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Agricultural Land Conversion: Reviewing Drought Impacts and Coping Strategies

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Reviewing Drought Impacts and Coping Strategies

ABSTRACT

This paper aims to review the impacts of drought on agricultural land conversion (ALC) on the one hand and the impacts of ALC on intensifying drought on the other. The paper further investigates coping strategies at three levels; i.e., micro (local), meso (national), and macro (international), in order to mitigate drought impacts that are classified as economic, social, and environmental. This paper shows that ALC, drought and coping strategies are in a reciprocal relationship and can have either a positive or negative influence on each other. The paper concludes that the complex and multidimensional nature of drought requires the development of an integrated approach that focuses on the governments' collaboration with different stakeholders. Such an integrated approach can improve drought risk management implementations, decrease vulnerability and construct resilience and coping capacity at all levels in order to deal with droughts.

KEYWORDS: land use change; human environment; coping and mitigation policies; vulnerability; adaptation.

INTRODUCTION

Many researchers have paid attention to the conversion that happens from agricultural to urban uses (Azadi *et al.*, 2012; Dewan *et al.*, 2012; Teshome, 2014; Thuo, 2014). However, concerns about the possible impacts of climatic variability on agriculture have considerably changed research interests over the last decade (Aydinalp & Cresser, 2008). There is a large economic bulk of literature concerning climate change impacts on agriculture (for example Adams, 1989; Deschênes & Greenstone, 2007). However, as Féres *et al.* (2010) states, little effort has been devoted to studying climate change impacts on ALC. They assessed the impacts of climate change on land use changes in Brazil and found that farmers may convert farmland to pasture in areas where farming is not beneficial due to climate change. Drought is a gradual consequence of climate change (Zarafshani *et al.*, 2012) and can adversely affect the agricultural sector, leading to drastic ALC. For instance, climate incidents, including freezes and droughts, have negatively influenced the agricultural sector in the US and as a result, land use conversion has occurred in this country (Spreen *et al.*, 2006).

Agricultural land conversion (ALC), by which land is converted from agricultural to urban uses, is occurring at an intensive level all over the world with much higher rates in emerging economies (Azadi *et al.*, 2012). According to Wood *et al.* (2004), among other socio-economic drivers, population growth has played a crucial role in ALC. According to the UN's (2015) report, in the last century, the world population has tripled and it is expected to rise from the present 7.3 billion to an estimated 9.7 billion by 2050 and 11.2 billion by 2100. As the world population increases, more arable land needs to be converted for urban uses. Recently, the conversion of productive land into urban areas has been a crucial obstacle to world food production (Khan *et al.*, 2008). For example, in Indonesia around one million hectares of arable lands in the last five years have changed into urban areas in order to meet the increasing

demands of industrial and infrastructural development (Halim *et al.*, 2007). Bio-physical drivers of ALC, on the other hand, comprise a wide range of factors, including topography, soil types, fertility, water scarcity and climate change (Rey Benaya *et al.*, 2007). Among others, climate change is considered to have a substantial effect on the living conditions of the rural poor, especially in developing countries. For instance, in India, about 2% of farmlands were influenced by salinity, which decreased crop rice yields by 22% (Nkonya *et al.*, 2011). In its fourth assessment report, the Intergovernmental Panel on Climate Change (IPCC) cited that agricultural production in many African countries will be considerably influenced by climate change (Mbilinyi *et al.*, 2013). This is in line with the study of Washington *et al.* (2006) and Rudi *et al.* (2012), who showed that in sub-Saharan Africa, it is hard to tackle climate changes. They found that poverty and underdevelopment is more likely to happen in this continent, which is frequently exposed to droughts, floods, high temperatures and land degradation. All these issues may pose more pressure to rural households who need to take ALC as a solution.

Climate change has been confirmed as a serious bio-physical driver of ALC and a main factor for agricultural production (Mbilinyi *et al.*, 2013). This driver is the cause of different impacts on agricultural systems, like losses in crop yields and livestock production, input supplies, soil and water resources (Mbilinyi *et al.*, 2013; Le, 2013). According to the Peterson Institute, agricultural production in developing countries may decrease between 10% to 25% by 2080. It is noticeable that there will be 40% reduction in agricultural capacity of India by 2080 if the issue of global warming is not addressed through mitigation plans (Hanjra & Qureshi, 2010).

Drought is a gradual consequence that can adversely and drastically affect the agricultural sector. In recent years, a concern has grown worldwide that droughts may be increasing both in frequency and severity given the changing climatic conditions. As per definition, the frequency and severity of drought is often defined on the basis of the degree of dryness and the duration of

the dry period (Monacelli *et al.* 2005). According to Barati *et al.* (2015), increasing the frequency of environmental hazards, such as droughts, and their intensity is one of the most significant impacts on ALC. Countries in East Asia, North America and Europe had all lost cultivated lands during their periods of economic development (de Mûelenaere *et al.*, 2014). As a result, cultivated lands have been converted to built-up areas that can intensify problems associated with drought. This reduces the volume of groundwater, causes low levels of water reserves in aquifers, and increases the extent and frequency of intensive floods, all of which lead to greater vulnerability of the area exposed to drought.

