CHAPTER 2

Literature Review

This chapter will review some literature about drought and its impact on crop production. It also review the farmer perception, adaptation as well as factors impact on farmers' adaptation to drought in farming activities, especially, in maize production and other food crops which mentioned in previous researches.

2.1 Definition of drought

Drought is a phenomenon of climate. It occurs almost everywhere but its features are different between regions. According to Bui Duc Tinh (2006), there are two types of drought definitions, namely a conceptual definition and an operational definition. The conceptual definition, held in general terms, makes it easier to understand the drought concept and is essential to establish drought policies. The operational one helps people understanding more details of the drought itself, such as duration, frequency, and severity of droughts in various time scales. Whilst, Eriyagama *et al.* (2009) assumed that drought can be generally defined as a temporary meteorological event, which stems from a deficiency of precipitation over an extended period of time compared to some long-term average conditions. Drought always starts with a shortage of precipitation (compared to normal or average amounts), but may (or may not, depending on how long and severe it is) affect streams, soil moisture, groundwater, etc. It is a recurring natural event and a normal part of the climate of all world regions, regardless of how arid or humid they are.

Drought is a normal, recurrent feature of climate, although it is erroneously considered as a rare and random event. It differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate (Monacelli, 2005). Drought occurs over most parts of the world, even in wet and humid regions. This is because drought is defined as a drought relative to its local normal condition (Sun *et*

al., 2006). The deficiency of precipitation over an extended period time, usually a season or more is also called drought. Therefore, drought is considered as unbalance between precipitation and evapotranspiration in a particular area in a period. It is also related to the timing, as delays in the start of the rainy season and the effectiveness of the rains, such as precipitation intensity or number of precipitation events (Le Thi Hong Phuong, 2011).

Table 2.1 Selected general definitions of a drought

Ben-Zvi (1987)	Drought is a severe shortage in the appearance of natural waters with respect to normal
Beran and Rodier (1985)	The chief characteristic of a drought is a decrease of water availability in a particular period and over a particular area
McMahon and Arenas (1982)	Drought is a period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance and carries connotations of a moisture deficiency with respect to man's usage of water.
Takeuchi (1974)	Drought is a condition whenever the amount of water which has been expected and relied upon for use in any of man's activities cannot be met for some reason.
Palmer (1965)	Drought is an interval of time, generally of the order of months or years in duration, during which the actual moisture supply at a given place rather consistently falls short of the climatically expected or climatically appropriate moisture supply.

According to technical aspects, drought is the decrease of water availability, which might qualify when precipitation falls below about 80% of the average availability of the preceding 30 (or more) years. According to farmers, drought is changes in precipitation patterns, so lack of sufficient water or of sufficient precipitation for paddy cultivation is regarded as drought (Shaw, 2008).

In short, there are a lot of different definitions about drought, its definitions vary not

only from the exposure regions but also from the view of experts and researchers. Table 2.1 shows some selected general definitions according to Smakhtin and Schipper (2006). From the literature as well as basing on the expression of the climatic conditions in the study area, the drought definition will be applied in my research is understood as high temperature and lack of rain for a long time combined with strong wind which occur at least 90 days per year in the specific area.

2.2 Drought classification

Wilhite and Glantz (1985) categorized the definitions in terms of four basic approaches to measuring drought: meteorological, hydrological, agricultural, and socio-economic.

Meteorological drought

Meteorological drought is defined usually on the basis of the degree of dryness (in comparison to some "normal" or "average" amount) and the duration of the dry period. Definitions of meteorological drought must be considered as region specific since the atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region because the atmospheric condition causing precipitation deficit varies significantly from region to region.

Agricultural drought

Agricultural drought is expressed by the lack of soil moisture over a certain period of time for a particular crop. This indicates the consequences of a meteorological drought (i.e. lack of precipitation) for a specific crop. The water demand of a crop depends on the prevailing weather conditions, biological characteristics of the specific plant, its growth stage, and the physical and biological properties of the soil. Therefore, a good agricultural drought definition should account for the variable susceptibility of crops during their different development stages, for instance the moisture deficit in the topsoil at planting may decrease plant populations per hectare and reduce the final yield.

