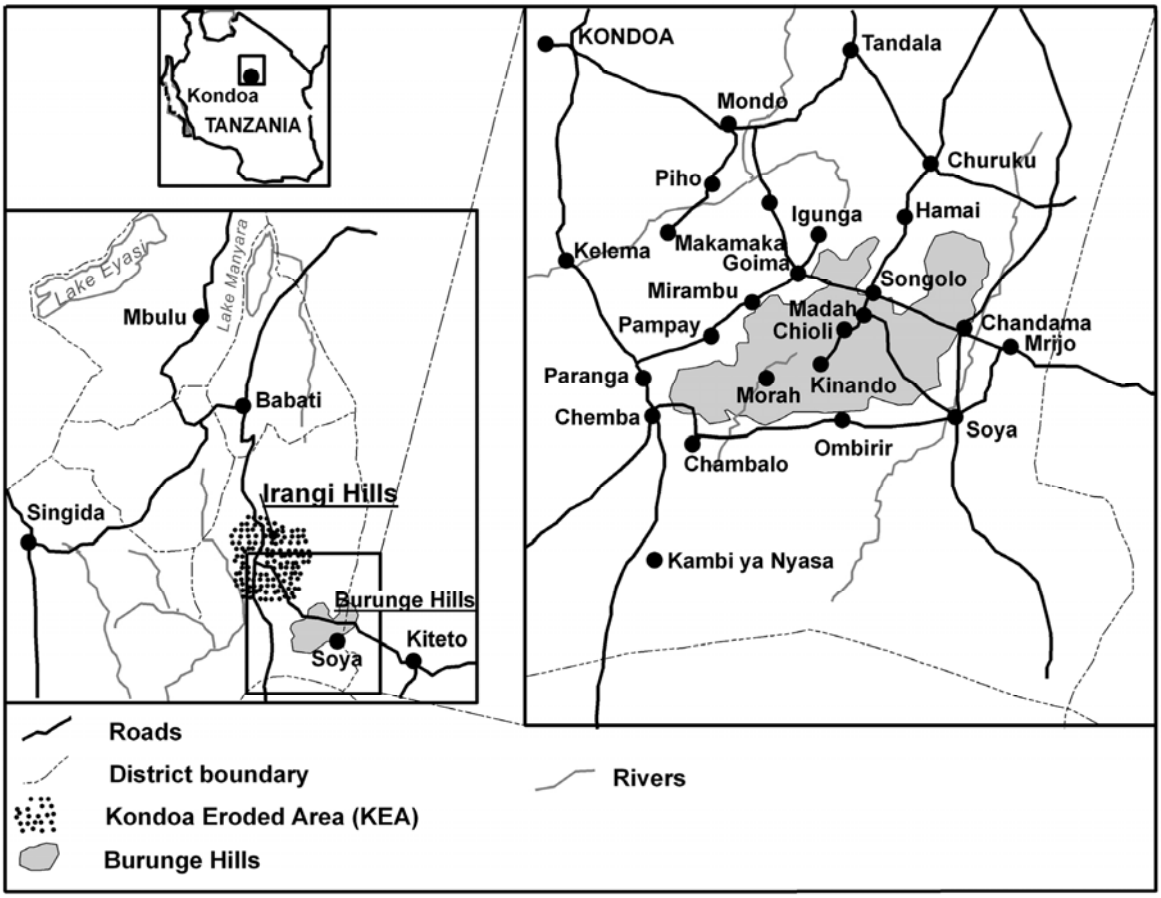

Figure 7.1. Goima and Mirambu villages on foot slopes of the Burunge Hills, south-east of Kondoa town and Kondoa Eroded Area

Table 7.1. Population size, average household size and annual population growth rates (%) for Goima and Mirambu villages and for Kondoa District.

	1967	1978	1988	2002	2005
Goima and Mirambu					
Population		2,989[a]	3,836[b]	5,101[c]	5,748[d]
Average household size			4.8[e]		4.9[d]
Kondoa District					
Population	212,195[f]	275,278[f]	340,232[f]	429,824[f]	446,800[f]
Average household size	4.2[f]	4.8[f]	5.1[f]	4.8[f]	
Population density (people km^{-2})	16.6[f]		25.8[f]	32.5[f]	33.8[f]
Annual growth rate (%)	**1967-1978**	**1978-1988**		**1988-2002**	**2002-2005**
Goima and Mirambu		2.6[g]		2.2[g]	3.1[g]
Kondoa District	2.4[f]	2.1[f]		1.7[f]	1.0

[a](Tanzania, 1981), [b](Tanzania, 1991), [c](Tanzania, 2005), [d]Goima and Mirambu Village Offices, [e](Östberg, 1995), [f](Tanzania, 2003), [g]calculated

The villages are situated below the Hills, which previously were characterised by small, scattered Burunge communities. During the villagization campaign in 1974, people were moved off the Hills and settled in the foothill communities. When this policy began to falter after some fifteen years a number of families trickled back into the Hills soon to be followed by a rapidly increasing number of immigrants, particularly from the central parts of the District, which for a long time had been afflicted by severe problems of land degradation.

7.3. A history of environmental change

7.3.1. Kondoa District, the historical setting

In the 19th Century Coastal tradesmen had settled at the permanent spring of today's Kondoa town (Koponen, 1988: 82, 93). There they came to form a strong community, which developed into a centre for the spread of Islam (Iliffe, 1979: 47, 213). In the mid-19th Century Kondoa became a provisioning point on one of the caravan routes. The caravans required provisions and larger and larger parts of the Irangi Highlands were put under cultivation. Kjekshus (1996: 86) mentions Kondoa as an important centre for production and trade of iron implements in the 19th century. This in fact had a long pre-history: farming and herding in the region dates back to 2000 to 1800 BC, and iron has been produced in the area since the middle of the first century AD (Lane et al., 2001: 804).

The caravan trade of the 19th Century between inland and coast involved several hundreds of thousands of people who passed through the central plateau every year and the strains placed on the land and food resources were considerable. The increased trading options in Kondoa in the late 19th Century made some people rich and they invested in livestock. Both the increased cultivation to cater for the needs of the caravans and the growing herds came to affect the landscape (Mung'ong'o, 1995: 61ff). Likewise, during the First World War, Kondoa was one place where provisions for the troops could be found (Christiansson, 1981: 163) and an increasing stress on the environment was registered. The Great Rinderpest Epidemic reached Kondoa around 1891 (Kjekshus, 1996) and greatly decimated livestock. However, this may not necessarily have reduced grazing pressure drastically, as Kikula and Mung'gong'o (1993: 21) observe, since it halted the by then on-going expansion from the Irangi Highlands, which may have remained under stress.

7.3.2. Environmental history of the Irangi Highlands

A missionary who visited the central parts of Kondoa in 1884 met a densely settled area with grains in abundance (Håkansson and Widgren, 2007: 240). A decade later the cartographer Oscar Baumann visited Kondoa and reported that rich fields surrounded the Arab traders' settlement. Sugar cane and dates were grown, and the merchants lavishly entertained him throughout his stay (Baumann, 1894: 113ff). Another early visitor to the Irangi Highlands noted a denuded landscape in the hills and wide, sand rivers, but also

endless green carpets of grain fields hiding the *tembe*[2] houses. "So densely and diligently is this area settled, that it is not easy to find another in our Colony, where every piece of land is so scrupulously utilized by industrious farmers" (Kannenberg, 1900: 156, our translation). The Arabs knew well what they did, he adds, when they established a trading post here to exploit the "benefits of the prosperous lands".[3] This was very soon to change. In the Haubi basin, traces of land degradation were evident (ibid.), and a decade later another visitor found hill slopes "dissected by thousand and thousands of gullies" (Obst, 1915: 46). In 1911-1912 sand rivers as wide as 40-150 m had been recorded (Tosi et al., 1982: 13) and half a century later the central parts of the District were to become singled out as harbouring the country's most degraded lands (Tanzania, 1977; Iliffe, 1979: 350).[4]

Kondoa District forms part of the central plateau of Tanzania, regarded as the country's most marginal agricultural region. The rich fields described by early visitors related to a limited period of time when farmers exploited the trading options that had emerged, and it is more relevant to foreground people's reminiscences of famines, which in pre-colonial times came to one in a decade (Iliffe, 1979: 70, 269; Maddox, 1986: 30). It was to become worse. The most devastating recorded famine hit Central Tanzania in 1917, caused by failed rains but also by the considerable demands of the British and German troops at the time active in the area and requiring provisions (Patton, 1971: 3-6; Iliffe, 1979: 269). An official text tells of "human skulls scattered over the countryside between Kondoa-Irangi and Dodoma, the remains of some of those who had tried to walk to the Central Line[5] to fetch the food there provided by the Government" (Moffett, 1958: 91).

Maddox (1996) has argued that colonial rule fundamentally changed the food provisioning systems of central Tanzania. The men were drawn into the cash economy, losing their economic autonomy, while women were assigned to subordinate subsistence activities and the informal economy. Men were conscripted for military service and contracted for work on the rubber and sisal estates. The colonial restructuring of the economies also included large scale agricultural experiments with groundnut- and range schemes on the central plateau, which proved hazardous, and added further to the strains on local economies. The region has a difficult climate but food deficiency did not only have natural causes.

Throughout the 20th Century the themes of land degradation occupied officers at the Kondoa District Headquarters. Land rehabilitation programmes were launched in the 1930s, and continued with varying intensity through the next decades, to wane off in the late

[2] A *tembe* is a house with flat earthen roof, common in Goima Division, as in some other parts of Dodoma region, but today hardly found in the Irangi Highlands.
[3] Not only Arabs, incidentally. By 1912 ten farms owned by Europeans were found in Kondoa, covering an area of 3,809 ha (Koponen 1994: 608).
[4] However, it also needs to be pointed out that land degradation in the Irangi Highlands has a much longer history than what can be linked to recent human activities. One phase occurred towards the end of the Pleistocene and was linked to climate change, another began about 900 years ago and is still ongoing but with varying intensity. A period of major gully formation occurred some time between 600 and 300 years ago. However, the land degradation of the 20th Century has been drastically accelerated by anthropogenic activities (Eriksson, 1998: 19ff.).
[5] The railway line from Dar es Salaam passing through Dodoma.

Colonial period only to be reinstalled some five years after Independence. Another major environmental intervention was clear felling of large forested areas to prevent the spread of tsetse. It had begun already during the German period and continued under the British with varying intensity into the 1960s.

After Independence a new major programme of soil conservation, HADO (*Hifadhi Ardhi Dodoma*, Dodoma Land Rehabilitation Project), was initiated in the Kondoa Irangi Hills. The project management argued that the major cause of soil erosion in the Kondoa area was overgrazing and the draconian decision was taken to ban all livestock from the most severely eroded parts of the area. This covered 19 villages, 1,256 km^2, and some 90,000 livestock were removed in 1979. At the same time the cutting of greenwood, charcoal production and forest clearance for cultivation were forbidden, while also a number of rehabilitation measures were introduced (Mbegu and Mlenge, 1983; Östberg, 1986). Today the HADO project is starved of resources, and the quarantine on grazing can no longer be maintained. The considerable regeneration of vegetation throughout the Irangi Highlands that did occur (Backéus et al., 1994; Backéus et al., 1996) is disappearing. Grazing of livestock and cutting of trees, charcoal making and brick burning are now again the order of the day (Östberg, 2000; Kikula, 2004; Madulu, 2004: 99ff; Yanda and Kangalawe, 2004: 135ff).

The heyday of the HADO project coincided in time with another very major transformation of the landscape, the villagisation programme. Tanzania's ambitions to improve living conditions (health services, schools, water supply, tractors-services etc.) for her citizens were thought to require that people were concentrated in villages (Lev and Shriver, 1990). In 1974 the policy became compulsory, and land use fundamentally changed. Those who lived scattered on their lands were moved into villages and those who already lived in places designated to become villages had to share the land with a large number of newcomers. Large tracts of land were evacuated as they were situated too far away from the officially recognized villages, while new lands were cleared closer to the new concentrations of people.

The environmental changes have thus been dramatic in Kondoa District. Against a general background of inadequate rainfall and recurring droughts, there have also been periods of relative agricultural prosperity in the 19th Century only to end up as the country's most degraded area by the mid-20th Century. However, the experiences of the study area, located a mere 40 km Southeast of Kondoa town and outside the badly eroded Irangi Highlands, are rather different. A sketch of the environmental history of the study area will provide a background to the discussion of why the Burunge area has fared differently compared to the neighbouring Irangi Highlands and the central plateau more generally. This will lead over to a discussion of changing environmental perceptions during the last few decades in the study area. The background will help to explain both how Burunge views on their environment evolved, and how these could change drastically in recent years.

7.3.3. Environmental history of the Burunge area

Some information about the landscape and food provisioning can be gained from the writings of travellers who passed through the area. Count von Götzen, travelling in 1893/4, noted that the Burunge see themselves as fortunate people who get a good production from the land. Reaching the village of Mondo[6], he had passed through forests, while that area today is an open cultivation steppe. At Mondo he saw fields as far as the eye could reach. This was in January, and thus in the planting season, and he noted that farmers were sowing their land by making a hole with the front of their feet into the loosened soil, throwing in maize or bean seed and then covering up the hole again. He wrote that it gave the impression that the Burunge were moving forward in a rhythmic dance-like movement (von Götzen, 1895).

The crops grown were bulrush millet, finger millet, sorghum, maize, groundnuts, small pumpkin, and beans. Cultivation was with a short hoe, still the agricultural implement used by most Burunge farmers, but also a long-handled wooden spade for planting seeds, which has long since disappeared from use. Meat, milk, and honey were part of the diet. Tobacco was smoked, chewed and snuffed. Salt was imported from the Mount Hanang area (Kannenberg, 1900; Reche, 1914).

Kannenberg (1900) found the Mirambu settlement, in our study area, surrounded with thick 1,5 metres high Ngama grass. He noted that the seeds were eaten during periods of hunger. He passed a large forest and a small lake as he moved towards the river Kelema, encountering more forest but also cultivated fields.

In the 19th Century livestock were traded from Dodoma to the towns Arusha, Moshi and Tanga (Kannenberg, 1900; Stuhlmann, 1894) and this would have affected the Burunge area. Old people in Chemba and Chambalo villages, at the southern end of today's Burunge area, could in the early 1990s relate memories of where the livestock traders used to camp, and how travelling parties had bought grains, chicken and other food stuffs from the Burunge. The livestock required water and grazing, and their keepers food, water and, firewood. In Goima old people could remember how their parents had been selling food to people of the caravans who passed at Aimabu (today's Igunga) a few kilometres north of the village. Merchants from the coast visited to recruit men to hunt elephants for ivory. All this meant income but likely also increased stress on the environment and on social relationships. Koponen (1988: 127) has argued that the build up of the 19th Century commercial systems was accompanied by recurring famines, disease and war. Nevertheless, half a century later The Tanganyika Handbook noted that elephants still were in plenty at the Kelema River, "a great haunt of elephants on passage", but also eland, roan antelope, greater and lesser kudu, zebra, giraffe, buffalo and rhinoceros were present (Sayers, 1930: 399ff).

However, famines are remembered also in the Burunge area. There have been times when parts of the population left for other areas and today Burunge tell of relatives living in other districts since generations back. They also remember women and children being sold

[6] Mondo village, situated along the road between Kondoa town and Goima village, was at the time within the Burunge area but is today totally dominated by the Rangi and part of Kondoa Irangi, not Burunge.

to other people in times of distress. It is based on such experiences that Bagshawe (1925: 64) could write "Many of the Burunge through poverty and famine have become parasitic amongst other tribes and aliens, with the usual bad results to their women (prostitution)." But overall the pattern is rather that Burunge country was able to feed its people.

As long back as we can follow its history Goima area has been less affected by soil erosion than the central parts of Kondoa district. Still, an early observation of soil erosion was made also in the Burunge Hills near Goima. In 1912 Erich Obst observed a big weathered rock that he believed was in the process of dissolving into smaller rocks. The foot of the rock was already buried under a young sediment layer of sand and loam (Obst, 1915).

During the Colonial period overgrazing was singled out as a major cause of land degradation in Kondoa District and the Government introduced several schemes to limit the number of livestock. However, the Burunge area became treated as a special case. Joseph Bahe Silooti, 1922-1992, who was the last Chief of the Burunge, managed in the 1950s to convince the District Commissioner at Kondoa that the Burunge Chiefdom should be exempted from compulsory culling of herds since the area was not particularly affected by soil erosion.

Likewise, Goima area escaped the tsetse clearing campaigns, at least as far as we have been able to establish. The areas around Chambalo, at the southern end of the Burunge area, were affected (Banyikwa et al., 1979: 5ff) and possibly also the north-western parts of the Burunge Hills. This major transformation of parts of the Kondoa landscape must have carried a deep significance for the forest oriented Burunge people.[7] Discussing how immigrants currently are clearing in the Burunge Hills for farms, an elder of Goima village, Mzee Paskali Saki, reflected on how the Burunge in the past were forced by the government to contribute 'community work' for forest clearings "while we live from the forest. That is where our people are. We place our beehives there." He shuddered at the thought of those times, and went on to talk about the healthy forests where fields are well shaded and the land stays "cool". As a field is rested, allowed to revert to forest, fertility is restored which can again be harvested on a later occasion. But when forest is cleared land becomes exposed, and it is, with the words of another Goima elder, Mzee Omari Kumbi, "like heath from the fire". When Chief Silooti, commented on the same situation his words took on eschatological dimensions: "The soil dies. It no longer has the strength to make the grass and bushes grow. Nothing living will remain. The power of the sun turns the soil into ash."

It can thus be argued that a Burunge world view has served the forested landscape of the Hills well. The environment should not be interfered with unduly lest it may lose its "coolness".[8] Add to this that some trees harbour spirits of the ancestors and should therefore not be felled, and that good land in Burunge thought is land that is undisturbed (Östberg, 1995: 91ff). This is in sharp contrast to the practices of the immigrants. Already during the Colonial period officers had pointed out how determined people in the central parts of the District were to clear forests which they regarded as inhibiting the pastures for the livestock and harbouring game destroying their crops (Banyikwa et al., 1979: 26). Since two decades

[7] The role of the forest in Burunge life is explored in Östberg, 1995: ch. 4.
[8] The concept "cool" in Burunge thinking is discussed in Östberg, 1995: 56, 91.

back it is such modes of operation that characterize the present colonization of the Burunge Hills. The Hills have totally changed appearance, from a well vegetated landscape with clearings for houses and fields into an open cultivated landscape where trees only remain on some of the hilltops.

7.4. The cultural and socio-economic environment during the last three decades

7.4.1. World views

In traditional Burunge thinking spirits of the ancestors are prominent. They are thought to reside in caves in the Burunge Hills and in certain trees. If nature is not abused, and people behave decently towards one another, there will be rains, crops will do well and beehives will be full of honey. Such modes of thought were common some 15 years ago in Goima area. However, our surveys taken with a bit more than a decade's latitude brought out a dramatic change in orientation; something has apparently happened that has affected the rather confident relationship the Burunge had with their environment.

In 1991 less than a quarter of the Burunge headed household were noted as Christians, 12 per cent were Muslims and the rest, 43 per cent, were considered Burunge traditionalists. However, the 2005 survey identified almost all of the Burunge to belong to either one of the two world religions. This major change may to a degree be a function of the differences between survey methods. The 1991 figures come from a total roaster for Goima and Mirambu villages and the religious affiliation was based on informed estimates by key informants, local leaders, the field researchers and self-identification by those who were included in a 10 per cent sample drawn from the complete list of households. The 2005 figures are based on a sample and are self-estimates by the informants. Given that both Christianity and Islam are influential and prestigious social forces in this village environment, a possible security network in time of distress, and also that the field researchers unavoidably were identified as associated with Christianity, informants had every reason to present themselves as either Christians or Muslims. Still, the figures may well point to a dramatic shift in worldview in Goima and Mirambu villages. The implications would be considerable. No more rain making ceremonies, initiation and marriage blessings gone, and no more sacrifices to the spirits of the ancestors when sickness strikes. Not quite, though. Many who were active Christians and Muslims in the early 1990s did participate in Burunge celebrations and rituals and this is the case also now.