From a socio-economic perspective, the problems of drought, which may result in ALC, include health issues (Keshavarz *et al.*, 2013), negative effects on the quality of life (Pandey & Bhandari, 2009), loss of income, access to alternative income, huge workloads, issues related to educational access, and access to support (Alston & Kent, 2004). All these issues can be considered as influencing factors on farm families' decisions to leave farming. A good example of the social impacts of drought is reported in the Karnataka state of India, where the drought-stricken regions produced lower crop yields and, as a result, are now facing more poverty in the region. Due to the shrinkage of agricultural operations, the total loss in rural employment was estimated at 1,250 million man-days putting GDP under shrink to 3.1% and the total loss of agricultural income accounts for 3.9 billion during 2008. The annual revenue of households is dropped by half in drought years, which caused increased financial pressure on farm families that had to deal with questions of whether to leave the farm or change the use of their farmlands for more profit (Nagaraja *et al.*, 2010). Regarding health related problems, Dey *et al.* (2011) found that local population in the Kishoriganj and Badarganj regions of Bangladesh, could not access to ponds or other surface water due to dryness or unhygienic low levels of water, causing several health hazards. Dey *et al.* (2011) observed that only 5% of the farmers in Kishoreganj suffered

from diarrhea in normal years, while about 28% people suffered from this disease in a drought year, demonstrating the fact that the occurrence of diarrhea during extreme drought was considerably higher. The World Health Organization (2011) also identified that the impact of drought leads to water and food shortages and is likely to have a long-term environmental and health risks for the people. To deal with such impacts, many people will escape from a drought-stricken area in search for a new location with a better water supply, enough food, and a place that is far away from the diseases that exist in the region. All these may explicitly result in ALC, in which a farmland remains without being used by farming families.

Economically, drought brings about food and livelihood insecurity (Roncoli *et al.*, 2001; Habiba *et al.*, 2012). Overall, land degradation has caused a significant reduction (at 0.4% each year) in global productivity from irrigated and rain-fed crops and rangeland over the last three decades (Khan & Hanjra, 2009). Another substantial economic impact of drought as an extreme climate event is the way that it affects food prices. Drought was considered as one of the main causes of the global food price crisis in 2008, especially in some major food producing countries like the USA and several countries in Europe (Piesse & Thirtle, 2009). Intensive droughts and unreliability in regard to their long-term effects on soil productivity precipitate immutable changes in agricultural production and use agricultural lands in a sustainable manner.

With regard to environmental impacts, drought affects land degradation and biodiversity loss. Every year, around 8.5 million ha of rain-fed land and 1.5 million ha of irrigated lands are abandoned because of salinization (Hanjra & Qureshi, 2010). Water scarcity is also considered as an important environmental consequence of drought. Scarcity refers to the shortage of supply systems that may lead to restrictions on consumption (El Kharraz *et al.*, 2012). One good example, in this regard, can be found in Mexico, which has accepted to release an average of 350,000 acre-feet of water a year to Southern Texas under international agreements. However,

Mexico was unsuccessful in releasing that much water due to drought and as a result of this incapability, Texas farmers have lost approximately \$1 billion from the lack of water since 1992.

The potential effects of drought on agriculture has an important role in determining the capability of agricultural land (Dunn *et al.*, 2012; Ostwald & Chen, 2006). Moreover, since global warming is likely to raise the occurrence and severity of droughts in the future (Sheffield *et al.*, 2012) and given the important role played by agricultural lands in food security, local livelihood, economic development, poverty reduction, etc., there is a clear need to understand the relationships between drought and agricultural land use change as well as how their interactions could be aggravated by each other. Although some studies already discussed the various aspects and impacts of drought as an individual natural disaster and a global multifaceted phenomenon limited, there is no particular and comprehensive study that explicitly highlights drought impacts on ALC that is considerably important from the sustainability concept that includes environmental, social and economic points of view (El Kharraz *et al.*, 2012; Keshavarz *et al.*, 2013). To fill this niche, this study intends to investigate the various economic, environmental, and social impacts of drought on ALC, as well as the role of ALC on drought intensification. Understanding the relationships between drought and ALC is necessary in order to develop measures and coping strategies to mitigate the impacts of droughts on ALC and vice versa. Accordingly, the main goal of this study is to review and synthesize the effect of drought on ALC and vice versa to investigate different coping strategies at micro (local), meso (national) and macro (international) levels. This study contributes to the efforts being undertaken towards monitoring the impact of drought on ALC and would improve the policies associated with drought mitigation.

Accordingly, the next section includes a comprehensive discussion on how drought can affect ALC from environmental and socio-economic perspectives? Afterwards, various impacts

of ALC on drought have been identified. A review was done to see how farmers had been tackling the effects of drought by analyzing their coping mechanisms on three different scales (i.e., local, national and international), followed by proposing a conceptual framework that provided a guideline for drought mitigation programs in regions highly exposed to drought.

METHODOLOGY

This study has used several “inclusion” and “exclusion” criteria to review the effects of drought on ALC and vice versa to investigate different coping strategies. This was done through a comprehensive review of the process of collecting, appraising, and then synthesizing data from a large number of sources. A detailed state-of-the-art on ALC has been conducted. The following sections describe the impacts of droughts on ALC in detail.