Hydrological drought

Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (i.e., stream-flow, reservoir

and lake levels, groundwater). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system. Hydrological droughts are usually out of phase with or lag the occurrence of meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, stream-flow, and groundwater and reservoir levels.

Socio-economic drought

Socio-economic definitions of drought associate the supply and demand of some economic good with elements of meteorological, hydrological, and agricultural drought. It differs from the aforementioned types of drought because its occurrence depends on the time and space processes of supply and demand to identify or classify droughts. The supply of many economic goods, such as water, forage, food grains, fish, and hydroelectric power, depends on weather. Because of the natural variability of climate, water supply is ample in some years but unable to meet human and environmental needs in other years. Socio-economic drought occurs when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply.

This research will not separate or focus on any specific drought term as mentioned above. View on drought in this research is the synthesis of characteristics of the above drought terms.

2.3 The impact of drought on crop production

Drought is perceived as the most significant environmental stress in agriculture worldwide, and improving yield under drought is therefore a major goal of plant breeding (Cattivelli *et al.*, 2008). In fact, drought is one of the most complex natural hazards, affecting natural resources and human development recurrently. Drought affects agricultural production globally, triggering significant food and health insecurity and habitat loss through land degradation and desertification (Smakhtin and Schipper, 2006). The specific researches of Wilhelmi (2002), Luers (2003), Barron (2004), Arian (2011), etc. also proved that drought has strong impact on the productivity of crops. This phenomenon was indirectly increases the input costs for farmers by using more fertilizer, investing the irrigation systems, etc.

Extended drought and rainfall deficits cause damage to crops and pasture. Crop failures and pasture losses are the two primary drivers of the direct economic impacts of drought in the agricultural sector. Production losses brought on by drought cause negative supply shocks and alter the market for agricultural products. On crop farms, a substantial portion of the costs of producing the crop have been experienced before the drought event (Kemper *et al.*, 2012). Drought often creates economic and financial difficulties for agricultural producers. Drought that persists for several years can create substantial and devastating agronomic difficulties and genuine economic hardship for agricultural producers and agriculturally-based businesses in rural communities. Agricultural producers experience crop production losses and concomitant losses in revenues from crop sales (Johnson and Smith, 2003).

Maize is the world's third most important cereal crop (after rice and wheat) and it requires adequate water in all stages of its physiological development to attain optimum productivity. But like other cereal crops, there are critical points in its growth stages where lack of soil moisture greatly impacts grain production and yield. Significant yield losses in maize from drought are expected to increase with global climate change as temperatures rise and rainfall distribution changes in key traditional production areas. These trends, coupled with an expansion of cropping into marginal production areas, are generating increasingly drought-prone maize production environments (Campos *et al.*, 2004). In fact, maize is often grown in less-favored areas because better land is reserved for higher-value crops. Where farmers know that drought is highly probable, they will usually not risk capital losses by applying fertilizer, even if it is available. Thus, these stresses often occur together in the tropics (Edmeades, 1996).

According to Heisey and Edmeades (1999), drought stress is one of the two physical factors most responsible for limiting maize production in developing countries; soil infertility is the other. Annual drought losses in the early 1990s across non-temperate maize areas totaled about 19 million tons, representing a 15% reduction in production. Losses can be far more extreme: a devastating drought in southern Africa in 1991-1992 reduced maize production by about 60%. Zhang Liquan (2004) in a study of risk assessment of drought disaster in the maize-growing region of Songliao Plain, China assumed that, the sown area affected by drought accounts for 60% of the total area

affected by agro-meteorological hazards, resulting in a serious loss of maize production. And drought has a tendency to occur often, and its degrees of damage on maize production have increased recently with global warming.

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. (Douglas and Wildavsky, 1982). It is not possible to avoid droughts, but their adverse impacts can be avoided or mitigated, perhaps even more effectively than the impacts of other natural hazards (Smakhtin and Schipper, 2006). And awareness seems to be necessary to cope with these phenomena.

2.4 Perception on drought

As noted by Golledge (1981, cited by Taylor *et al.* 1988), the term "perception" is sometimes used where "cognition" might be more appropriate. Perception refers to a range of judgments, belief s 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.

Awareness about drought can help farmers avoiding risks. According to Kandasamy (2012), knowledge of the distribution of droughts during the monsoon period is essential for successful rain-fed farming. It is also important to know the chances of occurrence of droughts during the critical stages of the crops for deciding the sowing date, cropping pattern and planning for protective irrigation and intercultural operations.