A Burunge worldview in the early 1990s could be described as permissive. Burunge people liked to talk of themselves, and others also talked about them, as *watu wataratibu*, gentle people. Some of their neighbours were quick to point out that this not only implied that they tended to stay away from confrontations, and preferred life in isolated hamlets in the Hills, but also that Burunge could not discipline their children but allowed them to roam around at leisure, easily disobeying adults. Discussing these stereotypes with informants it was confirmed that many Burunge felt that it may be perilous to impose oneself on others.

Let men, women and children do what they want. If you are not happy with your neighbour, it is easier to move than try to change him or her. Their relationship with nature followed a similar logic. Why interfere with natural processes? Let soil and water, trees and bees, do their work, and there will in the end be something for everyone. To intervene in these processes, as people of the land rehabilitation projects demand, is a risky undertaking that easily ends in unforeseen consequences. Better than to fight gullies, or neighbours, is to move and start anew. If you leave a quarrel behind, it will not affect you any longer. Life returns where there was despair. And grass and trees return to exhausted fields.

Minimal involvement could be seen as a safe strategy in an area of unpredictable rainfall. Ridges along the contour may break during a rainstorm, and will result in soil erosion. A carefully weeded slope may dry up more easily than a less disturbed field if the rains should stop. Not to disturb the spirits of the ancestors may be just as good an argument for conserving trees as the Forest Department's ecological reasoning.

Many Burunge reasoned that when you cultivate it is in fact the forest that you harvest, and they trusted that when land is rested and given back to the forest it will be replenished. The forest, with its virgin soils, its trees where spirits dwell and where bees produce honey, all this wealth, this strength, is there to guarantee that life goes on. When the young marry their union was confirmed with gifts of beehives and mead. It appears a logical conclusion that if the forest supports life no one can monopolize it. It is for everyone. When farming outside your own group's area, a *hhapeeloo'ay*, the original owner of the land, should be approached before one starts to clear, but normally permission was granted without further ado.

Suter Doo of Goima village, a man in his 50s, explained: "My father must have had about fifteen places where he cultivated. I can remember that we moved a dozen times. Our family was reasonably well off and my father had livestock. He cultivated about four acres, but to do this he made use of perhaps 60 acres. He harvested from four acres but he used a large area. He cleared and cultivated. Then he moved, cleared and cultivated. Maybe people in other areas think this was not a good practice, but it is how it was, and we must say this without feeling guilty. The Burunge have used a lot of forest to feed themselves."

The guaranteed access to new fields made it easy to move on without losing important assets if one finds oneself in quarrel with someone. This is one reason why Burunge country appears a peaceful area, and why the Burunge so easily say about themselves that they "do not like quarrels" and also tend to give up resources when these are being challenged by others.

This is how the situation appeared before the massive immigration to Goima Division. Now land has become a scarce commodity and the well-tried option to find "new wealth" when old farms get exhausted is not really feasible any longer. The world has changed for the Burunge.

7.4.2. Livelihoods and social differentiation

The farmers in Goima area are generally subsistence farmers and grow a variety of crops for home consumption and for the market. The crops grown differ in their drought-resistance and growing period and therefore, in their required sowing date.

About half of the farmers own chicken and about one-third of the farmers keep livestock. For the female-headed households this figure is about 10%. The Burunge farmers mainly have chicken, goats and sheep, while the Rangi farmers have a greater share in cattle and donkeys. More often they own an ox-plough or donkey-cart.

Farming and livestock keeping are complemented by other activities. In the early 1990s half the households had to take on temporary agricultural wage-work to make ends meet. 15 years later this was still the case. Some activities are gender-specific, such as beer brewing which females do and honey production, which is a male preoccupation; and predominantly a Burunge trade. The sale of animals and petty trading help to raise cash. Livelihoods become more diversified with increasing subsistence level.

A wealth-ranking was carried out in the early 1990s using criteria identified by the farmers themselves (Table 7.2)[9]. In Goima and in Mirambu farmers constructed six and five wealth classes respectively to make their rankings. Farmers did not pick the amount of land one cultivates as a criterion to assess wealth. What counted was the ability to cultivate it. Therefore, important criteria for wealth were capacity to plough with oxen or tractor and to hire labour, and also the ownership of livestock[10].

In a survey carried out in 2005, the amount of land a farmer is able to cultivate had become a wealth estimate. In this ranking the wealth categories were reduced to four as the first two wealth ranks and the last two ranks were small and difficult to distinguish.

The first wealth class consisted of farmers who were considered to be well-off, or at least always had the resources to pay for casual labour or a tractor and who owned some small stock, cattle, and maybe a donkey. The second wealth class consisted of farmers with

Table 7.2. Wealth-rankings in 1991/3 and 2005, percentage of households.

Wealth ranks as identified by farmers	**1991/3 Wealth ranking (%)**		**2005 wealth ranking (%)**	
	Goima	Mirambu	Goima	Mirambu
"Rich"	2	2	4	8
"With resources"	12	8		
"Of average ability"	33	40	41	37
"Poor, but with ability"	35	40	47	45
"Needing and getting assistance"	10	10	8	10
"Needing but not getting assistance"	7			

[9] A description of criteria and procedures of wealth rankings in Goima and Mirambu is available in Östberg, 1995: pp. 36-44.

[10] A wealth ranking carried out in the more recently colonized interior of the Burunge Hills, dominated by Rangi farmers, interestingly showed that there the size of land holdings were important criteria of wealth, as well as access to draught animals, reflecting both the capacity of virgin land to generate profit, and the value of land to the immigrants some of whom had previously been landless (Östberg, 1995: 45).

average ability, producing enough food to feed the family throughout the year. They sold crops or livestock, or had some other source of income to meet their other needs. The third class of farmers was considered as poor, but with ability to provide supplemental income. In case of sickness or drought these households would face difficulties. The fourth wealth class consisted of farmers who always needed assistance from neighbours or relatives.

The general outcome of the 2005 wealth rankings shows similar results as the wealth rankings in 1991-3. As in the 1990s, more than half of the farmers had difficulties to support themselves from their fields.

7.4.3. Land issues

Land registration is a task of the village authorities (Hyden, 1980). The village council grants permission for clearing new land after the Ward Agricultural and Forestry Extension Officers have checked the land's suitability for agriculture. Large tracts of the Burunge Hills are not supposed to be cleared because of the steepness of the land and its susceptibility to soil erosion. However, neither the village councils of the communities surrounding the Hills, nor the District administration have been actively managing the colonization of the Hills. Instead informal village committees organised among the immigrants guided newcomers to suitable areas to clear.

In the villages below the Hills the situation is different. The 2005 survey in Goima and Mirambu showed that more than half of the fields in the sample had been inherited, nearly a quarter had been cleared and about 10% had been purchased by the current users. Clearing of land as a source of land has lost importance over the years. Less than 15% of the farmers aged 30 and below had newly cleared land. This figure increased with age groups and reaches a level of 32% for farmers in the 61-70 age group. More Rangi farmers than Burunge farmers gained access to land by clearing bush and purchasing land, reflecting their role as immigrants to the area (Table 7.3). Inversely, more Burunge farmers had inherited fields than Rangi farmers.

Traditionally, only men inherit land, however the data show that also women inherit. Moreover, a woman could claim virgin land just as men do. In such a case she would hire young men to clear while she would participate in all other phases of preparing the land. We know of several women who had acquired farms in this way. However, female-headed households did have less land than the male-headed households.

Table 7.3. Sources of land (% of fields in sample) according to ethnic group and sex of household heads.

	Inherited	**Cleared**	**Purchased**	**Gift**	**Government offer**	**Other sources[a]**	**Total**
Burunge (N=264)	62	22	5	6	4	1	100
Rangi (N=90)	32	28	21	8	7	5	100
Male (N=300)	55	24	8	5	5	3	100
Female (N=54)	52	17	17	9	2	3	100
Total (N=354)	54	23	9	6	5	3	100

[a]Rented in, communal land, borrowed

According to Burunge practices, trees would not be destumped when clearing the land to allow regeneration during fallow. Some trees would be left untouched to provide shade. Land preparation was minimal and could be described as conservation tillage. Land was fallowed after a few years of cultivation. The Rangi newcomers, by contrast, removed all vegetation when clearing land. They cultivate permanent fields, which are often ploughed. Currently, a variety of cultivation techniques is used; however, the majority of Burunge farmers continue to use hand hoe.

To the Burunge land was thought to be abundantly available. This was the dominant feeling in the early 1990s despite the fact that rotational bush fallow was falling out of use in Goima area because of shortage of vacant land (Östberg, 1995: 53ff). Most of the land currently not under cultivation is located on the slopes of the Burunge Hills. There people have for a number of years made good profits. However, signs of accelerating soil erosion are there and the situation is anything but stable (Östberg, 1996: 99ff).

Currently, farmers' opinions about the availability of land are mixed. According to some, land is still available. However, the phrase: "all land already has an owner" was commonly used. Farmers using that expression were often concerned about a future land shortage. Some expected that it might take one or two generations before land shortage will become a serious problem, while others assumed that it would take longer. A few who anticipated land shortage had cleared or bought large plots of land to ensure that the next generations will have land to live from.

Farmers in Mirambu village were specifically concerned about the availability of land as they were already short of grazing. One Mirambu farmer mentioned how his fathers' generation "did not value land" as an important asset and had sold land that bordered Makamaka and Piho villages to Rangi farmers living in these villages. The situation was growing tough in Mirambu while farmers agreed that there was still enough pasture in Goima.

In the early 1990s, many farmers were of the opinion that land is for everyone to use and therefore should not be sold (Östberg, 1995: 54), which does not imply that land was never sold. Many Rangi farmers have expanded their acreage by buying land from Burunge farmers. Land prices mentioned at that time varied from 1,500 to 2,000 Tanzanian Shilling (TZS) per acre. Increased pressure on the land and the benefits of mechanized cultivation, have raised awareness about the economic value of land, particularly of virgin land in the Hills. Land prices mentioned during the 2004-6 field study varied from 10,000 to 15,000 TZS per acre, thus sevenfold the prices mentioned in the early 1990s[11]. Compared to the central parts of the District this remains very low. There, people paid at least 100,000 TZS for land of poor quality compared to what one gets in the forests of the Burunge Hills. No wonder that immigrants arrive in great numbers.

[11] As a reference, the prices for renting a tractor or oxen-plough have quadrupled. The Consumer Prices Index for 2005 was 463 (1992 = 100) (IMF)

7.5. Perceptions of environmental change

7.5.1. Growing concerns about drought

A general statement among farmers in Goima area is that “if only it would rain, our harvests will be good”. It may appear as a paradox that farmers in this drought-stricken region firmly stated that they had never personally experienced a drought. The reason is that they adhere to the principle that drought would imply complete crop failure due to absence of rainfall, the land being bare and dry. In less severe situations, in a year with reduced crop production due to deficient rainfall or when “rainfall and sunshine are out of balance” farmers prefer to talk about a bad year or about a scorching sun (*jua kali*) instead of drought (*ukame*) (Slegers, 2008b).

Farmers interpret different signs of nature such as trees and stars announcing the coming of the rainy season or an approaching rainfall (Slegers, 2008b). It is a widespread belief that all natural phenomena emanate from the hands of God; the rains as well as its indicators. Many farmers felt, however, that the signs had lost accuracy in recent years. Young farmers seemed to have lost interest in interpreting these signs. Increasingly, farmers turn to the forecasts from the District Agricultural Office and the radio to plan their farming activities.

Most farmers felt that the variability of rainfall had increased over the past decade or two. Most farmers felt that droughts had become more frequent. However, they were most concerned about an increased severity of droughts. This was particularly so among female-headed and younger households. Particularly the first group was less endowed with resources, and therefore particularly vulnerable to drought, while the younger farmers had a shorter memory for droughts. The past few seasons had been dry, which may also partially explain the general feeling regarding the increased severity and frequency of droughts.

Droughts are to be expected in the future, but no prediction can be made. Farmers believe that God decides the timing and amount of rainfall. However, this is not to say that farmers had a fatalistic attitude. Farmers in Goima area, Burunge as well as Rangi, believe that trees bring rainfall. Different explanations were given to support this statement. One was that trees stop the wind that brings the clouds, thereby preventing the rain-carrying clouds to move on to other areas. Another explanation was that trees create wind, clouds and rainfall. “Where there are trees, there is rainfall” was a common statement by farmers. Farmers were concerned that the ongoing deforestation has made the rains more unpredictable.

Rains are expected to commence in November and continue until April/May, with an expected dry spell of about three weeks in February. When rains delay, as they do in this area of unpredictable rainfall, people worry and start to ask each other about possible causes, and ceremonies are conducted to pray for rains and to ward off bad things that have happened during the year and which may inhibit the rains. But it may also be the case that someone has actively stopped the rains. Whatever the reason, the area should be “cooled” to make it possible for the rains to fall.

In the main ceremonies for rain people walked the boundaries of the village gathering the rain clouds to their area, praying for rains. Someone could also take an individual initiative to pray for rains, taking a branch of *gorogombimo* (*Ipomoea kituiensis*) in the hand, and smearing his or her face with the white faeces of the python to create the calm politeness required to enter into prayer, and ask for rains. There were also the sacrifices performed because a tree where spirits dwell may accidentally have been cut or damaged, or because people have misbehaved in a way that offends the spirits of the ancestors, or because "unnatural" things have happened. In 1992 a big baobab tree fell. Not surprisingly people decided that it was necessary to "cool" the land. These are normal events. But what seemed to be happening with increasing frequency was that someone had placed "bad things", or cursed the rains. This had happened also before, but now many felt that it was now happening all the time and this created a feeling of being vulnerable in a new way.

7.5.2. Farmers' perspectives on drought vulnerability

Perceptions of drought were substantially the same for most farmers in the area. However, their actual drought vulnerability, and with that their respective experience of the costs of drought, differed. Drought vulnerability not only depends on the risk of exposure, but is also influenced by more internal factors (Watts and Bohle, 1993). In this area farmers recognized that one has to be an active farmer to withstand drought conditions. Good timing of agricultural practices can make the difference between being food-secure and food-short.

Farmers did not consider drought in strictly meteorological terms. Farmers have area-specific knowledge about how the location and the state of the land create differences in drought vulnerability. Studies about drought perceptions in Burkina Faso (Slegers et al., 2005) and Ethiopia (Meze-Hausken, 2004 ; Amsalu et al., 2007) show similar results. Farmers recognized that human-induced environmental changes influence vulnerability to drought, which implies that farmers distinguish drought conditions that are 'an act of God' from those that are human-induced (Roe et al., 1998). Three relevant changes will be discussed here. In the early 1990s, farmers did not consider these changes as real problems.

Deforestation

Forest, bush and trees are disappearing due to increased pressure on the land and changing cultivation practices. This process was already ongoing during the 1990s, especially in the Burunge Hills, and worried farmers, and has since accelerated. Farmers' concerns are growing because practically all land surrounding the Hills and on the pediment slopes has already been claimed.

In the early 1990s, a number of small settlements had emerged in the Hills (details are recorded in Östberg, 1995: Chapter 6). Today all reasonably flat areas are under the plough and fields appear also on steep slopes. One full-scale village in the Hills has been registered. This is Madah which today matches Goima in size; i.e. the main Burunge village and also the Division headquarters. The number of households only in Madah is today bigger than what was the case for all communities in the Burunge Hills in 1994. At Chioli, also in the

Hills, the residents expect that their settlement will be recognized as a formal village in 2009. A well-built school is already in place. The colonization of the Hills has been fast and efficient.

An elderly Burunge farmer, a descendant of the last Burunge Chief, explained his concerns about the new era in farming, brought about by immigrants and young farmers. “People don’t care. They know that trees bring rainfall, but still they cut trees as they are only interested to get more produce and to cultivate by tractor”. He noted that the practice in Goima village remains not to cut trees in and around the homesteads but that no such rule is maintained in Mirambu. “That village looks bare”. While he urges farmers to plant trees on their land, as befits his social standing to do, he admits the difficulties of raising trees in this environment. “How can we nurse seedlings when we have great difficulties in getting water even for daily household needs”? He observed how young farmers cut and uproot trees from their fields to enable tractor cultivation. When reminded of his own farming practices, a big smile came onto his face; he has cleared large tracts of land using a tractor. He explained how he had been convinced by his children and tried to go with modern times. However, his view remains that using a tractor does not benefit the land.

The presence of forest has a positive effect on soil fertility, farmers argued. The falling leaves will rot on the soil and give the land strength. Run-off will reduce where there is a forested area upslope. Vegetation reduces the speed of the water, thereby stimulating water infiltration. Run-off water from bush or forest is rich in nutrients and gives strength to cultivated land down slope. Burunge farmers explained that for them there was no need to use manure as they had their forest. They argued that Rangi farmers were forced to use manure because they had cut all trees from their land and use land permanently. This is the practice that increasingly characterizes farming in the area. This notwithstanding only a minority of interviewed farmers used manure in 2005.

The Burunge have seen the forest disappear from their area. With the forest, also a large part of the trust they held in the land went. It was the trees, the forests that renewed life to their land during fallows. When harvests failed, the forests still provided honey and game; it harboured the spirits of the ancestors and new hope.

Loss of soil fertility

In the early 1990s, Burunge farmers described the land in and surrounding the Burunge Hills as healthy; it was essentially good and productive and a crop was expected even when inadequate rains made crops to wilt on other land. The health of the land was understood in terms of soil quality.

Farmers considered the soil layer up to a depth of 30 cm as useful soil, as decaying grass, leaves and crop residues had enriched it. The soil below this layer lacks fertility and therefore, the land should not be disturbed too much. However, some degree of mixing is also needed. Only topsoil can be too “strong” for the crops and a certain amount of interchange adds stability to the soil. “You must mix to get strength.” Yet, many Burunge were suspicious of tractor ploughing because it would bring up too much subsoil of poor

quality. Similarly, SWC structures such as infiltration ditches or structures to stabilize gullies were regarded with suspicion as these were thought to unduly disturb the soil.

Land that is cultivated for several years loses strength and gets "tired". By fallowing the land, it regains soil fertility. The rotting grass and decaying leaves make the soil to be strong and healthy again. Since land was considered to be abundantly available, diminishing soil fertility was not considered as a problem; as production dropped after about three years, a farmer would open another field. After twenty years or so, a farmer would "remember" that field and decide to use it again.

The 2005-2006 study showed that farmers still relate to their area as having good land. However, many farmers did feel that the land's productivity had gone down. They reasoned that the land had become "tired" due to the continuous cultivation over the past years. About half of the sampled farmers stated that the productivity of their land had gone down. The five most important reasons given were: shortage of rainfall, not adding manure, continuous cultivation, soil degradation and too strong sunshine.

One elderly female farmer explained that the productivity of the land is stable when comparing good years. However, she remembered that her parents were not struggling like she is. Her parents used to be able to fill three large grain storage baskets (*virindo*) from one acre of land, which was enough to feed the whole household. She has inherited land from both her parents and from her late husband, but has difficulties making ends meet. "The land has become tired".

Besides declining production, the infestation of weeds was another indicator for tired and infertile soils. Farmers complained that Striga[12], a parasitic weed that penetrates the root system of cereal crops such as sorghum, millet and maize, had become more prevalent. In the 1990s, Striga was already visible in some fields, but not considered by farmers as a big problem.