RESULTS

Drought Impacts on Agricultural Land Conversion

Drought has been determined to be a time period in which a region is faced with an unusually dry climate, adequately extended due to the unavailability of precipitation and resulting in major hydrological problems that have the connotations of a moisture deficiency with respect to water use requirements (McMahon & Arenas, 1982). When a region is experiencing drought, its ecosystem services and, consequently, its economy becomes vulnerable. Among all, the agriculture sector is usually the most vulnerable sector affected by drought (Pandey & Bhandari, 2009). Drought plays an important role in determining the capability of agricultural land to be used in different ways (Dunn *et al.*, 2012; Ostwald & Chen, 2006). Agricultural area in total makes up to 37.72% of the world land area. From 2000-2013, the overall land use for agriculture reduced approximately 0.4% in the globe, with large regional differences (World Bank, 2017).

Due to drought and desertification each year 12 million hectares are lost (23 hectares/minute!), where 20 million tons of grain could have been grown.

Drought impacts on ALC can generally be classified as socio-economic and bio-physical impacts (Habiba *et al.*, 2012; Keshavarz *et al.*, 2013), all of which could directly or indirectly lead to ALC. From a social aspect, the impacts of drought include the way it jeopardizes health (Keshavarz *et al.*, 2013) and the quality of life (Pandey & Bhandari, 2009). Economically speaking, it threatens livelihood security (Roncoli *et al.*, 2001; Habiba *et al.*, 2012) and from an environmental aspect, it causes land degradation and biodiversity loss. Each of these impacts is further discussed in the following sections.

Socio-economic impacts

Drought is a contextual event which has an effect on the living quality of farm households, local livelihoods and societies (Kenny *et al.*, 2008). Social impacts involve public safety, health, conflicts between water users, reduced quality of life, and inequities in the distribution of impacts and disaster relief. All of these factors (directly or indirectly) influence farmers' decisions to engage in ALC (Kenny, 2008). Drought also poses many concerns for farmers on the urban margin. It decreases the availability of lands for food production, and particularly, the “critical mass” of cropland, that is essential for the local agricultural economies to be able to gain the least required revenue, falls dramatically.

As ALC intensifies due to droughts and consequently urban area development, conflicts between agricultural and nonagricultural land users become more drastic and this leads to new local regulations (Wu & Irwin, 2008). For instance, according to Udmale *et al.* (2014), access to water (that could be affected by the severity of droughts) is one of the sources of conflict in some of these areas. ALC will also affect land suitability which can bring conflicts over the use of land

especially in the context of droughts. Consequently, it is important to renegotiate the formal statutory regulations which can encourage optimal land use practices (Rudel & Meyfroidt, 2014). Consequently, the local agricultural economy may suffer as all agricultural related sectors decline or disappear. Nevertheless, there are some studies illustrating the point that changing agricultural lands into urban areas may provide a number of significant advantages to farmers as well. The study of Lopez *et al.* (1988) illustrates that farmers who produce vegetables are likely to sell their crops at higher prices in urban areas. Many farmers have demonstrated noticeable compatibility in changing their businesses to benefit from new economic opportunities in urban areas as they are demanded to produce more food in more populated regions. For example, since the last drought in 2000, rural households in Australia have significantly taken off-farm jobs in order to earn additional income (Alston & Kent, 2004), particularly women who engaged in such works in order to meet the family's financial needs and to pay for the education of their children (Alston & Kent, 2004; Stehlik *et al.*, 2000). Larson *et al.* (2001) found that majority of the revenue of the total U.S. farm production is gained from the counties with a high population density (Larson *et al.*, 2001; Wu & Irwin, 2008).

Another major impact of drought is that it may result in increased rates of farmers who flee the area, possibly as a part of temporal or permanent migration to regions with better paid job opportunities. In Australia, for example, 10% of household members moved away from the intensely drought-stricken areas over a 3-year period (2006-2008). This percentage was slightly higher (2%) than migrations from below- average rainfall areas. In a survey carried out by Mbilinyi *et al.* (2013), drought was mentioned as a major constraint in crop production and livestock keeping in Tanzania, as 79% of interviewees mentioned that the impact of drought was so intense that many animals died and many young people migrated to urban areas to look for jobs.

When drought occurs, there is an increase in farmers' workloads and at the same time their incomes decrease. According to Kenny *et al.* (2008), family life would greatly be affected by the adverse effects of drought, such as increasing family workloads and putting women under more pressure to engage in off-farm work. Alston and Kent (2004) conducted 120 interviews across three communities, and reported that 75% of women increased their workload on the farm during drought period and 50% of women had engaged in off-farm work in order to gain more income. To compensate for their loss, farmers decide to convert their agricultural land for non-agricultural use or sometimes, to migrate to other regions with higher land capacity.