Taylor *et al.* (1988) in researches of drought perception in the Ogallala Quifer region have specifically depicted how four coherent elements shape drought perception (Figure 2.1).

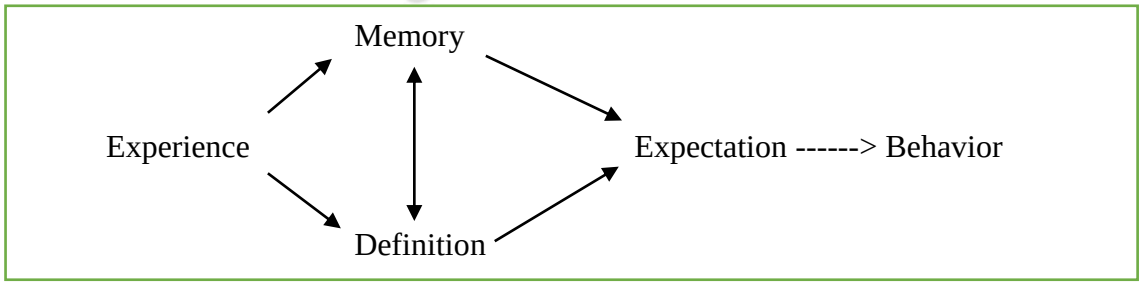

Figure 2.1 Element of drought perception (Taylor *et al.*, 1998)

Experience as assessed by Slegers *et al*. is an important factor influencing an

individual's perception of drought. Tayler *et al.* (1998) confirmed that droughts experienced indirectly, such as through oral, written, or pictorial accounts, may have had an influence on perception. Whilst, the second element "drought memory" consists of those drought events that were part of the farmers' direct experiences and could be recalled (Taylor *et al.*, 1998). Drought memory indicates ability of people in memorizing the drought events which occurring in the past, such as the most severe drought years and its impact on production and human living. The memory of people reflects their concerning as well as understanding about this climate phenomenon. The third element "drought definition" shows ability of people in realizing the popular characteristics of drought. According to Taylor *et al.* (1998), a drought definition is a set of criteria, usually moisture shortage, for classifying a time period as a "drought" and is no generally accepted definition of drought-it means different things to different people. With the final element, he indicated that farmers' expectations of future droughts included how often they expected droughts to occur and how severe they expected them to be. They also included expectations about the impacts of droughts, such as whether the effects of future droughts could be overcome.

Regarding drought elements, Slegers *et al.* (2008) indicated that experience, memory, definition and expectation have close relationships with each other and directly impact on people behavior. 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 and the way drought is defined, influence an individual's expectation of future droughts and one's behavior.

Attitudes towards risk depend on individual personalities. Kates (1971, cited by Taylor *et al.* 1988) 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 (Douglas and Wildavsky, 1982).

The fact that, farmer's experience, perception, and behavior have been inter-linked during twentieth century drought and have been described elsewhere (Saarinen l966, Taylor *et al.* 1988). However, according to Sleders (2008), the objective to reduce agricultural drought as well drought vulnerability is a challenging one. 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.

2. 5 Farmers' adaptation in agricultural and maize production

According to Smith and Wandel (2006), numerous definitions of adaptation are found in climate change or climate hazard literature, mostly variations on a common theme. Adaptation, whether analyzed for purposes of assessment or practice, is intimately associated with the concepts of vulnerability and adaptive capacity. Adaptations are manifestations of adaptive capacity, and they represent ways of reducing vulnerability. Adaptive capacity is the ability of a farmer to influence his vulnerability through adaptation. Adaptation is the action taken by a farmer to moderate the impacts of future droughts or to better cope with the consequences (Adger, 2006).

Adaptations vary not only with respect to their climatic stimuli but also with respect to other, non-climate conditions, sometimes called intervening conditions, which serve to influence the sensitivity of systems and the nature of their adjustments. For example, a series of droughts may have similar impacts on crop yields in two regions, but differing economic and institutional arrangements in the two regions may well result in quite different impacts on farmers and hence in quite different adaptive responses, both in the short and long terms. (Smit *et al.*, 2000, cited by Olmos 2001).