To maintain or increase productivity of their land, farmers practice crop rotation, fallow or ridge cultivation. Only seven per cent of the sampled farmers applied manure during the 2004/5 crop season. This figure was the same for both ethnic groups in the sample. A fairly widespread opinion is that manure makes the field dry, producing small harvests. More than half of the Burunge farmers practiced fallow, while one-third of the Rangi farmers followed this practice. Most commonly, a fallow period of three years was used. To maintain their production levels, a few Rangi farmers included areas with virgin land elsewhere. Some of the farmers who said that they did not fallow land as a fertility-increasing strategy did in fact not cultivate all their land during the 2004/5 crop season. The main reason for this 'accidental' fallowing was that they had not been able to cultivate all their land in time before the soil became too dry. This was due to labour constraints, illness of the farmers or the need to do daily labour on other people's land.

Soil erosion

Soil erosion was not considered an urgent problem in the early 1990s (Östberg, 1995: 89ff, 127). With the long history of land rehabilitation efforts in Kondoa District it seemed

[12] *Striga hermonthica* as well as *Striga asiatica* were observed in the field

surprising that farmers could remain so indifferent to the issue. However, four circumstances help to explain. One, the Burunge area was remarkably less affected by soil erosion than the Irangi Highlands, although natural conditions were rather similar. The difference was that Burunge modes of farming and of resource extraction were more forbearing on the environment than those practised by their Rangi neighbours. Two, the Burunge took a rather optimistic view of how soils form and change over time. They told of all the leaves that trees shed every year and said that new soil is continuously formed on the ground, and this happens faster than what soil erodes.[13] They certainly recognized that moving water carries away topsoil, but they claimed that the soil would eventually be deposited somewhere and there they can cultivate. Thirdly, they allowed selected trees to remain in their fields so that the forest could quickly re-colonize land that was fallowed, and produce new strength. And finally, they were convinced that land was abundantly available and that it would always be possible to take up new land if a particular field became exhausted.

Fifteen years later this had all changed. The 2005 survey brought out that almost all farmers (95%) considered soil erosion to be a problem. They elaborated on how soil erosion washes away fertile topsoil to expose unfertile subsoil; creates gullies; washes away seeds from the field; causes formation of hard soils; makes crops to become weak; and exposes roots of plants to the sun.

Farmers detailed changes in their area that increase erosion risk. The forest is no longer there to reduce the speed of run-off water from upslope and cultivation practices have also changed. Increasingly, fields are cleared and trees are uprooted. This had already started in the 1990s, sometimes with disastrous consequences (Östberg, 1995: 197 ff.). However its impact was not yet severely felt. Now the situation is different.

Six out of ten farmers from the 2005 survey saw indicators of erosion on their own land, mostly in the form of gullies, paths where livestock and people normally pass, and of stones on the land.

Farmers applied some kind of SWC measures on half of the fields in the sample. They favoured agronomic measures such as ridge cultivation, contour planting and contour ploughing.[14] Farmers characterized the fields where no SWC practices were used as flat land that did not require any protective measures. One out of ten farmers protected their fields from run-off at its border by constructing a diversion ditch or a big ridge.

Deposition of soil was considered as both a positive and a negative process. Nearly half of the farmers saw deposition of soil or sand as a problem. About a third of the farmers cultivated fields on which deposition was occurring. Farmers' reasoning was in accordance with earlier findings from the area, that deposition of sand had negative effects on a soil, while deposition of fertile topsoil had positive effect. Another negative effect was that seeds are buried too deep to successfully germinate. Some farmers, who cultivated heavy soils,

[13] Burunge soil science is explored in detail in Östberg, 1995: ch.3.

[14] These methods have been advocated by the agricultural extension service for decades. Soil conservation interventions started as communal efforts but after WW2 the focus shifted to protection of individual plots. Already in 1937 it became compulsory in Central Province (today's Dodoma Region) to cultivate cassava on contour ridges as famine protection (Patton, 1971:32).

saw the deposition of sand on their fields as a positive event. During cultivation, the deposited sand mixes with the heavy soils, with beneficial effects on soil—water interactions.

7.6. Losing strength

There was a time for the Burunge people when their area was the centre of a world that stretched far outside today's Burunge area. The Burunge were at Mondo in the West, even in places like Hebi in the Irangi Highlands, they lived in Itiso and Chenene in the South, which today is Gogo country, and Jangalo, Busi, Mrijo to the North and East were all Burunge country. Today the Burunge note that immigrants set the agenda even in their very core area, Goima and the Burunge Hills, which have become a periphery to a centre that lies elsewhere.

This feeling of being overpowered by developments was there already in the early 1990s but it had not changed the basic trust many Burunge held in their environment. The land was, they felt, basically healthy, and the forests were there to bring new life to tired soils, and land was abundantly available. A majority of them trusted that their rain ceremonies would help to bring in delayed rains, and that a respectful relationship with the spirits of the ancestors was a prerequisite for the fertility of the land. Soil erosion was noted but taken as a natural thing.

Such views may come across as surprising in a region that is held to be the Nation's most difficult area for farming, and where the neighbouring Irangi Highlands are notorious for severe land degradation. In the historical sketch we noted that the Burunge area has had its share of droughts and famines, but by and large their area remained a better place to live compared to most other parts of the region. They were only on the periphery of the impacts of the 19th Century caravans. They did business with the Kondoa-based merchants from the coast but not to a degree that exhausted their natural resources. They were much less affected by major government interventions like tsetse clearings and soil conservation programmes than people in the central parts of the district. Being on the periphery gave them a chance to develop their forest-based economy with bee-keeping, hunting, small-scale slash and burn agriculture and livestock keeping. Rotational bush fallow became an efficient and stable system as long as land was abundant. Their modes of exploitation were relatively forbearing on the environment, and in return they developed a conviction that the forest will replenish degraded soils. Not every year, for sure, since many of them more often than not were forced out of the area to look for temporary farm work elsewhere, but they remained convinced that the forest and the land would still provide. That was the situation in the early 1990s. In a surprisingly short period of time, less than fifteen years, this changed.

How Goima farmers differentiate a good from a bad year has not changed over the past few decades. A good balance between rainfall and sun is needed for a good harvest. Deficient rainfall and poor timing of the rains were considered as major reasons for a diminished production. Farmers in the 2005-6 study perceived that especially the severity of drought had increased since the past ten or twenty years, proof of which could not be found

in the meteorological data. Farmers had knowledge about how different biophysical conditions, such as the state of the soil, influence crop performance in a dry year. The 2005/6 study showed that farmers had become concerned over soil erosion within the past fifteen years, and that they were worried that their children would not have land enough to cultivate. While Goima had indeed been connected to the wider world as far back in history as records tell now a realization had taken root that they did no longer control the world they inhabited – and the specific characteristics of their adaptation to the environment appeared to lose ground. Today, only patches of forest remain and the land is losing its strength. Immigrants rule in the communities all over. The Burunge no longer have their forested environment. They must find new strategies to adapt to new circumstances.

Figure 7.2. A Burunge farmer showing his arrow and bow.

Figure 7.3. A Burunge farmer maintaining the roof of his tembe with soil and straw at the start of the rains.

Figure 7.4. A contractor from Arusha Region with his tractor in Mirambu.

Chapter 8

Farmers' strategies to deal with the unreliable rains in Tanzania and Ethiopia: their challenges and constraints

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8. Farmers' strategies to deal with the unreliable rains in Tanzania and Ethiopia: their challenges and constraints

Abstract

Most farming systems in East Africa are rain-fed and labour-intensive. Food security in such areas is directly affected by rainfall variability and highly depends on the options that local people have to cope with it. Our objective was to explore how farmers in Tanzania and Ethiopia deal with the ecological insecurity of the rains. We classified farmers into farm types using Principal Components Analysis and Cluster Analysis and looked at their livelihood strategies. Both areas face their own challenges and constraints in agriculture. These case studies show that not only the external risk of exposure determines how farmers deal with the insecurity of the rains. For both areas strategies differed between households. Farmers recognized that farmers have different resilience levels, which they explained in terms of ability and attitude. In Tanzania, most farmers depend on hand hoe cultivation and farming strategies were focused on timely cultivation. Farmers who are not able to cultivate on time or who do not practice timely cultivation while they have the ability are considered most vulnerable to drought. In Ethiopia, the most important farming strategy was to cope with land shortage and to maximize the use of all arable land in the area. Farmers who are not able to plough their own land, who do not have land, or who cannot buy inputs are considered most vulnerable to drought. Strategies to deal with the insecurity of the rains mentioned in both areas included agronomic measures, livelihood diversification, food security and preparedness in case of a possible dry year.

8.1. Introduction

Drought is a recurrent and normal feature of a climate, a natural hazard (UNCCD, 1994; Kassas, 1995) that causes temporal changes in productivity (Slegers and Stroosnijder, 2008). Most farming systems in East Africa are rain-fed and labour-intensive. Food security in these areas is directly affected by climate variability (Ziervogel et al., 2008) and highly depends on the options that local people have to cope with it.

Drought cannot be viewed solely as a physical event. How drought impacts on people's lives, their vulnerability to environmental hazards, depends on their personal situation. Judgments about a drought's severity and impacts are culturally defined and should be taken into consideration (Slegers and Stroosnijder, 2008; Stroosnijder, 2008).

Studies on local perceptions of drought in Tanzania (Slegers, 2008b) and Ethiopia (Slegers, 2008a) showed that farmers in both areas perceived that the reliability of the rains had decreased, which they at least partially attributed to the ongoing deforestation in their area. Farmers recognized that there were local differences in drought vulnerability. These included characteristics of their land, land management practices and farmers'

characteristics. Farmers described farmers' characteristics in terms of their ability and attitude.

These studies demonstrate the interrelationship between human and natural systems (Folke et al., 2002; Walker et al., 2002; Adger, 2006). Since humans are intertwined with ecosystems, resilience should be seen in the context of integrated systems of people and nature (Richards, 1985; Rockström, 2003b). Every environment has a different resilience level to withstand environmental stress, while local land users have different adaptive management strategies to cope with environmental stress. Besides ecosystem resilience, social resilience should be taken into consideration. Social resilience is the ability of groups and individuals to respond to environmental and socio-economic constraints through adaptive strategies (Bradley and Grainger, 2004: 452).

People's vulnerability to drought is not only determined by the external risk of exposure (Watts and Bohle, 1993). Whether physical changes can be resisted – and how – depends on the economic, social and cultural contexts in which these take place (Agnew and Warren, 1996). Capability to cope and to recover play influential roles herein (Watts and Bohle, 1993). It is difficult to generalize about coping strategies in response to stress (Ziervogel et al., 2008). Local communities are dynamic and internally differentiated (Leach et al., 1999). Therefore support to adaptation measures needs to be grounded in the local context (Ziervogel et al., 2008) and adapted to local perceptions of the problem (Quinn et al., 2003) and it is, therefore, important to gain knowledge on this issue.

The objective of this study was to explore how farmers in above-mentioned two countries in East Africa deal with the ecological insecurity of the rains. First we will explore what farm types can be distinguished and what their livelihood strategies are. How are livelihoods adapted to the possibility of a 'bad' year, and how do farmers cope with drought conditions when they occur? We will ultimately consider farmers' views on constraints to one's capacity to deal with the unreliable rains, and will apply these to the different farm types.

8.2. Study areas and methodology

8.2.1. The Goima area, Tanzania

The Tanzanian case study was undertaken in two villages in Goima Ward. Goima and Mirambu villages[1] (population 5750 people within 1163 households) lie on the foot of the Burunge Hills, at an altitude of between 1,300 and 1,400 m.a.s.l. Goima area is situated in the northern part of semi-arid central Tanzania, 40 km south-east of Kondoa town. The area is characterized by an undulating landscape of plains and scattered small hills and has sandy soil. Population density is about 34 people per square kilometre (Tanzania, 2003).

The upper slopes of the hills consist of bare rocks and forests. More and more areas are being cleared, both legally and illegally, as a result of population growth. Goima farmers

[1] When referring to both villages, "Goima area" will be used. To refer to Goima village, "Goima" will be used

traditionally practiced rotational bush fallow in which long periods of fallow were common. The use of fallow has decreased in recent decades due to increased population pressure. Crop residues are most commonly left on the field and burnt during land preparation before the onset of the rains. It is also common to plough the residues under or to feed it to livestock.

Goima area has a uni-modal rainfall pattern; rain can be expected between November and May. Inter-seasonal and intra-seasonal rainfall variability is high. The mean seasonal rainfall (1970-2006) measured at the nearest meteorological station at Kondoa town is about 670 mm. Annual potential evapotranspiration in the area is about 1,700 mm (Östberg, 1995: 31). Rivers are ephemeral and have high peak discharges during and shortly after rainfall events.

Not only rainfall is a problem, but the availability of water altogether. No structure is present to provide villagers with water throughout the year. The only sources of water in the long dry season are from small earth dams, and shallow wells in the dry river beds. The farmers dig these out themselves and reach beyond four metres in depth (personal observation) towards the end of the dry season. At that time, people spend most of their day or night waiting for their turn at the well and it may take up to half an hour to fill up a bucket with water. Some people travel a distance of 10 km on foot or with donkey cart to neighbouring areas where water is more easily found. Farmers who have some money, buy water at a price of US$ 0.16 per bucket of 20 litres.

8.2.2. The Asfachew area, Ethiopia

The Ethiopian case study took place in two villages in Asfachew Kebele. Asfachew and Chira Meda villages[2] (total population of about 825 people within 175 households) are situated in North Shoa Zone, some 200 km north-east of Addis Ababa along the tarmac road which runs between the two small towns of Debre Sina and Shoa Robit. The average population density in Tarmaber Woreda, an administrative division between Zonal and Kebele level, is 185 people per square kilometre (CSA, 2006). Asfachew and Chira Meda are two of ten villages within the administrative unit of Asfachew Kebele. Chira Meda is located 15 km downhill from Debre Sina, at an altitude of 1850 m.a.s.l.

The terrain of Chira Meda is rugged. The village is constructed on a plateau, from where steep cliffs and ridges go down to different small terraces (Bekele-Tesemma, 1997). Asfachew is situated at an altitude of 1470 m.a.s.l., 5 km further down along the road from Chira Meda, and is situated at the foot of the mountains where Chira Meda and Debre Sina are situated. Asfachew has areas with moderately steep and gentle slopes, covered with colluvial depositions. The remaining land is relatively flat towards the floodplain of the braiding Tikurso River, where wide river beds are covered with deposited stones. The river has a high peak discharge both during and soon after rainfall events, and turns into small braided streams shortly after the rain stops.

[2] When referring to both villages, "Asfachew area" will be used. To refer to Asfachew village, "Asfachew" will be used

Both Asfachew and Chira Meda have a bi-modal rainfall pattern. The short rainy season, which is locally called *belg*, commences at the end of January or in February and lasts for three months. The main rainy season, which is locally called *meher*, begins at the end of June or in July and also lasts for three months. *Meher* rains are generally more predictable, more intense and more frequent than the *belg* rains. Because rainfall can be very intense, it can be highly erosive. The mean annual evapotranspiration in Shoa Robit is 1517 mm (Bekele-Tesemma, 1997).

Water is available the whole year round. In Chira Meda there are three water taps. A natural spring is situated about 20 minutes walk from Asfachew and provides the villagers with clean water. Since 2006, a hand pump has been constructed at the border of the village from where people can get their water. Livestock is taken down to the river for drinking.

8.2.3. Methodology

A case study approach was used for this research. Sociological field research in Tanzania and Ethiopia took place in the period from November 2004 to September 2006, and was conducted in two phases: an exploratory phase of three months per country and a second much longer phase for more detailed research.

In the first phase, a baseline questionnaire with mainly open-ended questions was used in each area (Goima area, N=120; Asfachew area, N=58) to get general information about the areas, livelihoods, assets, farming practices, and problems perceived. The sampled households were selected using a stratified random sample from local officials' lists. Only the household heads were interviewed.

The second phase took place during the 2005-2006 cropping seasons. This phase in both study areas was used to follow farmers during the cropping season in terms of their agricultural practices, opinions regarding the state of their land, weather conditions, drought and livelihood strategies. Information was gained through informal talks; field visits; in-depth interviews; and a series of group discussions.

Farm household classification

Before looking at how farmers in Goima area and Asfachew area have adapted their livelihoods to the possibility of a drought and at the strategies farmers follow to cope with it, we first present the farming households according to household characteristics, farming practices and livelihoods. To classify the sampled households, a Cluster Analysis (CA) has been performed on part of the data set from each study area. For the Tanzanian dataset, first Principal Components Analysis (PCA) was performed to reduce the size of the dataset. The initial data set was first tested for interdependencies in their variables. Data have been standardized as both PCA and CA can be sensitive to scale differences across variables (Lattin et al., 2003).

To determine the number of factors to extract from the Tanzania dataset, we applied Kaiser's rule, Horn's parallel procedure and looked at the variance explained by the factors

(Allen and Hubbard, 1986; Lattin et al., 2003). The factor solution was rotated with the Varimax rotation method.

Cluster analysis was used to classify the households based on the factors retained from the PCA. Ward's clustering method was applied with squared Euclidian distances as a measure of distance. The clusters were explored for significance of group means of the factors and the original unstandardized variables using one-way ANOVA and for equality of variance by Levene's test. When Levene's test was not significant, a normal F-test could be performed. When the assumption of homogeneity of variance was violated, Welch F-ratio was used (Field, 2005).

We also attempted to perform a PCA on the Ethiopian dataset, which was not successful because the dataset did not meet the criteria set. We therefore immediately performed a CA on the standardized dataset from Ethiopia.

Farm household strategies

After classifying the households, we described for both areas the livelihood strategies of different households in the samples according to their own judgment about their self-sufficiency level in a normal year. A normal year was a year in which rainfall is according to their expectations. Farmers were categorized into three self-sufficiency levels: they either did not produce enough food in normal year to meet subsistence level, they were just self-sufficient, or they produced more than they needed for their own consumption needs.

We also described how farmers deal with the ecological insecurity of the rains (section 5). Farmers in both areas have set criteria for households that are more vulnerable for drought conditions, and that have lower capacities to recover from its effects. These livelihood strategies, vulnerability criteria and the limitations these impose for coping and adapting strategies will be compared with the different clusters of household types to see how these compare.

8.3. Classifying farm households according to their resources and farming practices

8.3.1. Farm household types in Goima area

Data reduction

The data set showed a high enough level of correlation to perform a PCA (Bartlett's p=0.000 and KMO= .53) (Field, 2005). According to Kaiser's rule and Horn's parallel procedure, ten factors should be retained. A total of 65% of the total variance is explained by these factors, which is beyond minimum requirement of 50% (Allen and Hubbard, 1986; Lattin et al., 2003).

The first factor (F1) can be termed self-sufficiency level. Self sufficient farmers generally sell part of their produce as an income strategy and tend to have more land per household member. Male-headed and Rangi-headed households tend to have higher self-sufficiency levels. These farmers more often practice a system of crop rotation, use tractor

or animal traction and own animals such as cattle and donkeys. Households that score high on this factor more often live in Mirambu. Local farmers themselves mentioned that Rangi farmers are generally wealthier.

The second factor (F2) could be called livestock-orientation. Farmers with bigger herds of livestock more often sell livestock as an income strategy. Male farmers are more often livestock-oriented.

The third factor (F3) is the use of SWC. The variables that showed highest correlations with this factor are the use of SWC measures in the field and the use of run-off protection measures at the border of the field, mostly a large ridge or cut-off drain. Farmers with more than one plot more often use such measures. Most common SWC technique used is ridge cultivation and is done by hand hoe, which explains the negative correlation with the cultivation technique used.

The number of fields owned is the most important variable of the fourth factor (F4). Farmers with more fields often live in Goima and more often practice intercropping. The technique used for cultivation also loads high in this factor. Farmers with more fields more often use animal traction or tractor. The number of fields is not necessarily representative of the total amount of land a farmer has. The Burunge seem to have more fields compared to the Rangi, which is also according to the stereotype sketched by the farmers themselves. Rangi seem to have bigger-sized plots and Burunge more and smaller plots. This may be the result of the traditional system of rotational bush fallow, which was practiced by the Burunge.