Drought also results in poor rural health conditions. Anderson (2009) and Dean and Stain (2010) confirmed that the mental health of rural communities has been noticeably affected by prolonged droughts in Australia. This issue can influence women more drastically due to the fact that to some extent, they have a secondary place within the family (Boetto & McKinnon, 2013). As a result, they tend to ignore their own health in order to care of their family's health more (Alston, 2011; Alston & Kent, 2004). Men are also more likely to end up with dramatic mental health problems due to financial-related pressure, including depression and suicide as a result of drought events (Alston, 2011). Impairing the people's health mentally and physically, this could have detrimental effects on the community stability and cohesion as a whole, resulting in households that move in order to find another way of living.

On a global scale, Figure 1 shows the Socio-economic Drought Vulnerability Index (SDVI) developed by Eriyagama *et al.* (2009) which estimates the vulnerability level of each country with regard to socio-economic impacts of drought. According to the figure, the SDVI is typically higher across Asia and Africa considering the fact that many Asian and African countries have large agricultural economies. On the other hand, Australia, North and South America, and Europe illustrate a much lower SDVI. Many African countries (for instance

Ethiopia, Guinea-Bissau, and Niger), and some Asian countries (like Cambodia and Afghanistan) are the most vulnerable countries to drought while others (Hong Kong, Singapore and Macau) illustrate a much lower SDVI. Countries that economically rely on their agricultural sector are largely vulnerable to such negative societal effects. When agricultural yields are less stable due to drought and when the more complicated the economy of developed countries is, the more isolated the population is expected to be (Eriyagama *et al.*, 2009). However, focusing on the vulnerability of agriculture to drought is just one side of vulnerability. The other component is the vulnerability of farmers to the prolonged effect of worldwide food economy and the policy of business liberalization (Campbell *et al.*, 2011). Habiba *et al.* (2012) demonstrated that from the farmers' point of view, there are several unavoidable drought impacts by which farmers can more likely be affected. Such impacts include shortage of food, shortage of food and cattle feed, lack of jobs, and increasing the price of basic necessities.

[Figure 1 near here]

Apart from the social impacts of drought, there are also many different economic consequences that could lead to ALC. Many economic impacts of drought occur in agriculture and related sectors due to the reliance of these sectors on surface and groundwater reserves. With regard to drought, scarcity often has its roots in water shortages and in a time of drought, farmers regard water as a 'difficult resource to obtain', mainly because it is expensive and often exceeds their economic capacity to afford it (Campbell *et al.*, 2011). Also, during droughts, farmers must also irrigate the field, meaning that the costs to farmers increase significantly. Water scarcity, and therewith higher costs of water, can make farmers leave agriculture as their main profession and look for new jobs or change the use of their agricultural land, which could put food security at risk.

Severe droughts damage soil, lower productivity, reduce farming profits and accelerate permanent ALC to urban use. Its adverse impact on productivity and increased human poverty could be measured during periods of crop losses. Furthermore, the loss due to milder intensity drought, although not visible, should also be considered (Pandey & Bhandari, 2009). In For example, crop diversity dropped by 71% and productivity by over 50% in Afghanistan in the western provinces of the country over a five-year period of drought (2000-2004) (Bhattacharyya *et al.*, 2004). Another example of the economic effects of drought can be found in Australia, one of the most significant producers of food and a country with large amounts of arable lands, where drought has decreased agricultural and food production within the country significantly (Goesch *et al.*, 2007).

Drought not only had a direct negative impact on production capacity, but also its effect on the successive land conversions have adversely influenced whatever minor agriculture remained. The conversion often damages water-regulating services, like evapotranspiration and water retention, which can threaten food production systems (Azadi *et al.*, 2012). High levels of food insecurity are known as an economic result of drought (Roncoli *et al.*, 2001) that has resulted in major famines in various parts of Asia and Africa (Pandey & Bhandari, 2009). The reduction of products would then lead to a reduction of farmer's income and therefore livelihood vulnerability and therewith, migration and ALC occur. Therefore, drought not only causes agricultural losses for farmers but also reduces their income, job opportunities, inputs and investment in the agricultural sector (Habiba *et al.*, 2012). In Afghanistan, many households, and in particular the young and physically-able individuals, have migrated to cities, the capital (Kabul), and further into Iran and Pakistan due to both water shortages and the lack of job opportunities in the areas affected by the adverse consequences of drought (Bhattacharyya *et al.*,

2004). Accordingly, the abandonment of arable land due to declining productivity is an agricultural land use change that may be a result of drought and soil erosion.

Bakker *et al.* (2005) showed that some of the environmental impacts of drought (such as soil erosion) influence yield loss. Consequently, farmers decide to convert agricultural land in order to achieve higher yield production and income. The effect of farmers' declined income spreads beyond the local scale. The business of retailers and those who manufacture the products and inputs that farmers require would also decrease. This results in unemployment, additional risks to the credibility of financial organizations, capital pitfalls, and the financial loss of tax profit for local, regional, and national governments.

The reduction of supplies would then result in an increased cost for products such as food and energy. Drought has significantly influenced the poultry and egg prices in the US. Over a one-year period (2012-2013), poultry prices increased 5.5% and egg prices rose 6.9%. In the time of drought, many farmers may utilize a strategy that looks outward in order to provide income by migrating to distant places and, sometimes, never returning in time to resume their normal agricultural activities even when the drought is over (Pandey & Bhandari, 2009) and this can exacerbate ALC.