However, according to IPCC (2007), various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation. Firstly, anticipatory adaptation, according to IPCC, is an adaptation that takes place before impacts of climate change or climate hazard are observed. It also referred to as proactive adaptation. Next, autonomous adaptation is an adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems, also referred to as spontaneous adaptation. Whilst, planned adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

On a similar point, Klein *et al.* (2003) divided adaptation to climate change or changing in climate phenomena into two types (anticipatory and reactive), and he separated the way that different objects apply these adaptation type by giving examples as showed in Table 2.2.

Table 2.2 Adaptation classified by Klein *et al* (2003).

		Anticipatory	**Reactive**
Natural systems			- Changes in length of growing season - Changes in ecosystem composition - Wetland migration
Human systems	**Private**	- Purchase of insurance - Construction of house on stilts - Redesign of oil-rigs	- Changes in farm practices - Changes in insurance premiums - Purchase of air-conditioning
	Public	- Early-warning systems - New building codes, design standards - Incentives for relocation	- Compensatory payments, subsidies - Enforcement of building codes - Beach nourishment

Obviously, by this classification, autonomous and planned adaptation largely correspond with private and public adaptation although Klein did not mention about these kind of adaptations.

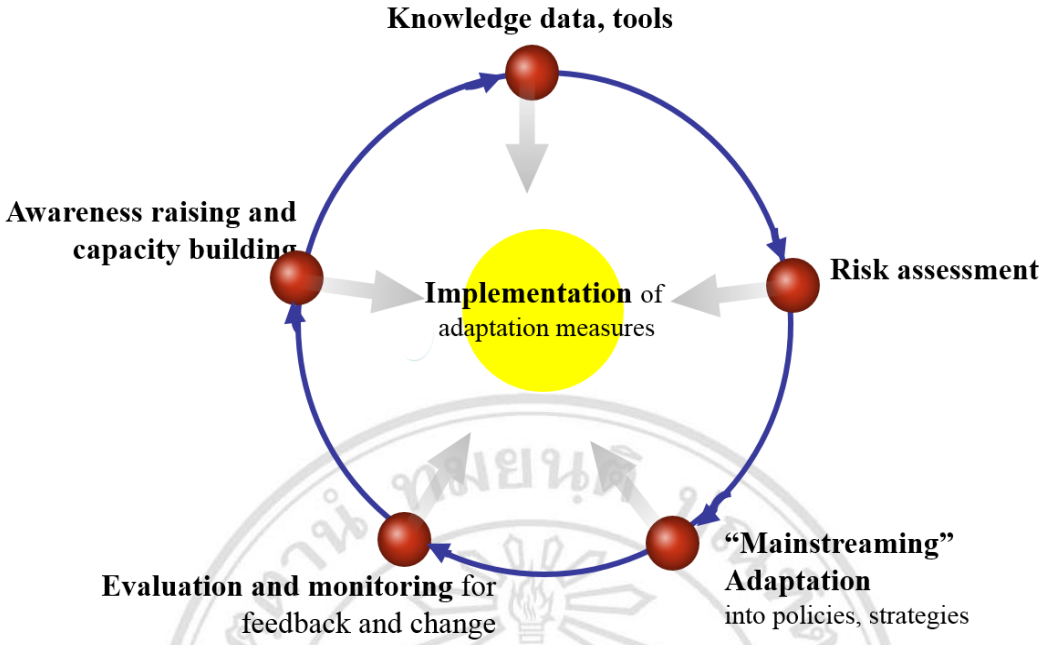

Figure 2.2 Adaptation as a process (IPCC, 2007).

Nowadays, climate change as well as its variability is known widely and almost countries over the world is considering it as a big problem, planned adaptation is playing an important role in coping process. This adaptation usually refers to specific measures or actions, it can also be viewed as a dynamic process that evolves over time. In "Climate Change Fourth Assessment Report", IPCC (2007) showed that, planned adaptation involves five major pre-conditions for encouraging implementation (Figure 2.2).