The fifth factor (F5) relates to the characteristics of the household head. The younger household heads are often literate and male. These households more often have chicken and/or small ruminants.

Households that apply manure (F6) on their land, less often use conservation tillage when the rains are late. The number of hand hoes also loads high on this factor. It is noticeable that there is a negative relation between the use of manure and the ownership of cattle and donkeys.

Whether a farmer practices fallow (F7) depends for a great deal on the ethnic group of the household head. Burunge farmers more often fallow as a strategy to maintain soil fertility, which is according to traditional farming practices of this ethnic group. The Rangi are known to have more intensive cultivation practices.

The next factor (F8) indicates what households consider as their priority problem. Farmers who worry about rainfall-related problems tend to be older farmers and more often cultivate their land with hand hoe.

A household’s income level represents the next factor (F9). Farmers with higher income levels tend to have bigger land holdings per household member and a smaller number of hand hoes, cattle and donkeys. Households that score high on this factor more often live in Goima.

The last factor (F10) represents livelihood diversity. The variable that loads highest on this factor is the number of income-generating activities. Households with more diversified livelihoods not necessarily have a higher income level. Households that score high on this

factor more often cultivate by hand hoe and tend to have smaller land holdings per household member, which might indicate that households are forced to have other sources of come to reach subsistence level.

Clustering

The seven cluster solution best fitted the local situation (Table 8.1). Clusters 1 to 4 and 6 are mixed in terms of ethnic composition and their ratios resemble the sample ratio. Cluster 5 is Burunge-dominated and the last cluster is Rangi-dominated.

The first cluster can be termed "large arable farmers" and consists of male farmers, middle-aged and well endowed with resources. All households in this cluster live in Goima. These farmers seem not much conservation minded in their predominantly arable farming. Timely cultivation is not an issue of particular interest as many of these farmers use animal traction or tractor and do not practice conservation tillage in case the rains start late.

The second cluster is named: "large mixed farmers", focusing on both crops and livestock. These farmers are keen on fallow, crop rotations and SWC, but not on applying manure. Land holdings per person are the largest in this cluster and farmers predominantly use hand hoe cultivation. Without additional labour from outside the household, these farmers will not be able to cultivate all their land on time. Many farmers in this group do sow before the rains start using conservation tillage.

The third cluster are the "small arable farmers" and contains farmers who are keen on SWC and manure application, not on fallow and crop rotations. Most of these households are situated in Mirambu. These farmers mainly cultivate by hand hoe.

The fourth group, the "young farmers", consists of educated male farmers, with diversified income sources, including small livestock. They are keen on fallow, but less so on SWC. Some apply manure.

The fifth group, the "small, old, female farmers", consists of Burunge and illiterate female-headed households. They do not have much livestock and do not apply manure, but practice fallow. They fear that drought may affect their production. Due to their old age and small household size, they may face problems in timely cultivation. They mostly use hand hoe cultivation and use conservation tillage before the onset of the rains. Self-sufficiency levels are low. Farmers in this cluster have diversified livelihoods as a means to reach subsistence level.

The sixth cluster, the "small, younger, female farmers" contains poor female-headed households who do not own much livestock. They are not conservation minded and fear that soil fertility may affect their production. Also in this group many use conservation tillage before the onset of the rains.

The last cluster, the "large mixed Rangi farmers", contains educated male farmers living in Mirambu. They are wealthy and have relatively much livestock, especially cattle and donkeys. This group has the highest self-sufficiency level and most often uses animal traction or tractor. None of these farmers use SWC measures, while some protect their fields at its border. These farmers are not strong in using fallow; however they are keen on crop rotations and intercropping.

Table 8.1. Characteristics of households in Goima area, Tanzania classified in seven clusters and significance level for equality of group mean (ANOVA).

Factors	C1 N=18	C2 N=27	C3 N=23	C4 N=11	C5 N=20	C6 N=9	C7 N=12	Mean	St. Dev	P
F1: Self- sufficiency	0.17	0.50	-0.24	-0.50	-0.70	-0.51	1.12	0.00	1.00	0.000
F2: Livestock orientation	-0.19	0.49	-0.13	0.36	-0.47	-0.59	0.32	0.00	1.00	0.000
F3: SWC	-0.50	0.49	1.07	-0.53	-0.54	-0.36	-0.72	0.00	1.00	0.000
F4: Number of fields	1.21	0.15	-0.43	-0.12	-0.30	0.17	-0.84	0.00	1.00	0.000
F5: Characteristics HHH[a]	-0.24	-0.07	0.02	1.28	-0.68	-0.26	0.63	0.00	1.00	0.000
F6: Manure use	0.49	-0.59	0.88	0.75	-0.66	-0.42	-0.37	0.00	1.00	0.000
F7: Fallow	-0.30	0.56	-0.52	0.42	0.38	-0.19	-0.67	0.00	1.00	0.000
F8: Priority problem	0.25	-0.11	0.22	-0.43	0.49	-2.09	0.59	0.00	1.00	0.000
F9: Income	0.04	0.19	-0.18	0.90	0.17	-0.52	-0.86	0.00	1.00	0.000
F10: Livelihood diversity	-0.47	0.39	-0.06	0.50	0.17	-0.57	-0.36	0.00	1.00	0.010
Variables										
Household characteristics:										
Village 0=Mirambu 1=Goima	1.00	0.74	0.39	0.82	0.80	0.89	0.00	0.67	0.47	0.000
Ethnic group HHH 0=Rangi 1=Burunge	0.83	0.81	0.70	0.73	0.95	0.89	0.17	0.75	0.43	0.000
Gender HHH 0=female 1=male	0.83	0.96	0.83	1.00	0.40	0.44	0.92	0.78	0.41	0.000
Education HHH 0=illiterate 1=literate	0.39	0.56	0.43	1.00	0.25	0.33	0.83	0.51	0.50	0.000
Age HHH	50.94	48.07	43.39	37.27	61.00	43.78	42.92	47.93	15.71	0.000
Land:										
Acreage per person (ha)	1.02	1.13	0.59	0.70	0.62	0.49	0.81	0.81	0.64	0.016
Acreage (ha)	4.25	4.51	2.88	3.44	1.66	1.23	3.72	3.32	2.27	0.000
Land management:										
Power input 0= hand hoe 1= animal/tractor	0.67	0.07	0.04	0.09	0.05	0.11	0.50	0.20	0.40	0.000
SWC 0=no 1=yes	0.11	0.44	0.91	0.36	0.10	0.22	0.00	0.36	0.48	0.000
Manure 0=no 1=yes	0.39	0.04	0.43	0.18	0.00	0.00	0.08	0.18	0.38	0.001
Run-off 0=no 1=yes	0.33	0.78	0.87	0.27	0.30	0.44	0.33	0.53	0.50	0.000
Fallow 0=no 1=yes	0.44	0.70	0.26	0.73	0.65	0.33	0.33	0.51	0.50	0.010
Crop rotation 0=no 1=yes	0.67	0.85	0.26	0.64	0.50	0.33	0.92	0.60	0.49	0.000
Intercropping 0=no 1=yes	0.94	0.81	0.52	0.73	0.60	0.44	0.75	0.70	0.46	0.110
Sow before the rain 0=no 1=yes	0.00	0.63	0.09	0.09	0.70	0.67	0.42	0.38	0.49	0.000
Priority problem:										
Rainfall 0=no 1=yes	0.56	0.30	0.57	0.55	0.75	0.00	0.67	0.50	0.50	0.000
Fertility/ productivity 0=no 1=yes	0.00	0.00	0.00	0.36	0.00	0.78	0.00	0.09	0.29	0.000
Livestock:										
Number of chicken	1.94	0.85	2.43	4.45	0.85	0.78	1.67	1.73	2.81	0.070
Number of goats/sheep	0.33	0.59	0.39	0.73	0.15	0.11	0.42	0.40	0.49	0.004
Number of donkeys/cattle	0.33	0.41	0.09	0.09	0.05	0.11	0.75	0.26	0.44	0.000
Livelihoods:										
Income from sale produce 0=no 1=yes	0.56	0.59	0.61	0.45	0.20	0.33	0.83	0.52	0.50	0.007
Income from sale livestock 0=no 1=yes	0.11	0.26	0.26	0.27	0.00	0.00	0.17	0.17	0.37	0.115
Income level from all income sources Range: 0 (no) up to 7 (700 000 TZS)	1.86	2.09	1.37	3.55	1.93	0.72	1.04	1.82	1.64	0.000
Number of income sources	2.22	2.67	2.30	2.73	2.50	1.56	2.00	2.36	1.03	0.068
Self-sufficiency 0=no 1=just 2=able to sell	1.78	1.81	1.39	1.18	1.30	1.56	2.00	1.58	0.60	0.000

[a] Household head

Table 8.2 shows the seven farm household types and some of the elements of their farming and livelihood strategies. Only those farm types that use animal and/or mechanized power are always able to sow their land at the right time and can count on relatively good harvests. The others have to gamble with the first rains and usually look for more diverse

Table 8.2. Farm household types in Goima area, Tanzania and elements of their farming and livelihood strategies.

Farm type	Land management	Farming strategies	Livelihood strategies
Large arable farmers	Intercropping, crop rotation and manure	Timely cultivation due to animal and mechanical power	Produce for market
Large mixed farmers	Use fallow, crop rotation, intercropping and SWC	Sowing before rains using conservation tillage	Focussing both on crops and livestock
Small arable farmers	SWC and manure	Protect land from soil and fertility loss	Small income from crops and small stock
Young farmers	Fallow, crop rotation, intercropping	Maintain productivity of the soil	Diversified income
Small, old, female farmers	Fallow	Problems with timely cultivation, therefore conservation tillage before rains start	Diversified income
Small, younger, female farmers	Not much attention; no means	Use conservation tillage before rains start	Off –farm income
Large mixed Rangi farmers	Crop rotations and intercropping	Timely cultivation due to animal and mechanical power	Focussing both on crops and large ruminants

sources of income.

The clustered data show no relation between ownership of livestock and application of manure. Manure is not commonly used in the area. Farmers generally feel that their land is productive enough. Farmers mentioned that manure is most commonly used on sandy soils and soils that are tired. Some farmers have problems transporting the manure to their fields or have negative experiences with "burnt" crops in dry years due to manure application. Some farmers sell their manure for a small price, while others give it away for free.

8.3.2. Farm household types in Asfachew area

Clustering households with land

Within the Ethiopian case study the four cluster solution best fitted the local situation (Table 8.3). The clusters are organized according to self-sufficiency level.

The first cluster, the "small intensive farmers" consists of farmers who are not self-sufficient. These farmers are strong in the use of inputs such as chemical fertilizers, manure, herbicide and pesticides. They use intercropping. Since they already use some fertilizers, they do not see soil fertility as their major priority problem. They are mainly occupied with arable farming and keep some livestock as an income source. All these farmers have the resources, *i.e.* the plough and draught animals, to cultivate their land or to make a sharecropping arrangement. Most of these farmers make sharecropping arrangements to get access to more land in an effort to reach subsistence level.

The second cluster consists of "old female farmers", who mostly live in Chira Meda. Since their households are small, their acreage per household member is relatively large. These farmers lack the resources (labour and capital) to cultivate their own land. Ploughing

Table 8.3. Characteristics of households in Asfachew area, Ethiopia classified in four clusters and significance level for equality of group mean (ANOVA).

Variables	C1 N=9	C2 N=17	C3 N=17	C4 N=15	Mean	St. Dev.	P
Household characteristics:							
Village 0=Chira Meda 1=Asfachew	0.78	0.29	0.82	0.93	0.69	0.40	0.001
Gender HHH[a] 0=female 1=male	0.89	0.29	0.65	1.00	0.67	0.39	0.000
Education HHH 0=illiterate 2=literate	0.44	0.29	0.12	0.73	0.38	0.44	0.003
Age HHH	45.89	54.82	50.24	40.27	48.33	15.16	0.060
Household size	4.78	3.41	4.59	6.13	4.67	2.05	0.006
Land:							
Acreage per person (ha)	0.15	0.27	0.31	0.15	0.23	0.16	0.004
Land holding size (ha)	0.74	0.75	1.1	0.84	0.88	0.40	0.038
Sharecrop/rent-out y/n	0.22	0.82	0.24	0.07	0.36	0.39	0.000
Sharecrop/rent-in y/n	0.56	0.06	0.12	0.60	0.29	0.40	0.003
Intercrop y/n	1.00	0.06	0.06	0.33	0.28	0.31	0.000
Land management:							
Fertilizers/manure y/n	0.78	0.41	0.35	0.67	0.52	0.49	0.096
Pesticide/pesticide y/n	0.67	0.24	0.24	0.40	0.34	0.48	0.107
SWC y/n	0.89	0.82	0.71	1.00	0.84	0.36	0.146
Run-off/drainage y/n	0.56	0.53	0.53	0.80	0.60	0.49	0.305
Priority problem:							
Rainfall y/n	0.78	0.71	0.41	0.67	0.62	0.48	0.198
Fertility/ productivity y/n	0.00	0.06	0.06	0.07	0.05	0.23	0.905
Livestock:							
Cattle y/n	1.00	0.06	0.88	1.00	0.69	0.22	0.000
Number of cattle	3.33	0.06	1.71	2.40	1.66	1.20	0.000
Donkeys y/n	0.44	0.06	0.29	0.93	0.41	0.38	0.000
Number of donkeys	0.44	0.06	0.35	1.07	0.47	0.47	0.000
Goats/sheep y/n	0.56	0.06	0.47	0.80	0.45	0.43	0.000
Number of Goats/sheep	4.00	0.18	1.41	3.27	1.93	2.75	0.001
Ox-plough y/n	1.00	0.06	0.88	1.00	0.69	0.22	0.000
Livelihoods:							
Sale produce y/n	0.11	0.29	0.76	0.87	0.55	0.41	0.000
Sale livestock y/n	0.22	0.00	0.12	0.00	0.07	0.25	0.100
Horticulture y/n	0.11	0.18	0.06	0.13	0.12	0.33	0.278
Number of income sources	1.33	1.65	1.94	1.93	1.76	0.90	0.327
Self-sufficiency 0=no 1=just 2=able to sell	0.00	0.24	1.00	1.67	0.79	0.70	0.000
Credit y/n	0.56	0.06	0.59	0.73	0.47	0.43	0.000

[a]HHH= household head

is done by men and most female-headed households do not have men available in their household to do this job. These farmers share out or rent-out their land. The farmers in this cluster do not have access to credit. Credit is mostly used for buying chemical inputs or for buying livestock, both of which are not done by these households.

The third group, the "large farmers", consists of middle-aged households with relatively big land holdings. Most farmers cultivate their own land and do neither rent-in nor rent-out land. These farmers are not conservation-minded and their use of chemical inputs is rather low. The farmers in this cluster are least concerned about rainfall-related problems. Most farmers have the resources to plough their own land. They keep some livestock and some sell livestock as an income-generating strategy.

Households in the last cluster are the "small self-sufficient farmers". They are relatively young male-headed households living in Asfachew area. Their land holdings are rather small while households are large. Many farmers rent-in land or make sharecropping arrangements in order to get access to more land. Farmers are conservation-minded and use chemical inputs and some apply manure. This group of farmers had the highest self-sufficiency levels and had the resources to plough their own land. Farmers keep livestock, but do not sell it as an income-generating strategy. Farmers are mainly arable farmers and the sale of produce is their major source of income.

Characterizing landless farmers

Land in Ethiopia belongs to the federal republic (Adal, 1999). The regional governments have the right to take the land and redistribute it again, which has led to fragmented land holdings and insecure land rights for the farmers. The last redistribution in Asfachew Kebele took place in 1997. At that time, 100 out of a total of 875 households in the Kebele were without land. Seventy households were given land. Farmers are not allowed to sell their land and lease contracts cannot be arranged for longer than three years. The regional government has stated that no general redistributions will take place in the future. Since 1997, new households have applied at the PA to be considered for individual distribution of land.

The farmers in the sample were all registered at the PA as land owners and had tenure rights over land. However, there is yet another group of farmers: "the landless farmers". Landless farmers can be divided into two classes: landless farmers who rent-in land and those who work as daily labourers on other farmers' land or who go for labour to other areas.

Table 8.4. Farm household types in Asfachew area, Ethiopia and elements of their farming and livelihood strategies.

Farm type	Land management	Farming strategies	Livelihood strategies
Small, intensive farmers	Fertilisers, intercropping, SWC	Rent-in land and sharecropping to enlarge farm, pest management	Livestock, off-farm activities
Old female farmers	Not much attention; no resources and access to credit	Rent-out land and sharecropping; rent-in specific labour (plough)	Off-farm activities, horticulture, cash or produce through land market
Diversified farmers	Not much attention; enough land	Low labour input	Diversified livelihoods: livestock, off-farm activities wage labour and trade
Small, self-sufficient farmers	SWC, fertilisers	Rent-in or sharecropping to enlarge farm	Selling crops
Landless farmers	Try to use fertilisers and SWC	Rent-in or sharecropping	Securing land and optimizing yield to earn back investment in land
Wage-dependent landless	According to employer's wish	Farming for others	Daily labour, handicrafts

The first group of landless farmers stated that they are active farmers and use SWC and try to use fertilizers to be as productive as possible and to show land owners that they are good farmers. The second group stated that they were not able to get the initial investment for renting the land. Costs range from US$ 16.50 to 22 per year for a quarter of a hectare of good quality land to as low as US$ 5.50 for poor quality land. They also lack the ox-plough and draught animals to make a sharecropping arrangement. They do wage labour on rich farmers' land and engage in handicraft.

Table 8.4 shows the four farm household types and the two landless households and some of the elements of their farming and livelihood strategies. Because of the extreme land shortage, renting in land or sharecropping is very important, and so are off-farm activities to reach self-sufficiency levels.

8.3.3. Goima and Asfachew farm households compared

Land holding sizes in Goima area are on average eight times larger than those in Asfachew area, where there is even a group of households without land. Land holdings in Asfachew area are too small to live from and therefore most farmers arrange contracts with farmers who do not use all their land. Contrary to Goima area, no land in Asfachew area is left fallow.

Another noticeable difference is the mode of cultivation. Farmers in Goima area mainly use a hand hoe to cultivate their land, which results in unplanned fallow whenever the rains do not come regularly early in the season. The ox-plough is a relatively new technique in the area and only few farmers can afford to buy one or have the animals to use it.

In Ethiopia, every plot of land is cultivated using animal traction, except for some very steep plots. It is a cultural-historical and engendered practice and farmers are able to make their own plough. Most land consists of very heavy clayey soil, which is difficult to till otherwise. Female-headed households and the elder households who do not have men strong enough to handle the plough, and the ones without draught animals or plough have to rent-out their land or to make sharecropping arrangements. They can also hire labour, which is expensive because the land has to be tilled three up to seven times before sowing.

These differences in land holding size and cultivation technique represent the major concerns of farmers. Farming strategies in Goima area are focused on timely cultivation: to cultivate as much land as possible before the land is too dry. In Asfachew area the most important farming strategy is to cope with land shortage and to maximize the use of all arable land in the area (Table 8.4).

Self-sufficiency levels in general were lowest in Asfachew area. Farmers there have less land and need more resources to be able to cultivate the land. Farmers need draught animals and a plough, and land has to be used intensively to meet subsistence requirements. In Goima area, more than 90% of the farmers were self-sufficient in a normal year. In Asfachew area this figure was below 50%. In both areas the female-headed households had lower self-sufficiency levels than the male-headed households.