Bio-physical impacts

The bio-physical impacts of drought include damaged natural habitats, decreased soil productivity, lowered water resources, reduced water quality, increased pollution and destruction of landscape patterns, and more instances of wildfires (Keshavarz *et al.*, 2013; Lasanta *et al.*, 2015). While some of these effects last for a short time, other environmental effects can become permanent or may be strong enough to shift the agricultural arable land use to non-agricultural uses.

The decreased quality of landscape patterns, including large amount of soil erosion, may result in a more constant harm to biological productivity. Noticeable severe drought and water scarcity around the world increase the lands vulnerability to salinization and desertification (El Kharraz *et al.*, 2012). An increase in drought periods, therefore, reduces groundwater quantity and quality (for example, an estimated reduction in quantity and quality of freshwater by 50% for Syria and 15% for Lebanon respectively (El-Sadek, 2010).

Other such on-farm effects, such as damage to endangered native vegetation, can threaten ecosystem services that are important, both to the local farmers' livelihoods and, to the broader community. Drought reduces phytomass ground cover and the number of plants and therefore reduces the protection of the soil from erosion (Torres *et al.*, 2015). Thus, abiotic extremes (such as severe drought and high temperatures) are major reasons of global soil erosion and the loss of vegetation cover (Zhao *et al.*, 2008). Furthermore, wind erosion and dust storms tend to be more common during droughts. Drought can also cause weeds to expand more from one farm to another. The other major environmental impact of drought is that it decreases the flow of water courses, which can be considered as a pitfall to the health of river systems.

Land use change and drought are both key drivers of biodiversity loss (Chazal & Rounsevell, 2009). The degradation of landscape quality because of the drought, including increased soil erosion, may lead to a more permanent loss of biological productivity. Erosion reduces productivity on average by about 4% for each 10cm of soil lost (Vaezi & Bahrami, 2014). Significant yield losses related to soil erosion, for example in Greece, France, and Germany over a 30 year period, from 1970–2000 (Bakker *et al.*, 2005), demonstrates the fact that there is a relationship between erosion-induced yield losses and the decline in agricultural area, which is closely linked to land use change. For example, in Lesotho, a general decline in the productive capacity of the soil and the eventual abandonment of arable land due to soil

erosion has been observed. Soil erosion also decreases soil biodiversity while also making soils vulnerable to diseases (Bakker *et al.*, 2005). In a survey carried out by Mbilinyi *et al.* (2013) in Tanzania, farmers indicated that some common crops, such as cassava and bananas, are not cultivated anymore as a result of drought. A number of other effects of drought in Tanzania include reduced soil fertility and the rise of new diseases and pest problems. Such soil problems increase the vulnerability of farmland stocks, which are under a high risk of exposure to natural disasters, and cause cropland areas to be abandoned due to fertility losses or further farming limitations.

In short, the resulting impacts of drought are the consequence of interactions between a natural hazard (rainfall shortage) and human responses (Keshavarz *et al.*, 2013). In other words, bio-physical and socio-economic effects of droughts are considerably related to one another. Loss of natural resources due to the bio-physical impacts of drought produce negative socio-economic consequences and vice-versa. Such effects are predicted to significantly reduce the growing season's period and yield capacity, mainly along the fringes of semi-arid and arid areas (Mubaya *et al.*, 2010: 172). Consequently, it affects the livelihoods of small-scale farmers with regards to productivity, food safety and household income. Table 1 summarizes various drought impacts that can lead to ALC in different ways.

[Table 1 near here]

The Effects of Agricultural Land Conversion on Drought

According to Barati *et al.* (2015), drought is one of the most significant impacts of ALC. Studies show that urban sprawl increases the amount of water that goes to waste and leads to water shortages at an increased rate if the population were smaller and the area was less developed.

Thus, urbanization has resulted in water scarcity and can be an important driver in drought severity.

Feddema *et al.* (2005) show that land use/cover change has an initial climate impact at global scale. Wang *et al.* (2012) found that during the periods of 1980-1995 and 2000-2007, conversions from paddy fields, forested land, grassland and wetland to arable land (mainly drylands) significantly increased in China and resulted in a number of negative impacts on local ecosystem services. According to their study, during 1980-2007, the correlation analysis between the changes of drought-flood disasters and land-use pattern showed that the occurrence of drought-flood disasters was mainly affected by the changes of land-use patterns.

However, when arable lands change back to forest or grassland, it may decrease the amount of available cultivated land, but at the same time, it may positively affect cultivated land resources. The promotion of the ecological situation and the prevention of natural hazards, such as drought, resulted from the conversion of cropland to forest or grassland can noticeably improve the productivity of cultivated land resources. In other words, the probability of losing cultivated land can decrease through the conversion of cropland that may occur due to both land degradation and climatic extremes. According to a study by Otieno and Anya (2012) across the North and North-East of Africa, conversion of croplands to forest resulted in a considerable drop in surface albedo and an absolute rise in net radiation that, in the long term, possibly increases precipitation, and reduces surface temperature. Such trends in precipitation and temperature will decrease the possibility of drought events as well.