These conditions are created by managers or planners who have charge in building farmer's capacity to cope with climate change or its consequences (drought, flood, etc.). They start by providing knowledge, data and tools for farmers that can help farmers aware the variability of climate and severe climate phenomena created by climate change. Then, they fulfill risk assessments and mainstreaming adaptation (plans, policies and strategies) before evaluating and monitoring for feedback and change. Awareness raising and capacity building is the last step which contributes to enhance the implementation of adaptation measure. The cycle will be repeated again until they can bring good adaptation measures to farmers to cope with climate change and uncertain risks under climate variability.

However, according to Klein (2001), the limited theoretical and practical understanding of adaptation to climate change and its consequences, combined with the considerable

uncertainties that remain concerning the location and magnitude of impacts, threatens to be an impediment to adaptation investment. Adaptation is intricately linked with non-climatic developments and takes place in a dynamic societal context, in which many different actors pursue many different interests. The identification of optimal and appropriate adaptation strategies, in part based on the balancing of their costs and benefits, is therefore fraught with difficulties. Thus, adaptation to climate change as well as its consequence such as severe drought, floods, cool spells, etc., is a complex process under the impact of many factors.

2.6 Factors impact on adaptation

Regarding factors impact on adaptation abilities of farmers, most of results are mainly found in climate change researches. Generally, the household characteristics considered to have differential impacts on adaptation decisions are: age, education level and gender of the head of the household, family size, years of faming experience, and wealth (Gbetibouo, 2009). A cording to Kuruppu and Liverman (2011 cited by Duinen, 2011), a farmer's adaptive capacity depends on the available resources and the ability to use the resources effectively in the pursuit of adaptation, for example the use of financial resources. Besides socio-economic and institutional factors, adaptive capacity also depends on psychological processes such as risk perception and efficacy beliefs. Farmers are utilizing their own experiences, resources and ascribed information from their own level and also from the organizational level to cope with drought (Habiba *et al.*, 2012).

Uddin *et al.* (2014) in a research of climate change adaptation in Bangladesh stated that age, education, family size, farm size, family income, and involvement in cooperatives were significantly related to self-reported adaptation. Whilst, Benedicta *et al.* (2010) in the same research topic in Ghana indicated that essess to credit and extension service helped farmerers more likely adapting to climate change.

Anyoha *et al.* (2013) in a research related to socio-economic factors influencing on crop farmers' adaptation to climate change concluded that farm size, farming experience, household size, and social organization were the main factors significantly impacted on crop farmers' adaptation.

Among the factors affecting the ability to adapt to climate change as well drought are found, perception is always considered as one of the factors that has significant influence. According to Park (1999) an individual builds up an understanding of the environment that is closest to him and makes decisions about how to respond and behave there in based on this understanding, previous experiences and his memory. 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, cited by Slegers, 2008).

Additionally, farmers have made significant changes to their farming practices due to changes in the agro-climatic factors (Terra *et al.*, 2012), depending on the perception and awareness, farmers make certain changes on their livelihood patterns that occur through climate change and drought (Umma, 2012). The main point is that from whatever level these adaptation measures are taken, the adaptation and coping measures depend on households' perceptions of extreme events and the problems associated with them (Chipo, 2012). Indisputably, once, the farmers are fully aware of climate hazards, they will be easier in making production decisions which minimize the risk and have good adaptation strategies. However, recent research suggests that information from personal experience and information from external description can yield drastically different choice behavior under conditions of risk or uncertainty (Hansen, 2004).

2.7 Use of Multinomial Logit model in other related studies.

The Multinomial Logit model (MNL) model used in generally effective where the response variable is composed of more than two levels or categories. The basic concept was generalized from binary logistic regression (El-Habil, 2012). The advantage of the MNL is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories (Deressa *et al.*, 2009). This method were used to analyze the factors impact on crop planting adaptation measures to cope with negative impacts of climate change in Ethiopia (Deressa *et al.*, 2009), South Africa (Gbetibouo, 2009), Nigeria (Fatuase and Ajibefun, 2011; Obayleu *et al.*, 2014), Tanzania (Komba and

Muchapondwa, 2012). Results from these studies are highly aggregated and the parameter estimates have little importance in identifying country specific impacts and adaptation methods given the heterogeneity of countries included. We cannot homogeneous awareness and adaptability then building the adaptive strategies among research areas because the awareness and adaptive capacity of farmers to drought are different depending on specific condition. Therefore, study for perception and adaptation in particular region has an important implication to develop suitable adaptive strategies for that area in the future.