In Goima area no credit facilities were available for buying inputs such as fertilizers, which were also not easily available. In Asfachew area there is a possibility to get credit for buying fertilizers. An increasing number of farmers have started to use fertilizers during the past few years, especially in Chira Meda where the productivity of the land is low. Farmers consider the land in Asfachew area to be fertile, so there is no direct need to use fertilizers. They believe the land will get used to fertilizers and will become "lazy"; a reason not to start fertilizers application until really necessary.

The government and the Amhara Credit and Savings Institution (ACSI) provide credit to buy the fertilizers. Farmers who have no land and thus are not registered at the peasant association (PA) or who do not have any collateral, such as a house or livestock, cannot get credit. Besides individual credit for fertilizers, there is a credit scheme for groups of farmers for purchasing fertilizers, purchasing and fattening cattle or goats or constructing a rainwater harvesting structure.

The government keeps Diammonium Phosphate (DAP) and urea[3] in stock for the Kebele in Asfachew. Urea is most popular among farmers because it is cheaper than DAP (urea costs US$ 0.36 kg^{-1}; DAP costs US$ 0.44 kg^{-1}) and because it only needs to be applied once in a season. DAP should be applied three times in a season. The advised amount of fertilizers to use (25 kg of DAP ha^{-1} and 49 kg of urea ha^{-1}) is not used by farmers, as they feel that fertilizers prices are too high, that fertilizers use increases a crop's water demand, and that fertilizers application makes land lazy. During the 2006 *meher* season, fertilizers were applied on 22% of all cultivated land in the Kebele.

With the high erosion risk in parts of Asfachew area and with the high land use intensity, farmers have to take measures to maintain productivity. SWC measures and fertilizers are such measures. The most commonly used SWC measures are contour ploughing and planting, cut-off drains, grass strips and shrubs. Stone bunds, terraces and rainwater harvesting pits are less commonly used. These structures are mostly constructed with forced community labour. In Goima area most common SWC measures used are contour ploughing and planting, ridge cultivation and diversion ditches.

8.4. Strategies to deal with the ecological insecurity of the rains

8.4.1. Farm household strategies in Goima area

Livelihoods and resources

The household classification already showed that most households have more diversified livelihoods than arable cultivation and small-scale livestock keeping. We will look deeper into farmers' livelihood strategies by comparing these to farmers' own judgments of their self-sufficiency level.

Livelihood strategies vary according to self-sufficiency level of the households, gender and ethnic group of the household heads (Table 8.5). Rangi-headed and male-headed

[3] In 2004-2006, 2750 kg of urea and 850 kg of DAP was sold on credit to farmers in Asfachew Kebele

Table 8.5. Self-judgment of subsistence level in a normal year by Goima household heads (Tanzania) compared to their household characteristics, resources available and sources of income (% of households).

Percentage of households		Not self-sufficient	Just self-sufficient	Self-sufficient with ability to sell
	Total (N=120)	6	30	64
Gender household head	Male (N=94)	3	27	70
	Female (N=26)	16	42	42
Ethnic group household head	Burunge (N=90)	6	35	59
	Rangi (N=30)	7	13	80
Percentage of households within subsistence level owning:				
Livestock	Chicken (N=56)[b,m]	57	33	52
	Goats (N=45)[m]	28	28	43
	Donkeys (N=20)[r,m]	0	11	20
	Cattle (N=22)[r,m]	0	6	26
	Sheep (N=9)	0	8	8
Implements	Ox-plough (N=11)[r,m]	0	6	11
	Ox-cart (N=3)[r]	0	0	6
Percentage of households within subsistence level with income source:				
Income	Sale of beer (N=66)[b,f]	57	61	52
	Wage labour (N=60)	57	61	44
	Remittances (N=15)[f]	29	11	12
	Sale of produce (N=62)[r,m]	14	11	74
	Sale of livestock (N=20)[r]	14	11	20
	Seasonal migration (N=31) [m]	0	28	27
	Sale of honey (N=17)[b,m]	0	6	20
	Sale of wood (N=10)[b f]	0	8	9
	Handicraft (N=4)[b]	0	3	4
	Other[a] (N=8)[r,m]	0	0	10

[a] Making and selling bricks, house construction, renting out draught animals and plough, para-veterinarian, pastor
[b]Burunge-dominated, [r]Rangi-dominated, [m]male-dominated, [f]female-dominated

households generally have higher subsistence levels. Livelihoods become more diversified with increasing subsistence level.

Some activities are gender-specific, while others are predominantly practiced by people from a specific ethnic group. Beer brewing is practiced by the female members of predominately Burunge households. All Rangi farmers in the sample are Muslim and do not drink alcohol. Another gender-specific practice is beekeeping, which is only done by men. It is a traditional practice for the Burunge people, however also some Rangi are involved in beekeeping. The younger households were less often involved in beekeeping.

About half of the farmers owned some chicken and about one-third of the farmers kept some other livestock. For the female-headed households this figure was about 10%. The Burunge farmers mainly had small animals such as chicken, goats and sheep, while the Rangi farmers had a greater share in livestock such as donkeys and cattle and more often owned implements such as an ox-plough or ox-cart. The sale of livestock was a source of income, mostly for male-headed households.

The male-headed Rangi households are also involved in activities such as renting out implements, making bricks and constructing houses. According to the farmers, it was the Rangi who introduced brick houses into the area. The traditional houses of the Burunge, *tembe*, are mud houses with a flat soil roof.

Adapting and coping strategies

Farmers have adapted their farming practices to the insecure climate conditions they live in. Farmers' strategies to deal with the insecurity of the rains can be divided into three categories (Table 8.6). The first strategy is focused on agricultural practices. The second strategy is all about diversification. In areas with low and erratic rainfall, having a high diversity of livelihood strategies is a way to overcome the climatic risks (Elfaig and Serdang, 1999; Kebebew et al., 2001). The third strategy deals with food security.

Agronomic strategies. Timely cultivation is crucial to use the little rainfall as effectively as possible for crop growth and development. This can be done by different means. One is to sow part of the land using conservation tillage before the onset of the rains (cf. Hella et al., 2003 for different areas in semi-arid Tanzania). By using ridge cultivation water will be conserved on the land. By using ox-plough or tractor one can save a lot of time and labour. However, when using tractor, the subsoil mixes with the fertile topsoil and, therefore, some farmers agreed that tractor cultivation should not be done on the same plot

Table 8.6. Adapting and coping strategies according to farmers in Goima area, Tanzania.

	Adapting strategies	**Coping strategies**
Agronomic	Good timing agricultural activities	Re-sowing
	Sowing before onset of rains	Intensifying labour on field
	Rotating tillage techniques	Further thinning of crops
	Ridge cultivation	
	Mixed cropping	
	Relay cropping	
	Wide spacing	
	Thinning	
	Timely weeding	
	Quick maturing varieties	
	Drought resistant crops	
	Crop rotation	
	Cultivate virgin land	
	Fallow	
	Application of manure	
Diversification/ Market orientation	Keeping livestock	Finding daily labour
	Selling produce at seasonally high price	Beer brewing
	Mixing market and subsistence crops	Sale of livestock
		Labour (migration)
		Borrowing money/food from rich farmers
Preparedness & Food security	Keeping food in stock	Making blood sausage from blood alive animals
	Keeping livestock	
	Communal labour	
	Forecasts	

every year. To avoid this and to save money, some farmers who are able to hire labour and inputs have a rotational tillage system in which they every year cultivate another part of the land using different techniques. This way they feel assured that they will get a harvest.

When farmers expect a dry year, or when the rains have started late, farmers may decide to sow drought-resistant crops or quick maturing varieties. When drought affects already germinated seeds early in the season, farmers will re-sow where necessary.

Farmers put two or three seeds into each planting hole to optimize germination. To optimize the chance of harvesting something, farmers intercrop and use relay cropping. This way they reduce the risk of crop failure because every crop has different water and nutrient requirements. Wide spacing, timely weeding and thinning of the crop are practiced to avoid competition for water and nutrients.

To maintain the productivity of the land farmers may fallow or apply manure. There was a lot of discussion among farmers about the advantages and disadvantages of manure application. Farmers agreed that soil fertility, productivity and water-holding capacity of the soil increase due to manure application, but some farmers had experienced that their crops burnt in a dry year due and therefore were afraid to re-apply it. The solution was to use two or three years old manure. Farmers mentioned that crop rotation protects the land from exhausting.

Diversification/market orientation. Livestock keeping is one of the security options farmers have as a back-up when there is a need for food or cash. However, livestock keeping is rather difficult in the area due to seasonal water and feed shortages and due to diseases. Market prices for livestock and produce show great seasonal variability. The seasonal market prices for livestock and food show opposite trends. Towards the end of the crop season the need for food is highest, especially after one or a few years with low production. This increases food prices. At that same time livestock prices are low. Many people need cash and supply of livestock on the market is high. Immediately after harvesting, food prices drop and livestock prices go up. In March 2006, after four years of poor harvests and at time of food shortage, a farmers could buy 20 kg of sorghum after selling one goat, while after harvest, that farmer would be able to buy about 150 kg of sorghum for that same goat.

Right timing of market transactions is thus important, however many farmers were not in the position to do so. Farmers who borrowed money or food from rich farmers have to pay back in cash or in produce immediately after harvest. One strategy that some farmers used to cope with these unfavourable conditions is to make a local brew from sorghum. The profit is about three times the investment price. By growing a mixture of subsistence crops, like millet and sorghum, and market crops, like maize and sunflower, farmers try to be food secure, get good income from produce and spread the risk of crop failure.

Another option to cope with the effects of a bad year is to do wage labour on other farmers' land or to find labour opportunities in other areas. Most of the labour opportunities are in agriculture and coincide with the farmer's own work. Farmers who are doing wage labour are not able to work their own land on time and will again suffer from food shortage the next year.

Preparedness and food security. Households try to keep food in stock. Some grains are kept as seed to sow next season and some as food reserves for when there is a need for cash or for when there is a (partial) crop failure. Livestock is kept for the same reason. Farmers who have some food in stock are also able to organize a communal labour party. The organizing household has to be able to provide the working party with some food and more importantly with local brew. Communal labour is most commonly organized to weed or to clear a field.

8.4.2. Farm household strategies in Asfachew area

Livelihood strategies

Also for the Ethiopia data we looked at the livelihood strategies of farmers according to their own judgment on self-sufficiency in a normal year (Table 8.7). Livelihood strategies varied according to each household's own judgement of self-sufficiency, gender of the household head and village where household lives. Contrary to Goima area, livelihoods

Table 8.7. Self-judgment of subsistence level in a normal year by Asfachew household heads (Ethiopia) compared to their household characteristics, resources available and sources of income (% of households).

Percentage of households		**Not self-sufficient**	**Just self-sufficient**	**Self-sufficient with ability to sell**
	Total (N=58)	55	10	35
Gender household head	Male (N=39)	46	13	41
	Female (N=19)	74	5	21
	Asfachew (N=40)	45	10	45
Village	Chira Meda (N=18)	78	11	11
Percentage of households within subsistence level owning:				
Livestock	Chicken (N=36)	59	50	80
	Goats (N=26)[m]	31	67	60
	Donkeys (N=24)[a, m]	22	50	70
	Cattle (N=40)[a, m]	53	67	95
	Sheep (N=10)	19	0	20
Implements	Ox-plough (N=40)[a, m]	53	67	95
Percentage of households within subsistence level with income source:				
Income	Sale of produce (N=32)[a]	28	67	95
	Sale of livestock (N=4)[m]	9	17	0
	Horticulture (N=7)[f]	16	0	10
	Rent-out/sharecropping (N=21)[c]	81	10	9
	Handicraft (N=7)	19	17	0
	Wage labour (N=9)	22	0	10
	Sale of wood (N=7)	13	0	15
	Sale of beer (N=7)	9	17	15
	Remittances (N=3)	9	0	0
Credit	Credit (N=27)[a, m]	28	50	75

[a]Mostly in Asfachew, [c]Mostly in Chira Meda, [m]male-dominated, [f]female-dominated

become more diversified with decreasing subsistence level. Mostly the female-headed households and households in Chira Meda that are not self-sufficient have other sources of income besides farming. Most of them rent or share out their land, which provides them with some money or part of the produce. These households mostly are engaged in handicrafts, such as basket-making for women and weaving for men or they have a tea or beer house.

Information we did not gain through the questionnaire, but during in-depth interviews and group discussions was that the poorest households, "those without land or with land of very poor quality", engage in charcoal burning whenever there is a direct need for cash. This practice is illegal since trees are not to be cut without official permission. Contrary to other areas in Ethiopia, such as Debre Birhan (Amsalu et al., 2007), no market exists in Asfachew area and nearby towns for manure (dung-cakes). These are not used as a fuel for cooking in the area because, according to one of the officials at the Rural Development Office, farmers still have other options. Some farmers were engaged in the sale of wood.

Most households in the area grow tef for the market because of its high market price. They buy sorghum, which is cheaper, for home consumption from the proceeds of the tef sales.

In Chira Meda there were relatively more female-headed households and small businesses compared to Asfachew where farmers are mainly farming. Chira Meda has electricity, which has attracted traders from nearby areas. According to the chairman of the Kebele, it has also attracted ex-prostitutes from nearby Debre Sina. Some of them are now running a tea house or small shop or have a vegetable garden.

Farmers in Asfachew and especially the male-headed households are more often self-sufficient and are able to sell produce. They have the resources to plough their land and are legible to get some credit. The poorer households do not have the required collateral to get a loan and the labour or inputs to plough their own land.

Adapting and coping strategies

Agronomic strategies. Farmers have a strict agricultural calendar that is founded on the long experience of a few generations of farmers. For each crop there is a different sowing period. We will mention a few crops here. When *belg* rains start early farmers are able to sow maize (January up to 14 February). Next crop to be sown is tef (14 February up to 14 March). Chickpea has the shortest growing period and can be sown during the remaining days of March. Sorghum is considered a *meher* season crop, but is sown in April. Residual moisture of *belg* season is used for seed germination and initial plant growth. Early in *meher* season tef will be sown (9 July up to 8 august) and late in *meher* farmers sow chickpea (26 August up to 3 September). When plants dry due to discontinuity of the rains, farmers plough the land again and re-sow with another crop (Table 8.8). When it happens in *belg* season, farmers may decide to wait until *meher*.

Preparation of land starts before the onset of the rains. This will allow the rainwater to infiltrate into the soil. Each field needs to be tilled several times, depending on soil type and

Table 8.8. Adapting and coping strategies according to farmers in Asfachew area, Ethiopia.

	Adapting strategies	Coping strategies
Agronomic	Ploughing many times before sowing	Re-sowing
	Relay cropping	
	Crop rotation	
	Fertilizers	
	Thinning	
	Weeding many times	
	SWC	
	Location of field	
	Cultivate good soils	
	Quick maturing varieties	
	Drought resistant crops	
	Irrigated land (if possible)	
	Use both seasons	
Diversification/ market	Multiple income sources	Finding daily labour
	Grow marketable crop with high market value	Sale of livestock
		(Labour) Migration
	Growing fruit trees	Sale utensils
		Using money from *idir* group to buy food for its members
Preparedness & food security	Keeping food in stock	Feeding cultivated plants to livestock
	Prepare forage	Food aid/food for work

crop to be sown. Therefore, farmers have to start tillage on time. Weeding and thinning has make crops to be strong and healthy.

Location and quality of the field influence a crop's vulnerability to dry conditions. Rainfall at higher altitudes especially in *belg* season is better, while temperatures and evaporation has lower levels. However, the soils are shallower and of poorer quality and are not productive without fertilizers. The soils at lower altitudes are deeper and more fertile, but also heavier. These soils are productive in good years, but vulnerable to drought. A risk-spreading strategy used by farmers is to cultivate different types of soils in different areas. This includes searching for sharecropping arrangements in the neighbouring area further downstream. The Tikurso River has been diverted for irrigated agriculture. However, contracts do not come cheap there; the share is 50:50.

The use of SWC measures helps to retain soils, nutrients and soil moisture. Commonly used measures by farmers are stone rows and grass strips at the border of the field. A few farmers have rainwater harvesting structures and a treadle pump. Besides the growing use of chemical and organic fertilizers, soil fertility is maintained by using crop rotation. After every harvest, farmers change crop. Most commonly intercropping patterns used are sorghum-tef and sorghum-tef-chickpea. This prevents land from getting "bored".

Diversification/market orientation. During *meher* season no land is left uncultivated. Farmers who are not able to cultivate their own land will rent-out land or make sharecropping arrangements to get some income or food. Most people have other sources of income besides farming, which is necessary since the majority is not self-sufficient in their farming. Growing tef is another way to get enough food for household needs. Farmers are able to buy a higher quantity of sorghum in exchange for the quantity of tef they produce.

The government is encouraging farmers to grow trees and shrubs to provide construction- and fuel-wood and to generate income from its fruits. Mango trees are popular trees among farmers. Besides these benefits, trees and shrubs prevent soil erosion as farmers are encouraged to plant these on steep slopes.

In case farmers are confronted with the negative effects of a dry season or with ill-timed rainfall, farmers have several ways of coping. Farmers will go out to search for wage labour. When they have some small stock, they will sell. Only when they have no alternative, farmers will sell their "precious" draught animals. Farmers can also go for labour in other areas that are not under drought stress or when droughts are severe, they may decide to sell their jewellery and utensils or even to migrate.

Almost every farmer is a member of *idir*, which is a group of households that pay a monthly fee that will be used to cover funeral costs. An *idir* group may decide to use the contributed money to buy food for its members.

Preparedness and food security. Farmers remember the 1984 famine and place a high value on keeping grains in stock. They try to have enough stock to be able to survive another drought year. Sorghum is stocked and kept in underground stores, tef in big storage baskets plastered with clay.

Common grazing areas are few and are being overgrazed. Farmers have difficulties feeding their livestock in a dry year. Crop residues are used to cook on and to feed to livestock. When *belg* season fails, at least the crop plants can be fed to the livestock. The grass strips between fields are cut and hay is kept as forage for livestock in case there is a shortage of feed.

In case the government has estimates of a local-scale food shortage, it may decide to organize food-for-work for those who are most in need. During the last food-for-work activity, digging rainwater harvesting pits, 300 "least food secured households" had been selected by Kebele members to participate.

8.5. Farmers' views on their resilience to drought and implications for the respective farm household types

Households with low levels of social resilience will be constrained in their efforts to withstand the effects of a dry year, let alone a consecutive number of bad years. These farmers are vulnerable to drought. Vulnerability has a historical and social dimension: vulnerability changes over time and it is different for individuals due to divergent political, social and economic influences (Adger, 1999).

Farmers in both Goima area and Asfachew area recognized various constraints that limit their options to resist drought (Table 8.9). These constraints were based on households' attitude and ability.

Table 8.9. Farmers' views on factors influencing their resilience to drought in Goima area, Tanzania and Asfachew area, Ethiopia.

Goima area, Tanzania	Ability	Weak or sick farmers
		Households who lack labour
		Households without livestock
		Households without food reserves
		Households without money
		Households who use hand hoe
		Households with only heavy soils
	Attitude	Lazy farmers
Asfachew area, Ethiopia	Ability	Female-headed households
		Households who lack draught animals
		Households who lack labour
		Households who have no access to credit
		Households without land
		Households with drought-vulnerable land
	Attitude	Lazy farmers

8.5.1. Which Goima farm households can resist drought?

The attitude that farmers in Goima area identified as limiting one's resilience to drought was "laziness". The lazy farmers are the farmers who do not work according to their abilities, who do not cultivate on time, while this is crucial for succeeding in agriculture. However, not only the attitude of a farmer, also the ability in terms of resources matters. In Goima area it was very important to cultivate on time. Those people who have no other option than to work their land using hand hoe are considered to be more vulnerable than the farmers who can afford to hire labour, ox-plough or tractor. The acreage that can be finished within two days when using animal traction or tractor requires a month's time when using a hand hoe. For the hand hoe cultivators it is therefore important to have enough labour available within the household, also for weeding and harvesting. Farmers who are weak or sick will have problems finishing their land on time. Households who have some money or livestock have some reserves when they are in need of extra farm hands or food. Therefore the ones who do not have these resources are more vulnerable for drought. Since rainfall is erratic and can come in a few big showers, it is important to be able to start working the land with the first big rain. Farmers with heavy soils have to wait until their land is workable. If one has some food reserves, it is possible to survive a year with poor harvests, but when one has no such reserves, money or livestock to sell, farmers have to do wage labour on other farmers' land. Labouring may coincide with work on the own farm what causes untimely farming, which will result in reduced productivity, food insecurity and a need for supplementary activities.