Land use patterns can also have a major impact on watershed hydrology, which is important to consider in situations of drought. ALC can lead to a water shortage, which is a driver of serious drought issues. Qiu *et al.* (2012) also tried to calculate how much land-use and climate change contributed to the drought events in North China and found that climate change is

not the only explanation for increased drought. They suggest that severe land-use change in this area over the past few decades has considerably affected drought severity. Findings confirmed the considerable amount of changes in land-use (34% bare, 25% grass, 20% farmland, 12% forest, 14 % shrub) that occurred since 1999 and this was mainly related to the critical 1999 national policy of “returning farmland and grazing land to forest and grassland”.

Precipitation and temperature changes that are a result of agricultural land conversion can also affect drought severity. Fall *et al.* (2009) investigated the relationship between sensitivity trends of surface temperature and land use/cover change across the adjacent states of the USA. They concluded that changing different land use/cover to agriculture significantly reduced the temperature level, while the over-encompassing changes of agricultural lands increased the temperature, which could increase the probability of drought occurring. Urbanization and desertification also had a remarkable relationship with increased warming, a potential driver of drought events. Furthermore, decreasing soil fertility, as a result of agricultural land conversion, can be considered as an influencing factor of a more severe drought situation (Bruun *et al.*, 2015). According to Ozalp *et al.* (2016), Turkey's forests have been continuously facing conversion into both agriculture and pasturelands, causing not only degradation and fragmentation of forested lands but also negative changes in soil properties.

Human socio-economic activity, like population growth and urbanization, could cause greenhouse gas emissions, which could break the terrestrial carbon cycle due to land degradation and the release of CO₂ into the environment and atmosphere would cause climate warming. Yet, further significant evidence is available that confirms agriculture’s contribution to climate change and that it has been affected by climatic variability. Through land conversion, agriculture plays an important role in greenhouse gas emissions, including carbon and nitrogen based emissions as well as methane, which has significant effects on global warming (Hazell & Wood,

2012). As a result, although much of the agricultural land use change is a result of human activity, some bio-physical drivers, such as climate extremes, could have a significantly indirect effect on ALC and vice versa. Long-term experimental studies have confirmed that organic carbon in soil is highly sensitive to land use changes in native ecosystems such as forest or grassland, to agricultural systems, and from agriculture to dryland, resulting in the loss of organic carbon (Beniston *et al.*, 2016). Utilizing soil management in order to increase soil organic carbon (SOC) levels can therefore increase the productivity and sustainability of agricultural systems (Cole *et al.*, 1997). As a result, significant changes in climate and land use cause SOC depletion, leading to a declining trend in productivity in addition to drought problems (Martin *et al.*, 2010). An improved understanding of these factors is beneficial when preventing further loss of organic carbon in these soils and drought problems.

Martin *et al.* (2010) evaluated the influence of climate and land use on the SOC in the Indian Himalayan region. The SOC storage in the soils of different landforms was estimated within a time period from 1978-2004. Rainfall and temperature data of the past 50 years were analyzed and it was found that rainfall has declined by 46% and that the maximum rainfall-receiving months shifted from June–July to August–September. The annual average air temperature also increased during this period. The decline in rainfall and the rise in diurnal temperatures (the range between the daily max and min temperature) caused glacial retreat in terms of areas with snow-cover by nearly 5%. The rise in the minimum average temperature by 1.6°C and average monthly temperature of 1.3°C, as well as the changes in land use, have significantly reduced soil organic carbon content in the soils of different landforms, which can contribute to drought event occurrence. The studies on the interactions between crops and climate reveal that the combination of important disturbances, like severe droughts and the changes that consequently appear in the conditions of soil and plant nutrients, is still one of the

major concerns when developing efficacious and pragmatic integrated systems associated with modeling ecological conditions and climate change (Adegoke *et al.*, 2007). Table 2 summarizes and synthesizes various impacts of ALC in drought.

[Table 2 near here]

Coping Strategies

The term ‘coping strategies’ is used to represent any action of the people, communities, and governments geared towards mitigating the impacts of an incident, here in our case, drought on farming systems. They are devised to buffer against short-term stresses and shocks within the farming systems and often exist alongside more long-term adaptive strategies (Campbell *et al.*, 2011), though coping and adaptive strategies can sometimes overlap (Smit & Wandel, 2006).

Drought coping strategies can either have a positive or negative influence on the ALC. Some of the strategies improve agricultural land conditions and prevent ALC (like changing irrigation systems which precludes soil degradation and erosion, therefore, ALC will not happen), and some intensify ALC (like migration, which occurs due to drought as well as decreased soil quality so that farmers have to leave their farms or convert them to urban or industrial uses). Spreading different coping strategies can result in a significant loss of potential gain. Anderson (1995) evaluated that risk incompatibility can result in an economic cost around 10% of the average revenue (Pandey & Bhandari, 2009). The damage relating to income reduction, the loss of assets as a result of drought events, and the unavailability of coping strategies can make households move into more remote areas in order to achieve better economic opportunities (Morduch, 1994).