When integrating farm household classifications, livelihood strategies and the adapting and coping strategies mentioned by farmers with the constraints to withstand drought conditions, it follows that the "large arable farmers" and the "large mixed Rangi farmers" show the highest levels of social resilience. They have most options to cultivate on time, by

hiring an ox-plough or tractor, or by hiring labour. In case the rains start late, they can buy quick maturing varieties from town. They can sell part of the produce and have reserves in case harvests fail. The “large mixed Rangi farmers” may be seen as “lazy”, since they have livestock and thus manure, and donkeys to transport the manure to the fields. These farmers would be the farmers to borrow food or money from or to ask for labour opportunities in times of need.

The “large mixed farmers”, the “small arable farmers” and the “young farmers” on average have the biggest households and labour available. These farm types are working according to their ability and maintain the land’s productivity. Income from crop production is supplemented by livestock sales and by other income sources. These farmers manage to survive a bad year.

The “small, old, female farmers” and the “small younger, female farmers” generally lack ability and have the lowest resilience levels. They have problems with timely cultivation. Their households are small and mostly lack male farm hands. When they need some cash, they can sell a chicken. They are working on rich farmers’ land when they are in need of cash or food, which interferes with work on their own land. As a strategy not to miss the rains they sow using conservation tillage before the onset of the rains.

8.5.2. Which Asfachew farm households can resist drought?

In both case study areas farmers explained attitude in a similar way, as “laziness” of the farmer. Lazy farmers could gain higher production levels if they would only be more active. In Asfachew area, the lazy farmers are those farmers who do not try to get more land and those who do take care of their land; who do not apply fertilizers or use SWC measures when they have the opportunity to do so.

However, not only the attitude of a farmer, also the ability in terms of resources was considered by farmers as influencing their vulnerability to drought. Those who have ability have options. Farming households in Ethiopia who lack labour will face difficulties making SWC structures; those who lack draught animals cannot plough their own land and the ones without financial means or access to credit may not be able to get rent contracts or to obtain credit. Farmers with small land holdings may feel that SWC structures will limit their production, since these structures occupy part of their precious land. Farmers without land have to invest money before they can cultivate, which makes them vulnerable. If the crop fails, they will have no food and have lost the initial investment. Farmers who are not able to cultivate their own land because they do not have male labour, draught animals, or because they are too old or weak may get some money or produce from land contracts. However, this will not be enough to subsist on. Households can get more produce from their land when it is of good quality or when it is located at higher altitudes where rainfall is more reliable and potential evaporation is lower compared to the lower altitudes. These factors will enable farmers to build up a stock or to get some income by selling part of the harvest.

The "small, self-sufficient farmers" have ability and are the most resilient. They are self-sufficient and are able to sell part of their produce. They are also active farmers who invest in SWC and have the option to get credit. This farm category had most farm hands available, which is useful for construction and maintenance of SWC structures. They are mainly focussed on agriculture and cultivate their own land and get additional land contracts. These farmers have livestock in case of need; produce enough to have food reserves in case of crop failure, to plant fruit trees and to buy quick maturing varieties.

The "diversified farmers" have some resilience. They are just self sufficient and can sell livestock in case of a partial crop failure. These farmers had the highest acreage and were least active on the land 'market'. These farmers can be considered as lazy farmers as they were least active in terms of land management.

The "wage-dependent labourers", the "old female farmers", the "small, intensive farmers" and the "landless farmers" had the least options to withstand drought. The "landless farmers" will do well as long as production is as expected. But since they are dependent on land contracts, they will have to share part of the produce or have to invest money before they are able to cultivate at all. The "small intensive farmers" have too little land to live from and also depend on other farmers' land. They have land and cattle and a plough, so they can cultivate their own land and are able to get credit. They are active farmers. The "old female farmers" were mostly not able to cultivate their land because of the lack of male labour, draught animals and plough. Their access to credit was also limited. They get some income or produce by renting or sharing out their land. They have also some other sources of income. The "wage dependent labourers" are most vulnerable. Since they cannot afford to make land contracts, they do not produce their own food and depend on wage labour. They are not legible for credit. In dry years the rewards for their labour is lower than in a good year, when there are more people searching for a job.

8.6. Conclusions

This study explored how farmers in Goima area, Tanzania and Asfachew area, Ethiopia deal with the ecological insecurity of the rains. The classification of the farm household types with PCA and CA was useful for this purpose. The distinguished farm household types, together with their descriptions in terms of farming and livelihood strategies and their resources, were consistent with the criteria used by farmers to explain differences in their resilience to drought. These case studies show that not only the external risk of exposure determines how farmers deal with the insecurity of the rains. Strategies differed for the different farm household types in the two areas. Farmers recognize that farmers have different resilience levels, which they explain in terms of abilities and attitudes. Those who lack ability, have a higher risk of lacking adequate coping strategies, while "lazy" farmers do not act according to their ability. The households who lack ability are the first to suffer the consequences in a year with poor rains and are less likely to have a fast recovery afterwards (Watts and Bohle, 1993). In both areas, the female-headed households were among the most constrained households.

In Goima area, the ability of timely cultivation was crucial. Farmers were struggling against time. By means of relay cropping and mixed cropping, the risk of crop failure is spread. When one can hire labour, an ox-plough or tractor one can finish the land in time. For the farmers who are dependent on the hand hoe, it is crucial to finish as much land as possible. Therefore, conservation tillage before the onset of the rains is important. Those farmers who can practice timely cultivation can harvest. Those farmers who are not able to practice timely cultivation due to lack of resources and those farmers who do not perform according to their ability were considered to be most vulnerable for drought.

In Asfachew area, getting access to land was crucial. Most farmers did not have enough land for subsistence, while some farmers were even without land. Since land availability is limited, it is used intensively. Over time more marginal land has been taken into cultivation. Crop rotation, fertilizers and SWC are important factors to maintain the productivity of the land and to reduce its vulnerability for drought. In Asfachew area, farmers were struggling to get user rights on enough land. This requires resources. For making a sharecropping arrangement, one has to have the draught animals and plough available and for making a rent contract, one has to have money to investment. Those farmers who do not take good care of their land and those farmers who do not have the required resources to cultivate their land or who do not have land, are considered as most drought vulnerable.

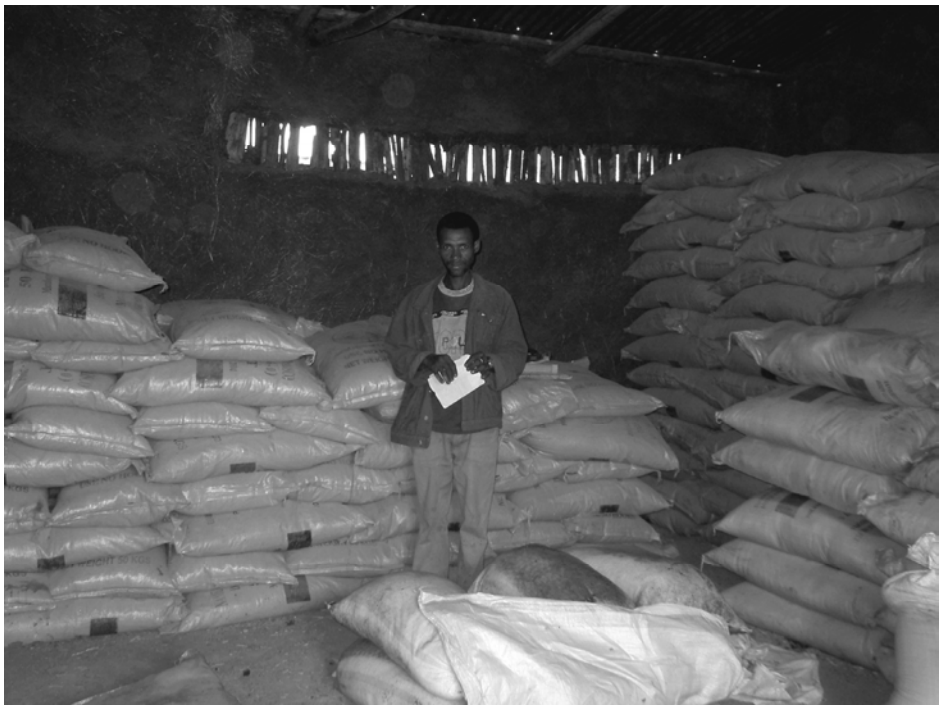

Figure 8.1. Store with chemical fertilizers in Asfachew, Ethiopia.

Figure 8.2. Distribution of tree and shrub seedlings by Rural Development Officials in Chira Meda, Ethiopia.

Chapter 9

Synthesis

9. Synthesis

At the start of this thesis, it was recognised that farmers mention drought and scientists mention land degradation as being the major factors in explaining low agricultural productivity in sub-Saharan Africa. As a consequence, many projects focusing on land degradation in semi-arid East Africa have met with limited success because they did not address the problems and needs of the target population. The solutions to problems that were developed were not considered to be relevant by local people. Therefore, an understanding of how they perceive the problem of drought is a crucial element in the design of practices that will improve their lives and the environment in which they live.

The starting point of this thesis was the hypothesis that farmers' perceptions of drought are different to the scientists' definition(s) thereof. The aim of the research was to bridge this 'gap' between farmers and scientists in order to improve the impact of interventions aimed at improving agricultural productivity. The objectives were:

1. To better understand farmers' perceptions of drought;
2. To relate farmers' perceptions to various forms of agricultural drought;
3. To explore the strategies that farmers use to deal with drought;
4. To recommend how to bridge the gap between farmers and scientists.

This chapter contains a synthesis of the research results that are presented in this thesis and directs the focus to alternative actions that will bridge the gap between farmers and scientists, thereby improving productivity in East Africa.

9.1. Understanding farmers' drought perceptions

Chapters 3 and 4 describe case studies in Tanzania and Ethiopia and shed light on how farmers perceive the concept of 'drought'. Particularly helpful is the Agricultural Drought Framework (ADF), which was developed after a literature study and theoretical reflections that are described in Chapter 2. The ADF proposes three types of agricultural drought: meteorological drought, soil water drought and a drought-like situation caused by a lack of plant nutrients. The latter is also called a soil nutrient drought, which is a term that is regarded as being too frivolous by some experts.

The insight that we gained from Chapters 3 and 4 is that farmers have a high threshold for what is described as a drought. What they commonly experience is less severe than a genuine drought according to their own definitions.

In Tanzania, farmers adhere to the concept of a drought being a complete crop failure due to an absence of rainfall, with the land being bare and dry. Accordingly, they believe that they have never personally experienced this phenomenon. The word drought is learnt through the extension service and from the radio, and the farmers use the term to refer to a year with reduced crop production caused by deficient rainfall, untimely rainfall, or an imbalance between rainfall and sunshine. The length of the expected dry spell is a major concern in relation to crop failure. However, Tanzanian farmers prefer to talk about a "bad

year" or "*jua kali*" (a scorching sun), since there is at least some rainfall every year and it is often the sun that burns the crop.

In Ethiopia, farmers adhere to the concept of a drought being crop failure during the main rainy season (*meher*) and sometimes also in the short season (*belg*), due to deficient or untimely rainfall, resulting in famine. Farmers depend on the *meher* for food production and are well used to failures in the *belg*. Whenever agricultural production is below expectation, farmers refer to their situation as "*chigir*", meaning problem, or to reduced production. The problems that were commonly mention are erratic or no rainfall, insect pests, weeds, and the illness or laziness of farmers. They also consider drought to be a *chigir*, and to some farmers any *chigir* is a drought when it results in reduced food availability.

Farmers in both areas feel that what is normal rainfall has changed. The prevailing feeling is that the rains have become less reliable over the past ten to twenty years. In both countries, many farmers attribute this change to deforestation, as "trees bring rainfall". Other studies on Ethiopia and Burkina Faso also reveal that farmers relate drought to deforestation (Meze-Hausken, 2004; Slegers et al., 2005; Slegers, 2008a).

9.2. Farmers' perceptions related to biophysical forms of drought

From previous descriptions, it may seem that the farmers' perceptions relate to meteorological drought, given their focus on the frequency and duration of dry spells. However, in both areas they have detailed and area-specific knowledge about how both local diversity in terms of soil properties, location and state of the land, and land management practices lead to differences in the impact that a bad year has on agricultural production (c.f. Meze-Hausken, 2004; Slegers et al., 2005). The farmers recognize that environmental changes influence the area's susceptibility to drought.

Within the ADF, "agricultural drought" refers to drought-like plant stress that depresses crop growth, crop development and crop production. This is caused by a shortage of water in the crop's root zone, a shortage of nutrients available to the crop, or both. Table 9.1 sets out the general factors that influence the vulnerability of both the land and its users to drought, as referred to in the ADF and by farmers in both study areas. The study of the farmers' perceptions of drought implies that their understanding of the term can be related to the concept of agricultural drought. Chapters 5, 6 and 7 provide details about how farmers' drought perceptions relate to ongoing biophysical processes.

9.2.1. Relating farmers' perceptions to rainfall data

To gain a deeper insight into how farmers' perceptions relate to actual rainfall patterns, rainfall data from meteorological stations near each study area were analyzed for annual and intra-seasonal patterns, the number of rainy days, the maximum daily rainfall, the mean rain per rainy day, and the lengths of dry spells (Chapter 5).

Table 9.1. Factors that influence the vulnerability of land and its users to drought as mentioned by farmers in Tanzania and Ethiopia.

Farmers' drought Tanzania	**Farmers' drought Ethiopia**
Soil properties:	***Soil properties:***
- Soil type	- Soil type
- Soil texture	- Soil texture
- Water holding capacity	- Soil depth
- Water infiltration	- Stones
- Soil fertility	- Soil fertility
- Erosion sensitivity	- Erosion sensitivity
Location of the land:	***Location of the land:***
- Slope	- Slope
	- Altitude
Weather conditions:	
- Sunshine	
- Rainfall	
Land management practices:	***Land management practices:***
- Cultivation technique	- Use of fertilizers
- Timing of cultivation	- SWC measures
- Crop type	- Crop type
- Manure use	
- Fallow	
- Weeding and thinning	
Farmers' characteristics:	***Farmers' characteristics:***
- Strength of farmer	- Gender household head
- Labour availability	- Labour availability
- Livestock ownership	- ownership of oxen and plough
- Available food reserves	- Access to credit
- Financial means	- User rights over land
- Ability to rent ox-plough or tractor	- Type/quality of land owned
- Type of soil in ownership	- Attitude of farmer
- Attitude of farmer	

The farmers in Tanzania are concerned about an increased frequency of droughts, but even more about an increased severity thereof. They complain that they can no longer rely on the rains falling according to their usual patterns. This is felt more strongly by the younger households and those with female heads. The latter group in particular is less well off, while the younger farmers have shorter memories when it came to droughts. The previous few seasons had been dry, which may partially explain the general perceptions regarding the increased drought trend.

Rainfall data (over 36 seasons) indicate that dry spells have lengthened and rainfall has reduced at the start and end of the rainy season. Mid-season reveals the opposite. Only December, the month in which the agricultural season is supposed to begin, shows a significant increase in mean dry spell length.

The farmers in Ethiopia also believe that the reliability of the rains has reduced and feel that they are "losing" the *belg* rains. Nevertheless, they are generally of the view that the frequency and severity of droughts has decreased because, according to their definition thereof, no droughts had occurred since 1984. Only those farmers younger than 20, the first generation who had not personally experienced the 1984 drought, unanimously agree that there had been no changes.

Rainfall data (over 21 years) indicate that dry spells have lengthened and rainfall has reduced during the *belg* season. The *Meher* season reveals the opposite. However, none of these changes are significant. Analysis of data from the last ten years shows significant reductions in the total rainfall and mean rain per rainy day during the *meher* season, which is explained by the rather high rainfall figures at the start of that period.

The results show that farmers' expectations of a normal rainy season are confirmed by the rainfall records. Trend analyses of rainfall and climatic indices indicate some changes which confirm farmers' perceptions, although most of these are not significant and cannot provide the farmers with scientific proof thereof. Several studies, wherein no clear evidence of changes in rainfall patterns had been found to support the farmers' concerns, explain these perceived changes as being the result of changes in other physical parameters (Dahlberg and Blaikie, 1996; Kinlund, 1996; Ovuka and Lindqvist, 2000; Stroosnijder, 2007).

9.2.2. Relating farmers' perceptions to soil moisture and soil nutrient availability

Since there is no unequivocal proof of an increased problem of meteorological drought, in Chapter 6 we look beyond the meteorological data for the Tanzanian case study area. This chapter compares the farmers' knowledge of spatial differences in drought susceptibility of crops with moisture and nutrient availability to maize during the 2005-2006 cropping season. The experimental set-up was based on the farmers' awareness of the effects that soil type and land management practices (ridge cultivation and manure application) have on crop performance. The three major soil types distinguished by farmers were based on their colour: Dark, Red and Pale. The first is the heaviest and fertile soil, the second is the lightest and not fertile, and the Red soil can be both heavy and light. Soil, moisture and crop data are analysed using a water balance model and QUEFTS, a model with which to evaluate soil fertility. Yield assessments of both analyses and by the farmers are compared.

According to the farmers, the relative productivity of each soil differs between wet and dry years. They perceive that in good rainfall years, the heavier Dark soil perform best, relatively, due to its high fertility status, while in a bad rainfall year the Pale light soil is, relatively, the most productive because of lower water demands. Crops on soils that are exhausted, or that have been affected by erosion, are less productive in a good year and are more susceptible to moisture deficiency.

Farmers recognize that a soil's natural conditions, as well as the effects of their management activities, influence nutrient and soil moisture properties and consequently the crops' susceptibility to dry conditions. When using the ridges, more water is retained, while

manure increases yield. The data show that the ridges had a positive effect on nutrient availability because of the concentration of top soil, while manure application only shows through increased yield and not on chemical soil analysis. This is explained by the concentrated application of manure in the seeding hole. None of the effects of management practices are visible on moisture availability, which can be different if there is a period of severe moisture stress.

Yield assessments by farmers are low compared to QUEFTS calculated yields and yield estimates based on the water balance model. These deviances might be attributed to moisture stress during periods when soil moisture is not readily available to the crop.

9.2.3. Relating farmers' perceptions to the environmental history of the area

Chapter 7 provides a greater insight into the environmental history of the Tanzanian study area. Environmental change is analysed in historical, cultural, socio-economic terms as well as in a biophysical context, so as to understand how farmers' environmental perceptions evolve over time and to explain why, until recently, they have remained relatively indifferent to land degradation. Three relevant environmental changes are discussed in this chapter: deforestation, soil fertility loss, and soil erosion. Farmers in the early 1990s did not consider these to be real problems but currently they are. The increased concern about these issues has emerged over the past ten to fifteen years, and coincides with the period during which the farmers have perceived an increased rainfall variability and drought severity.

9.3. Farmers' strategies to deal with the insecurity of the rains

Farming systems in both study areas are rain-fed and labour intensive, and food security is directly affected by rainfall variability. Drought cannot be viewed purely as a physical event. How it affects people's lives and their vulnerability to environmental hazards depends on their personal circumstances. In Chapter 8 we explore how farmers in Tanzania and Ethiopia deal with the ecological insecurity of the rains. The farmers were first classified into farm household types using Principal Components Analysis (PCA) and Cluster Analysis (CA). Livelihood strategies were also taken into account.

Seven farm household types are extracted from the Tanzanian sample, and four from the Ethiopian. The latter only includes those farmers who had user rights over land, and therefore the four-cluster solution is completed based on information gained through qualitative research, with two more "landless" clusters.

Both areas face their own challenges and constraints in agriculture. For the Tanzanian farmers, the timing of agricultural practices is crucial so as to not miss the rains. Rainfall is highly erratic, and most farmers depend on hand hoe cultivation. In Ethiopia, getting access to enough land of good quality is of utmost importance to the farmers, especially for those who are landless.

In both areas, livelihood strategies differ between households. Farmers recognize that they have different resilience levels, which they explain in terms of ability and attitude

(displayed as farmers' characteristics in Table 9.1). In Tanzania, farmers who are unable to cultivate on time, or who do not practice timely cultivation even though they have ability to do so, are considered to be the most vulnerable to drought. In Ethiopia, the most important farming strategy is being able to cope with land shortage and maximizing the use of all arable land in the area. Farmers who are unable to plough their own land, do not have land, or cannot buy inputs are considered to be the most vulnerable to drought. In both areas, the households headed by females are amongst the most constrained, and in Ethiopia this also includes the landless.

Households with low levels of social resilience are hampered in their efforts to withstand the effects of a dry year, let alone a consecutive number of bad years. The adaptive and coping strategies with which to deal with the insecurity of the rains, as are mentioned by farmers in both areas, can be divided into three categories: agronomic strategies, livelihood diversification and market orientation, and food security and preparedness.

The outcomes of these case studies reveal that not all poor households are equally vulnerable to the ecological insecurity of the rains, and not all vulnerable households are poor (cf. Eriksen et al., 2007). Drought vulnerability depends on a number of different factors including availability of resources, other livelihood strategies, land management practices, the quality of the land, and social and cultural affiliation and security. Confirming the findings of other studies (e.g. Boyd and Slaymaker, 2000; Posthumus, 2005; De Graaff et al., 2008), the farmers for whom agriculture is their major livelihood strategy, and where agricultural land is in short supply, are the most active in maintaining soil quality. In Ethiopia, the farmers who rent out their land make the least investment in it, while farmers without land are very active in optimizing production, hoping to get the chance to renew their rental contract. In Tanzania, the farmers with large land holdings and the option to cultivate most of them are less inclined to invest in their land. Finally, in both areas there is a group of farmers who do not have the resources available to make investments.

9.4. Alternative actions with a focus on sustainable land use and increased productivity in East Africa

9.4.1. Insights

Is there really a gap between farmers' and scientists' perceptions of drought? I believe that this question can be answered "no". It is easy to assume that farmers have a rather fatalistic view of drought, namely it is beyond their control and a 'convenient' problem to blame whenever yield is below expectation and there are no other obvious reasons for this. The case studies in this thesis revealed otherwise. The farmers do not believe that the difficulties they are facing should even be described as 'drought'. Indeed, for those in Tanzania the word is not in the vocabulary, and their only experience of the problem comes from stories they had been told. In Ethiopia, farmers have experienced severe famine and cannot, therefore, refer to their usual experiences of unreliable rains as drought.

The farmers have knowledge of both how land degradation processes reduce the environment's resilience to withstand drought conditions and what makes households differ in their capacity to deal with a bad year. They even feel that they are partly to blame for the problem of increased rainfall variability due to the deforestation that had taken place.

Irrespective of whether climate change in East Africa is manifesting itself through changing rainfall patterns, it must be noted that climate variability is real and does, occasionally, limit agricultural production. Land degradation processes increase the impact of occasional rainfall deficits on agricultural productivity. In Ethiopia, the frequency of drought is said to have increased since the 1950s, as a consequence of unsustainable land use, population growth, overgrazing and deforestation (Mersha and Boken, 2005).

Nutrient and water deficiency are two processes which are common in marginal areas. They occur simultaneously within a small area, and interchangeably on a temporal scale. This is also part of the farmers' knowledge. One demonstration of this knowledge is the way in which they explain the pros and cons of certain soil properties in wet and in dry years. An advantage of one soil in a good year is its disadvantage in a dry year. The farmers' explanation of this is that in a wet year the major limiting factor is soil fertility, while the major limiting factor in a dry year is soil moisture. Similar interactions are recognized by Ethiopian farmers.

It is estimated that for sub-Saharan Africa, agricultural water demands will triple by the year 2025 (Falkenmark and Rockström, 2004). Increased crop production has, until now, been achieved firstly by extensification and later by intensification processes, which are visible in both study areas. In the Ethiopian study area, there are no more margins for extensification and the farmers have started to invest in intensified land use. Ethiopian farmers are becoming aware that soil quality is more often a limiting factor than the availability of water.

Land use in Tanzania is also reaching its limits for sustainable extensification. More land is gradually being cleared which is unsuitable for agricultural purposes, while valuable trees are being cut down. Since vacant land has become scarce, practices of shifting cultivation with long fallow periods have been abandoned. These new practices have induced land degradation, whereas traditional management practices maintained soil fertility and improved soil properties (Rockström et al., 2004).

9.4.2. Recommended actions

Both case studies demonstrate the inter-relationship between human and natural systems. Rainfall patterns are perceived to be negatively affected by deforestation, while soil erosion and continuous cultivation diminish a soil's capacity to retain water. Farmers recognize that these human-induced environmental changes negatively influence the impact that rainfall deficiency or untimely rainfall has on their agricultural production, and that they have to be active to be productive and to withstand drought conditions. They can distinguish between drought conditions that are 'an act of God' and those that are induced by man (Roe et al.,

1998). This insight provides an opportunity to improve the impact of interventions that aim to increase agricultural productivity.

No one-size-fits-all solution exists for SWC strategies (Boyd and Slaymaker, 2000; Posthumus, 2005) or for strategies to deal with climate variability (Eriksen et al., 2007) and drought. The resilience of social-ecological systems depends on the local biophysical, economic and socio-cultural contexts.

Early Warning systems (EWS) can provide farmers with an indication of when the start of the cropping season is expected and about the expected rainfall pattern. Indeed, such a system is already available via radio and extension services. However, this is not a solution for the majority of farmers, who do not have the options to anticipate to likely conditions; they do not have the possibility to buy early maturing varieties of seeds (which may not even be readily available), or to hire an ox-plough with which to cultivate the land on time. These farmers will be dependent on poorly rewarded daily labour activities, which pay even less during bad years, and which further limit the timeliness of practices on their own land. Services to improve the farmers' ability to be pro-active should be part of the EWS.

The farmers' strategies for dealing with the insecurity of the rains are multifocal. An agronomic focus helps them to maintain production levels in good years, and focus on the market and livelihood diversity so that they are not totally dependent on the rains and one on food security to be prepared for a bad year. A concentration on agronomic measures with which to increase the efficiency of rainwater use, as suggested in Chapter 2, should focus on the synergy between soil water and nutrient improvement. An integrated water and land management approach which improves rainwater availability, techniques and the timing of cultivation practices, and soil nutrient management practices have a positive effect on yield and water productivity. However, interventions should target multiple sectors and the spheres in which people are engaged, so as to increase the resilience of both the natural environment and the people who depend on the land. It should, consequently, take social, economic and cultural circumstances into account. Actions have to be area-specific and must focus on local practices and the constraints that farmers have to deal with. In Tanzania, specific factors with which to improve the options for farmers include:

1. Cultivating on time;
2. Developing fertility management strategies to compensate for reduced fallows and reduce the farmers' reservations about applying manure;
3. Having water for household consumption easily available;
4. Planting trees, for which water is the major constraint;
5. Getting access to credit facilities;
6. Having better access to inputs;
7. Reducing dependency on the rains and, in the future, on the land by diversifying livelihoods.

In Ethiopia, specific factors with which to improve the options for farmers include:

1. Making it possible to enjoy longer-term lease contracts;
2. Reducing pressure on the land by creating off-farm job opportunities;
3. Developing rainwater harvesting structures that are less expensive;
4. Optimizing the use of precious space, by creating multi-functional uses thereof;
5. Developing alternative fertility management strategies that are affordable for farmers without credit.

One question remains to be answered, which is the one that was posed in the introduction: drought versus degradation? Natural scientists approach the problem of declining productivity from the point of view of the continuous threat of land degradation. For farmers, their first concern is the occasional problem of untimely rains, not drought and, according to them, as long as there is rain they will harvest. It seems as if the farmers and the scientists are walking along parallel roads when it comes to addressing major problems. However, the seemingly different problems of degradation and drought are actually well linked. Rather than “bridging a gap”, the issue is to find where both paths connect. To achieve this, Stroosnijder (2008) makes a plea for more integration: more emphasis should be put on integrated studies rather than on integration of disciplinary results, the interaction between farmers and scientists should improve, and household decisions should be considered crucial.

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Summary

Development actions focusing on land degradation in Sub-Saharan Africa have not been particularly successful in changing farmers' agricultural practices towards a more sustainable use of natural resources. This is due to scientifically biased top–down approaches, resource constraints, and a lack of consensus about major problems. Over time, programs dealing with land degradation have become more localized and participative, which is a positive step forward. However, these programs still depart from the productivity-reducing problems that are identified and perceived by scientists. Subsistence farmers in this region believe that other problems, such as drought are bigger constraints to them. Very little is known about how subsistence farmers in semi-arid East Africa perceive drought.

The aim of this research is to bridge this gap between farmers and scientists to improve the impact of interventions aimed at improving agricultural productivity. The study's objectives are:

1. To better understand farmers' perceptions of drought;
2. To relate farmers' perceptions to various forms of agricultural drought;
3. To explore the strategies farmers use to deal with drought;
4. To recommend how to bridge the gap between farmers and scientists.

The research focusses on two study areas within Tanzania and Ethiopia. During the period between 2004 and 2006, sociological and biophysical studies were conducted in Goima Ward, Tanzania and in Asfachew Kebele, Ethiopia.

Chapter 2 deals with issues of desertification and land degradation in the context of sub-Saharan Africa. It describes how the concept of desertification has evolved. Based on past and ongoing discussions about this concept and on the gained insight into the inter-relationship between land degradation and drought, a framework is developed for a subsequent study of farmers' drought perceptions. This agricultural drought framework (ADF) departs from the farmers' prioritization of drought and accommodates scientists' concerns about land degradation. It includes "meteorological drought", "soil water drought", and "soil nutrient drought". The framework increases insight into how different land degradation processes influence the vulnerability of land and farmers to drought. A focus on increased rainwater use efficiency is suggested, since this addresses the problems of both land degradation and drought.

The next two chapters describe how farmers in Tanzania (Chapter 3) and Ethiopia (Chapter 4) perceive their areas in terms of rainfall and drought. Chapter 3 firstly provides a framework of elements shaping one's perception and factors influencing the formation of perception to analyze farmers' perceptions in both case study areas.

A general statement made by farmers in Goima is that "if only it would rain, our harvests will be good". They firmly state that they have never personally experienced a drought, which may appear to be a paradox in this drought-stricken region. Farmers adhere to the principle of drought being a complete crop failure due to the absence of rainfall, the land being bare and dry. In less severe situations, in a year with reduced crop production due

to deficient rainfall or when “rainfall and sunshine are out of balance”, farmers prefer to talk about a bad year (*mwaka mbaya*) or about a scorching sun (*jua kali*) instead of drought (*ukame*). Farmers hear the word drought being used on the radio and by the extension service during what they refer to as being bad years.

The farmers in Goima feel that rainfall has become less predictable over the past ten to twenty years, especially early in the season. They are concerned about the increased frequency, but even more so about the increased severity of bad years. Farmers believe that trees bring rainfall and that deforestation has increased the drought problem. They regard drought from a wider perspective than that of deficient rainfall, and recognize the differences in drought vulnerability between soil types, location and state of land, land management practices and farmer types.

Ethiopia is well-known for its recurrent droughts and famines, especially those in the 1970s and 1980s. The farmers in Asfachew have experienced droughts before and the one in 1984, left everyone destitute; there was famine and people died or migrated to areas where the situation was less severe. Drought severity and frequency are considered to have diminished in recent years since the farmers have not experienced any severe droughts since 1984. Yet, the risk of drought is perceived to have increased since, according to their perceptions, rainfall had become more erratic, particularly during the short rainy season which farmers perceive to have “lost”. They recognize differences in drought vulnerability based on the characteristics of land and farmers, and on land management practices and they relate changes in rainfall to deforestation.

In Chapter 5, the rainy seasons in both case study areas in Tanzania and Ethiopia are characterized using long-term records of daily rainfall data. These data were analyzed for annual and intra-seasonal patterns, the number of rainy days, the maximum daily rainfall, the mean rain per rainy day, and the lengths of dry spells. The results were compared to the farmers’ perceptions about the rains. These analyses indicate some changes in rainfall and dry spell patterns that accord with the farmers’ perceptions, although most of these are not significant enough to provide farmers with scientific proof. The Tanzanian data reveal one significant change in the period between 1970-1971 and 2005-2006: an increase of the mean length of December dry spells. The Ethiopian data shows no significant changes between 1984 and 2005. Perceived changes in rainfall may be the result of changes in other biophysical changes. The farmers in both areas believe that deforestation has contributed to the rainfall problems, since “trees bring rainfall”.

Chapter 6 focusses on Tanzania. We look beyond meteorological data by comparing farmers’ knowledge of spatial differences in drought susceptibility of crops with moisture and nutrient availability to maize during the 2005-2006 cropping season. The experimental set-up was based on the farmers’ awareness of how the different properties of a soil and their management practices influence a crop’s ability to resist drought conditions. With help of farmers suitable fields were selected of the three soil types distinguished by farmers: Dark, Red and Pale. The experimental design was a 2^2 factorial with manure and water conservation as factors, each at two levels (with or without). The fields studied were managed by the farmers themselves and according to their usual practice. Farmers planted

maize of the Kilima variety. Rainfall, soil moisture, soil, and crop data were analyzed using a water balance model and QUEFTS, a model with which to evaluate soil fertility. Yield assessments of both analyses and by farmers were compared. The plots where manure was applied showed better crop growth than the other plots of the same soil type. Effects of the ridges, however, were limited, but might have been significant if a period of more severe moisture stress would have occurred during this particular cropping season. Chemical and physical properties of the Dark soil were best, and those of the Red soil were poorest. Farmers' knowledge about spatial differences in drought susceptibility of crops generally agree with the outcomes of the analyzed data. Farmers perceive that in good rainfall years, the less sandy soils perform relatively best due higher fertility status, while in a bad rainfall year lighter soils are relatively most productive because of easier water infiltration and lower water demands. Yield assessments by farmers are low compared to QUEFTS calculated yields and yield estimates based on the water balance model. These deviances might be attributed to moisture stress during periods when soil moisture was not readily available to the crop.

Chapter 7 contains an environmental history of the Tanzanian case study area and its surroundings and relates farmers' concerns about the rains to recent environmental changes in the area. Comparisons with a study performed in the same villages in the early 1990s disclosed a striking difference in their perceptions of environmental stress. The environmental history of the region helps to explain how the Burunge (ethnic group) way of relating to natural resources evolved. Dramatic changes in official land policies in the 1970s did not, in essence, change this. However, the cumulative effects of rapid immigration into their area, and liberalised land use made the Burunge farmers move from having an essentially trusting relationship with their environment to them becoming deeply concerned about increased deforestation, diminishing soil fertility and accelerated soil erosion. The increased concerns about these issues have emerged over the past ten to fifteen years, and coincide with the period during which the farmers perceive an increased rainfall variability and drought severity. Drought is not just understood in meteorological terms but also as a function of disappearing forests and declining conditions of the land.

Chapter 8 discusses the strategies that the farmers in Tanzania and Ethiopia use to deal with the unreliable rains. Most farming systems in East Africa are labour intensive and rainfed. Food security in such areas is directly affected by rainfall variability and depends greatly on the options that local people have available to cope with it. Farmers were classified into farm types using Principal Components and Cluster Analyses. Livelihood strategies were also considered. Both areas face their own challenges and constraints. The case studies show that it is not only the external risk of exposure which determines how farmers deal with the insecurity of the rains. They recognize that they have different resilience levels, which they explain in terms of ability and attitude. In Tanzania, most farmers depend on hand hoe cultivation and farming strategies are focused on timely cultivation. Farmers who are unable to cultivate on time, or who do not practice timely cultivation even though they have the ability to do so, are considered to be the most vulnerable to drought. In Ethiopia, the most important farming strategy is to cope with land

shortage and maximizing the use of all arable land in the area. Farmers who are unable to plough their own land, do not have land, or cannot buy inputs are considered to be the most vulnerable to drought. Strategies with which to deal with the insecurity of the rains, which were mentioned in both areas, include agronomic measures, livelihood diversification, food security and preparedness in case of a possible dry year.

Finally, Chapter 9 synthesises the research results presented in the previous chapters and directs focus to alternative actions with a concentration on sustainable land use and increased productivity in East Africa. It is easy to assume that farmers have a rather fatalistic view of drought, namely it is beyond their control and a 'convenient' problem to blame whenever yield is below expectation and there are no other obvious reasons for this. The case studies in this thesis reveal otherwise. Both case studies demonstrate the inter-relationship of human and natural systems. This is also part of farmers' knowledge. Farmers' perceptions relate to the scientific concept of agricultural drought. Rainfall patterns are perceived to be negatively affected by deforestation, while soil erosion and continuous cultivation diminish a soil's fertility and capacity to retain water. Farmers recognize that one has to be an active farmer to be productive and to withstand drought conditions.

No one-size-fits-all solution exists for which SWC strategies to use, or for strategies to deal with climate variability and drought. The resilience level of social-ecological systems depends on the local biophysical, economic and socio-cultural contexts. Early warning systems (EWS) are already available in the study areas via radio and extension services. However this is not a solution for the majority of the farmers who do not have options anticipate to expected conditions. Nutrient and water deficiency are two processes that are common in marginal areas. They occur simultaneously within a small area, and interchangeably on a temporal scale. A focus on agronomic measures to increase the efficiency of rainwater use should be focused on a synergy between soil moisture and nutrient improvement.

Farmers' strategies for dealing with the insecurity of the rains are multifocal. Interventions should target the multiple sectors and spheres in which people are engaged, so as to increase the resilience of both the natural environment and the people who depend on the land. These should, consequently, take social, economic and cultural circumstances into account. Actions have to be area-specific and focused on local practices and the constraints that farmers have to deal with. The synthesis finalizes by referring to a question that was posed in the introduction: "Drought versus degradation?" and is answered in the negative. It seems as if farmers and scientists are walking along parallel roads when it comes to addressing major problems. However, the seemingly different problems of degradation and drought are actually linked. Rather than "bridging a gap", the issue is to find where both paths are connected. To achieve this, more emphasis should be put on integrated studies and on improving the interaction between farmers and scientists.

Samenvatting

Ontwikkelingsacties gericht op bodemdegradatie in Afrika bezuiden de Sahara zijn niet erg succesvol gebleken. Deze acties waren gericht op het veranderen van landbouwactiviteiten van lokale boeren ten behoeve van een duurzamer gebruik van natuurlijke hulpbronnen. De wetenschappelijk georiënteerde aanpak van boven af, de beperkte middelen en het gebrek aan overeenstemming over de fundamentele problemen die aangepakt moeten worden zijn hier debet aan. Een positieve zet was dat in de loop der jaren de programma's om bodemdegradatie tegen te gaan meer lokaal en participatief zijn geworden. Deze programma's gaan echter nog steeds uit van de productiebeperkende problemen zoals die geïdentificeerd en ervaren worden door wetenschappers. Zelfvoorzienende, kleine boeren in deze regio geloven dat andere problemen, zoals droogte, een belangrijkere beperking zijn. Er is weinig onderzoek gedaan naar wat de perceptie is over droogte van zelfvoorzienende boeren in Afrika bezuiden de Sahara.