Although, drought coping mechanisms are practicable at different levels, a gap still exists in the current literature concerning appraisal and coping at local, national and international

levels. If drought occurs at small spatial and temporal scales, it is possible to prevent its destructive effects by applying coping strategies at a local level. But at larger scales and a higher intensity, coping strategies must be investigated at national and international levels so that the destructive effects of drought decrease. Furthermore, people in adverse conditions develop strategies to cope; strategies which remain unnoticed and less studied. Without a proper understanding of coping strategies, policy makers are most likely to make stereotyped responses in both the preventive measures of vulnerability reduction and relief work. Misdirected relief efforts may undermine rather than assisting the affected communities in their attempts to help themselves towards recovery. Analyses of coping strategies at different levels identify good practices and gaps within the strategy, promote positive actions that are crucial when identifying the concept of vulnerability related to drought, and adjust the implementation of practicable mitigation and preparedness measures when coping with drought (Pandey & Bhandari, 2009). The following discusses three levels of drought coping strategies that include micro (local), meso (national) and macro (international) scales.

Micro (local) level

Drought coping mechanisms that are implemented by farmers at household level within the province, district, and state are considered as “micro level” strategies. The adverse effect of drought at a household level is substantial. Farmers and rural societies employ different mechanisms in order to tackle this extreme event. In addition to the drought coping strategies of farm households, the local community can play a role in preventing farmers from the adverse effects of ALC. Training farmers who use appropriate methods of drought coping strategies can decrease ALC within the local communities. The impacts of drought on families with various financial conditions are, however, different and assets of subsistence farmers are primarily

identified by their capacity to deal with or adjust to drought (Campbell *et al.*, 2011). Here, we briefly explain some of drought coping strategies and their effect on ALC at a local level.

Divesting profitable assets, like productive livestock, and swapping farmlands for food is a coping strategy which may change the form of farming systems. Intensification of resource use as a coping mechanism, such as soil nutrients and fertilizer, accompanied by the over using of water storages, decreases soil fertility and moisture, leading to the erosion of soil, decreased agricultural land quality, and ultimately intensifying ALC. Another mechanism is the consumption of seeds, which threatens food security when it produces food shortages and this leads to vulnerability. As a result, farmers try to source other means of income, such as selling or using their farm for different purposes, migrating to neighbouring regions, and starting another occupation, all of which makes agricultural land conversion occur.

Migration as a coping strategy to search for jobs that exists in less productive sectors could be another reason to sell agricultural land for non-agricultural uses, such as industrial or urban purposes. In severe drought events, farming families may leave their home and move to urbanized areas or even refugee centres. Gray and Bilsborrow (2013) found that droughts in Ecuador increased local and international migration but decreased internal migration, perhaps due to the relative poverty of most internal migrants. Migration can lead to permanent abandonment of agricultural lands by farmers, and eventually these lands are sold for other usages. This option can result in intense ALC. In extreme drought cases, different categories of farmers choose other options that they may have, such as borrowing money from relatives and neighbours or using money that they saved to buy water. This strategy helps enrich agricultural lands and prevents ALC (Campbell *et al.*, 2011). In a study on drought coping strategies in Bangladesh (2012), the majority (more than 90%) of farmers engage in activities in order to improve agricultural productivity. In this regard, for example, the traditional agronomic activities

that Habiba and Shaw (2014) faced in their case study in North-Western Bangladesh consisted of composting and maturing, seedbed procedure, tillage and shedding. These practices help improve soil quality, adding organic matter into the soil, holding rain water and distributing rain water uniformly into their fields during the rainy period.

As another coping strategy, agricultural diversification gives this opportunity to farmers in order to decrease the risk of harm through combining crops and diversities in the cropland, by alternative planting and by spreading crops in various soils, lands and areas, as well as through utilizing different methods of water preservation (Roncoli *et al.*, 2001). This strategy helps enrich agricultural lands and prevents ALC. Other strategies employed during a drought include thicker mulching (i.e., applying a second layer of guinea grass), spraying plants with leaf fertilizer, sharing water, and borrowing money to buy water (Campbell *et al.*, 2011).

Coping strategies over a drought period are centred on measures in order to supply or better retain soil moisture because, from the farmer's view, there is a remarkable reduction in the production capacity due to drought and crop yields are lower in drought years for almost all crops and all locations. Sometimes, farmers decide to change the irrigation system so that they can deal with the adverse effects of drought. In years of drought, farmers pump additional water into their fields to irrigate them. Although there may not be a large amount of yield loss as a result, the cost to farmers increases, however, if the costs are more than farmer's income, the farmlands might be at risk of being abandoned and ALC can occur. According to the study by Song and Liu (2016), although there was a net increase in farmland in China, the most suitable and productive farmland decreased by 1.8% while low-quality farmland increased by 1.4%. Thus, focusing solely on maintaining the total farmland area did not prevent the overall loss of a substantial amount of high-quality farmland. Farmland protection policies should therefore take into account both farmland quantity and quality.