Het doel van dit onderzoek is om de kloof te overbruggen tussen boeren en wetenschappers om zo de uitwerking van interventies gericht op productieverhoging te verbeteren. Specifieke doelstellingen van dit onderzoek zijn:

1. Het beter begrijpen van de percepties die boeren hebben over droogte;
2. Het relateren van deze percepties aan verscheidene vormen van landbouwdroogte;
3. Het verkennen van strategieën waarmee boeren omgaan met droogte;
4. Het doen van aanbevelingen voor het overbruggen van de kloof tussen boeren en wetenschappers.

Het onderzoek richt zich op twee onderzoeksgebieden in Tanzania en Ethiopië. Tussen 2004 en 2006 zijn sociologische en biofysische studies uitgevoerd in Goima, gelegen in Tanzania en in Asfachew, gelegen in Ethiopië.

Hoofdstuk 2 behandelt de problemen van verwoestijning en bodemdegradatie en plaatst deze in een context van Afrika bezuiden de Sahara. Er wordt beschreven hoe het concept van verwoestijning is ontstaan en hoe het zich in de loop der jaren heeft ontwikkeld. Discussies over dit concept en de inzichten in de relatie tussen bodemdegradatie en droogte, vormen een kader welke gebruikt wordt voor de studie naar droogte percepties van boeren. Dit kader van landbouwdroogte gaat uit van het probleem droogte, welke door boeren als belangrijkste wordt ervaren, en houdt tegelijkertijd rekening met het probleem van bodemdegradatie, welke door wetenschappers als belangrijkste wordt ervaren. Het kader bevat "meteorologische droogte", "bodem water droogte" en "bodem nutriënten droogte" en vergroot het inzicht in hoe bodemdegradatieprocessen de droogte gevoeligheid van boeren en hun land beïnvloeden. Een aanpak die zich richt op een grotere efficiëntie van watergebruik wordt aanbevolen omdat deze beide problemen van droogte en bodemdegradatie aanpakt.

De volgende twee hoofdstukken beschrijven hoe boeren in Tanzania (Hoofdstuk 3) en in Ethiopië (Hoofdstuk 4) hun gebied ervaren wat betreft regen en droogte. Hoofdstuk 3 schetst eerst een kader van elementen die samen perceptie vormen en van factoren die de

vorming van perceptie beïnvloeden. Dit kader helpt bij de analyse van de droogte percepties van boeren in beide onderzoeksgebieden.

Een veelgehoorde uitdrukking in Goima is dat: “Als het maar zou regenen, dan hebben wij een goede oogst”. Deze boeren beweren stellig dat zij nog nooit persoonlijk een droogte hebben meegemaakt. Dit lijkt paradoxaal aangezien ze in een regelmatig door droogte getroffen gebied wonen. Boeren hebben het principe dat een droogte betekent dat zij gedurende een heel jaar helemaal geen oogst hebben door het compleet uitblijven van regen, waardoor hun gebied helemaal dor en droog is. Wanneer tijdens een jaar de oogst verminderd is door een gebrek aan regenval, of wanneer “regen en zonneschijn uit balans waren”, spreken boeren liever van een slecht jaar (*mwaka mbaya*) of van een brandende zon (*jua kali*) dan van droogte (*ukame*). Boeren spreken van een slecht jaar, maar de radio en bij landbouwvoorlichtingsdiensten gebruiken ze het woord ‘droogte’.

De boeren in Goima geloven dat regen minder betrouwbaar is geworden in de afgelopen tien tot twintig jaren, in het bijzonder aan het begin van de regentijd. Ze vrezen dat de frequentie, maar vooral de hevigheid van slechte jaren is toegenomen. Boeren geloven dat bomen regen brengen en dat ontbossing een oorzaak is voor het toenemende droogteprobleem. Boeren zien droogte in een bredere context dan alleen in de context van gebrek aan regenval en herkennen verschillen in droogtegevoeligheid tussen bodemtypen, locaties van het land, kwaliteit van de bodem, landgebruikactiviteiten en typen boeren.

Ethiopië staat bekend om de terugkerende droogte en hongersnoden, in het bijzonder die van de jaren ’70 en ‘80. Ook de boeren in Asfachew hebben ervaring met droogte. Die van 1984 maakte iedereen behoeftig. Er heerste een hongersnood en mensen stierven of migreerden naar gebieden waar de situatie minder ernstig was. Droogtes zijn minder frequent en minder heftig geworden volgens boeren aangezien zij sinds 1984 geen ernstige droogte meer hebben meegemaakt. Zij constateren dat het risico op droogte echter toegenomen is, omdat regenval tegenwoordig een grilliger patroon vertoont, vooral gedurende de korte regentijd. Boeren ervaren deze regenperiode als “verloren”. Zij zien verschillen in droogtegevoeligheid op basis van de karakteristieken van de bodem en van de boeren en op basis van hun managementtechnieken. Veranderingen in het patroon van de regenval worden toegeschreven aan ontbossing.

In Hoofdstuk 5 worden de regenseizoenen in beide onderzoeksgebieden in Tanzania and Ethiopië gekarakteriseerd op basis van lange termijncijfers van de dagelijkse regenval. De gegevens worden geanalyseerd op hun regenval patronen tussen en binnen seizoenen, de hoeveelheid regendagen, de maximale dagelijkse regenval, de gemiddelde regenval per regendag en de lengte van droge periodes. De resultaten worden vergeleken met de percepties die boeren hebben over de regen. De analyses laten enkele wijzigingen zien in de patronen van regenval en droogte die overeenkomen met de percepties van boeren. Deze zijn echter niet significant en vormen daarom geen wetenschappelijk bewijs voor hun vermoedens. De analyses van de cijfers uit Tanzania laten een significante verandering zien tussen 1970-1971 en 2005-2006 in de lengte van droge periodes gedurende de maand december: de maand wanneer het regenseizoen begint. De analyse van de Ethiopische cijfers laten geen significante verschillen zien over de periode tussen 1984 en 2005. De verschillen

zoals ervaren door boeren, zijn mogelijk het gevolg van andere biofischische veranderingen. De boeren in beide gebieden geloven dat ontbossing een veroorzaker is van de problemen met de regen aangezien “bomen regen brengen”.

Hoofdstuk 6 concentreert zich op Tanzania. We kijken naar andere factoren dan naar regenval. We vergelijken de boerenkennis over ruimtelijke verschillen in droogtegevoeligheid van gewassen met de beschikbaarheid van vocht en nutriënten voor maïs gedurende een groeiseizoen (2005-2006) in Tanzania. Op basis van de kennis van boeren over hoe verschillende karakteristieken van een bodem en hun landgebruik het vermogen van een gewas om droogte te weerstaan beïnvloedt, werd een veldexperiment opgezet. Met hulp van boeren werden geschikte velden geselecteerd van ieder van de drie bodemtypen die de boeren onderscheiden (Donker, Rood en Licht). Het experiment had een 2^2 factor opzet met mest en bodem- en waterconservering (aardruggen) als factoren. Beide factoren hadden twee niveaus (met en zonder). De bestudeerde velden werden door de boeren zelf bewerkt volgens hun gebruikelijke praktijken. Boeren plantten maïs van de Kilima variëteit. Regenval, bodemvocht, bodem- en gewasgegevens zijn geanalyseerd met behulp van een water balans model en QUEFTS, een model om bodemvruchtbaarheid te evalueren. De bemeste veldjes hadden een betere gewasgroei dan de veldjes van hetzelfde bodemtype zonder bemesting. De effecten van de aardruggen waren echter niet significant, hoewel dit anders had kunnen zijn als er een langere periode was geweest met water stress gedurende dit seizoen. De chemische en fysische eigenschappen van de Donkere bodem waren het beste, terwijl die van de Rode bodem het slechtste waren. De kennis die boeren hebben over ruimtelijke verschillen in droogtegevoeligheid van gewassen komen overeen met de uitkomsten van de analyses. Boeren weten dat de minder zanderige bodems productiever zijn tijdens een seizoen met goede regenval doordat ze vruchtbaar zijn. De zanderigere bodems zijn relatief productiever gedurende een droog jaar doordat water makkelijker infiltreert en de bodem minder water nodig heeft. De geschatte oogst door de boeren was relatief laag vergeleken met de schattingen gemaakt met het waterbalans model en QUEFTS. Deze verschillen kunnen het gevolg zijn van korte periodes van water stress gedurende het groeiseizoen waardoor vocht niet voldoende beschikbaar was voor de plant.

Hoofdstuk 7 bevat een milieuhistorische schets van het onderzoeksgebied in Tanzania en haar omgeving en relateert de bezorgdheid van boeren over de regen aan recente milieuveranderingen. Een vergelijking met de uitkomsten van een studie gedaan in dezelfde dorpen begin jaren ’90, wijst uit dat de percepties van boeren over stress op hun omgeving duidelijk veranderd zijn. De milieuhistorische schets van het gebied helpt bij het verklaren van de ontwikkeling van de manier waarop de Burunge etnische group zich relateert aan hun natuurlijke hulpbronnen. Ingrijpende veranderingen van het officiële beleid aangaande landrechten heeft hier in essentie weinig aan veranderd. Echter, de snelle immigratie en geliberaliseerde vormen van landgebruik maakte dat Burunge boeren overgingen van het in vol vertrouwen omgaan met hun natuurlijke omgeving naar een situatie van groeiende bezorgdheid over ontbossing, verminderde bodemvruchtbaarheid en versnelde bodemerosie. Deze groeiende bezorgdheid is ontstaan in de afgelopen tien tot vijftien jaar en valt samen met de periode waarover boeren een groeiende onzekerheid van regenval en hevigheid van

droogte ervaren. Droogte wordt niet alleen verstaan in meteorologische termen, maar ook als een functie van verdwijnende bossen en verminderde kwaliteit van het land.

Hoofdstuk 8 betreft de strategieën waarmee boeren in Tanzania en Ethiopië omgaan met de onbetrouwbare regenval. De meeste landbouwsystemen in oost Afrika zijn arbeidsintensief en afhankelijk van de regenval. Voedselzekerheid in deze gebieden wordt direct beïnvloed door de variabiliteit van de regen en hangt grotendeels af van de opties die boeren hebben om hiermee om te gaan. Boeren werden geclassificeerd in bedrijfstypen met gebruikmaking van principale componenten analyse en clusteranalyses. Ook de strategieën van levensonderhoud zijn in beschouwing genomen. Beide onderzoeksgebieden kennen hun eigen uitdagingen en beperkingen voor boeren. De twee studies laten zien dat niet alleen het externe risico van blootstelling bepaalt hoe boeren omgaan met de onzekere regenval. Boeren herkennen dat zij verschillende niveaus van weerbaarheid hebben, welke zij omschrijven in termen van vermogen en houding. In Tanzania zijn de meeste boeren wat betreft de wijze van grondbewerking afhankelijk van de hak, het op tijd cultiveren is een belangrijke strategie voor boeren. Boeren die niet het vermogen hebben om op tijd hun land te bewerken, of die hun land niet op tijd bewerken terwijl zij daartoe wel in staat zijn, worden gezien als het meest gevoelig voor droogte. De belangrijkste strategieën in Ethiopië zijn: het omgaan met het tekort aan land en het maximaliseren van landgebruik. Boeren die niet in staat zijn om hun eigen land te bewerken, die geen land hebben, of die geen grondstoffen kunnen kopen, worden gezien als het meest gevoelig voor droogte. Strategieën voor het omgaan met de onbetrouwbare regenval genoemd in beide gebieden kunnen onderverdeeld worden in drie categorieën: agronomische maatregelen, diversificatie van levensonderhoud en voedselzekerheid en daarmee voorbereid zijn op een mogelijk droog jaar.

Het laatste hoofdstuk voegt de onderzoeksresultaten van alle voorgaande hoofdstukken bij elkaar en richt de aandacht op alternatieve acties die zich concentreren op duurzaam landgebruik en verhoogde productiviteit in oost Afrika. Het is gemakkelijk ervan uit te gaan dat boeren een fatalistische houding hebben ten opzichte van droogte, als zijnde een ‘geschikt’ probleem welke te pas en te onpas gebruikt wordt indien de oogst beneden verwachting is en er verder geen aantoonbare reden is voor de verlaagde productie. De studies uiteengezet in dit proefschrift laten een andere werkelijkheid zien. De percepties over droogte van boeren komt overeen met het wetenschappelijke concept van landbouw droogte. De studies in beide gebieden tonen de interrelatie tussen menselijke en natuurlijke systemen, welke ook deel is van de boerenkennis. Volgens de perceptie van de boeren worden regenval patronen negatief beïnvloed door ontbossing, terwijl bodemerosie en continu landgebruik het waterhoudend vermogen van een bodem aantasten. Boeren weten dat ze actief moeten zijn om productief te zijn en om droogte te kunnen weerstaan.

Er is geen universele oplossing voor de toe te passen bodem- en waterconservering strategieën, of voor strategieën waarmee om te gaan met de variabiliteit van het klimaat of met droogte. De veerkracht van sociaalecologische systemen hangt af van de lokale biofysische, economische en sociaal-culturele context. Systemen om boeren voortijdig te waarschuwen voor een droog jaar bestaan al in beide onderzoeksgebieden via de radio en

voorlichtingssystemen. Zulk systeem is echter geen oplossing voor het merendeel van de boeren die niet de alternatieven hebben om te anticiperen op de verwachte omstandigheden. Nutriëntengebrek en gebrek aan bodemvocht zijn twee processen die veelvoorkomend zijn in marginale gebieden. Zij komen tegelijkertijd voor binnen een klein gebied en wisselen elkaar af als meest limiterende factor in loop de tijd. Agronomische maatregelen die een efficiënter gebruik van de regenval tot doel hebben, zouden zich moeten richten op een synergie tussen bodemvocht en nutriënten verbetering.

De strategieën die boeren toepassen voor het omgaan met de onzekerheid van de regenval zijn multifocaal. Interventies zouden zich moeten richten op de verschillende actievelden waarbinnen boeren zich bezighouden, opdat de veerkracht verbetert van de natuurlijke omgeving en van diegenen die daarvan afhankelijk zijn. Interventies moeten daarom de sociale, economische en culturele omstandigheden in beschouwing nemen. Acties moeten gebiedsspecifiek zijn en gericht zijn op de lokale gebruiken en beperkingen waarmee de boeren moeten omgaan. De synthese eindigt met de beantwoording van een laatste vraag welke in de introductie genoemd werd en welke negatief beantwoord moet worden: “droogte versus degradatie”? Het lijkt erop dat wetenschappers en boeren over parallelle wegen lopen als het gaat over hun belangrijke problemen. De blijkbaar verschillende problemen van degradatie en droogte zijn echter verbonden. In plaats van het overbruggen van een kloof, wat we verwachtte, is het zaak om uit te vinden waar precies beide paden verbonden zijn. Om hiertoe te komen is het belangrijk dat er meer nadruk gelegd moet worden op geïntegreerde studies en op het verbeteren van de interactie tussen boeren en wetenschappers.

PE&RC PhD Education Certificate

With the educational activities listed below the PhD candidate has complied with the educational requirements set by the C.T. de Wit Graduate School for Production Ecology and Resource Conservation (PE&RC) which comprises of a minimum total of 32 ECTS (= 22 weeks of activities)

Review of Literature (4.2 ECTS)

- Debated issues in natural resource management: the link between drought and degradation (2004)

Writing of Project Proposal (7 ECTS)

- Bridging positivist and hermeneutic epistemologies on drought in Ethiopia and Tanzania (2004)
- Exploring intertwined drought-degradation perceptions in Burkina Faso (2004)

Laboratory Training and Working Visits (0.3 ECTS)

- Soil moisture measurements and soil sampling; ESW (2005)

Post-Graduate Courses (10.8 ECTS)

- Complex dynamics in and between eco and social systems; Studium Generale/CERES (2004)
- Quantitative research methods; Mansholt (2006)
- Basic and advanced statistics; PE&RC (2006/2007)
- Ethical dilemma's for social scientists; Mansholt (2007)

Deficiency, Refresh, Brush-up Courses (1.4 ECTS)

- Use of Geo-information and remote sensing; ITC (2007)

Competence Strengthening / Skills Courses (5.4 ECTS)

- *Time planning and project management; DLV Academy (2004)*
- PhD Competence test; PE&RC (2005)
- Scientific publishing; WGS (2005)
- Techniques for writing and presenting a scientific paper; WGS (2007)
- Scientific writing; CENTA (2007)
- Career perspectives; WGS (2007)

Discussion Groups / Local Seminars and Other Scientific Meetings (5.5 ECTS)

- *Sustainable land use and resource management; PE&RC (2004/2005)*
- *Stakeholder participation in scientific research; PE&RC (2007/2008)*
- *Coordination field study in Burkina Faso on : "exploring intertwined drought-degradation perceptions in Burkina Faso"(2004)*
- *Interactive seminar: win-win solutions, myth or reality?; IAC (2005)*
- *One-day Multi-stakeholder platform (MSP) Tanzania: organization and participation (2006)*

PE&RC Annual Meetings, Seminars and the PE&RC Weekend (0.9 ECTS)

- 10-years PE&RC anniversary (2005)
- PE&RC annual meeting: "the scientific agenda: who is pulling the strings?"(2006)
- PE&RC annual meeting: "is our civilization able to stand the test of time? "(2007)

International Symposia, Workshops and Conferences (3.4ECTS)

- ASA/CSSA/SSSA International annual meeting New Orleans; poster presentation (2007)
- Landscape dynamics and environmental change workshop in Uppsala; oral presentation (2008)

Curriculum vitae

Monique Slegers was born on the 10th of December 1975 in Bakel, a village in the south-eastern part of the Netherlands. After finishing her secondary school in 1994, she continued her education at the Fontys Hogescholen in Tilburg where she studied Geography. After the first general year, she continued with a free degree course on "Development Issues". In 1997, Monique went to Morocco for a four-week period filled with field excursions and a two-week practical period in which she studied a local water and sanitation project in a village in the High Atlas Mountains. In 1998, she went to Zambia for four months to perform a field study on "The cattle in trust" project, a joint project by Africare and HPI International. She received her BSc degree early 1999. By that time she had already started her studies at Wageningen University, where she studied "Rural Development Sociology". In 2000, she performed a two-week study on the social and cultural value, and the economic importance of peat for a local community in County Donegal, Ireland. She was interested in natural resources management and followed several courses from the Erosion and Soil & Water Conservation (ESW) Group at Wageningen University. Monique performed her MSc thesis research in Ethiopia under the supervision of Sociology's Law and Governance Group and the ESW Group. It dealt with farmers' feelings of land tenure security in relation to their investments in SWC. After her graduation in 2001, she worked as a librarian at an accounting firm. In 2003, she joined the ESW Group as a Junior Researcher and wrote her PhD research proposal She commenced her PhD in April 2004. That same year, she got financial support through the Desertification, Drought, Poverty and Agriculture (DDPA) Challenge Programme from ICARDA/ICRISAT and partners to perform a short field study in Burkina Faso on drought perceptions of local farmers and natural resource management institutions. She worked together with her former colleague Robert Zougmoré and with prof. Stroosnijder. For her PhD fieldwork, she spent one-and-a-half years in Tanzania and Ethiopia. In 2006, Monique organized a multi-stakeholder seminar in cooperation with Sokoine University of Agriculture in Tanzania to bring together stakeholders in the drought problem from different levels and disciplines for mutual learning and face-to-face discussions. She presented preliminary results of the field study and was chief-editor for the seminar proceedings. This thesis is the final outcome of her PhD research.

Since October 2008, Monique is working at the Programme Office of the research programme "Knowledge for Climate" ("Kennis voor Klimaat"), where she is working as project coordinator. She can be contacted at: slegersmfw@gmail.com