The practice of rain water harvesting is another option that can help farmers use drinking water during a drought period (Habiba *et al.*, 2012). According to El-Kharraz *et al.* (2012), when drought occurs, some of the communities in the Middle East invent new technologies in order to enhance water management and provide water reliability where it is needed. Based on the study of Campbell *et al.* (2011), sharing water is an important coping strategy during a drought. Although all these methods increase the cost of farming systems, they prepare enough water for agricultural crops, thus, they prevent yield loss and ALC as there will be less of a water shortage or land degradation with appropriate usage of these methods and farmers can continue working. Therefore, there's no driving factor that lead to agricultural land conversion. Utilizing other ways of income is another drought coping strategy.

Regarding the relation between family income and economic losses, farmers may need an additional job. Habiba and Show (2014) mention that, in contrast, with agricultural adaptation measures, various categories of farmers undertake other jobs in order to earn the needed money, such as business, and other non- farming systems such as keeping livestock, dairy farm, poultry, cattle fattening, fish culture, making cow dung fuel, works with fixed regular payment, services and manufacturing occupations and the like. Using any of these ways of income generating as a replacement for agriculture would cause the farmlands to be abandoned, sold, or used for other purposes.

The above factors almost intensify ALC because, as already mentioned, ALC would be affected depending on whether the measures taken in response to drought have been successful or not. Therefore, with the lack of appropriate, safety oriented approaches and local financial strategies, rural families will not be capable of tackling droughts while still they are participating in sustainable economic practices. Although social assets assist farming households tackle drought conditions, it is barely related to the enhancement of their vulnerability level or quality

of living. Therefore, in order to prevent the expansion of ALC at higher levels, it is necessary to cope with the adverse effects of drought on farming systems at a national scale.

Meso (national) level

In general, a meso level mediates between the macro and micro levels. Following the work of Azadi and Filson (2009), who classified their analysis to micro, meso, and macro levels, in this study, the analyses are discussed at the household level within the province, district and state as a “micro level”, while “macro level” refers to international scales. Drought coping mechanisms that are implemented by formal institutions, governments and related authorities at national level are considered as “meso level” strategies. Farmers are not the only ones who suffer from droughts, but the retailers who provide goods and services to farmers must deal with reducing the business as well. This later leads to unemployment and loss of tax revenue for the government. Specifically, in relation to drought, there is a substantial need to improve the potential of business management within a comprehensive, as well as integrated framework of farm schematization (O’Meagher *et al.*, 1998). Jeopardizing the above factors may have the opposite effects and can influence agriculture and convert the farmland to alternate businesses.

Land tenure, land ownership and formal and informal institutional arrangements are the most influential factors that affect land use change and land use decision making. In this regard, Jawaharlal Nehru National Urban Renewal Mission (JNNURM), which seeks to encourage reforms and the rapid enhancement of planned development of India, clearly emphasizes the importance of undertaking reforms regarding the conversion of land from agricultural to non-agricultural processes. This program declares that lack of a structured plan and transparency in ALC, land evaluation, complexities in documentation and processes for holding/transferring clear titles, etc., all have only resulted in more limitations of land accessibility (Chatterjee,

2013). On the other hand, Lawry *et al.* (2014), in their review of qualitative literature on African agriculture, concluded that other factors such as small sizes of farmland, the importance of off-farm income to poor households and migration to urban areas, have a more important influence on ALC than tenure insecurity. Furthermore, governments may benefit from land conversion through increased budget revenue. Revenue increases result from changes in the tax system when agricultural tax is replaced by real estate tax (Wasilewski & Krukowsli, 2004). If the increases in taxes are higher than the farmer's income, there is a possibility that the farmer will leave the land or convert it into other uses.

The existence of a strong relationship between farmers can enhance the potential of adaption through innovating useful economic, emotional and management assistance. Such connections within these societies create a great opportunity for the government to actively engage in the enhancement, as well as the development, of agricultural regulations and rural plans (Campbell *et al.*, 2011). The importance of assets through economic and social capitals is also magnified during a drought. As a result, increased capacity to drought in these local areas focuses on the successful investment of public and private interests within the improvement of the "capitals and capabilities" of farmers (Campbell *et al.*, 2011). A strong institutional arrangement concerning land and interrelationships between different stakeholders, such as the government, agricultural extension services, researchers and farmers, facilitates the achievement of an effective adaptation policy toward drought (Habiba *et al.*, 2012). The primary result of drought is that those who are the poorest are impacted by it (Hazell & Wood, 2012) and the use of formal and informal credits would be a normal and regular coping mechanism in these rural areas (Pandey & Bhandari, 2009). Borrowing either cash or credit, may also occur. During drought, dependency on borrowing is likely to increase and within competitive credit markets, it does not have any negative consequences in regard to welfare. However, adverse economic and

social consequences can increase in regions where such markets are poorly developed and located in rural areas (Pandey & Bhandari, 2009).

Drawing on social networks and public programs is another national level coping strategy. Food aid assists households in surviving the impact of drought first, by presenting nutritional aid when there is no other food available, and second, by reducing the necessity for households to sell their assets in order to purchase food. There is a possibility that farmers spend the money on land modification and an improvement of agricultural methods, which in turn, prevents ALC due to one of their concerns regarding food supplement being assuaged. They might conceive of modifying the farmland instead of abandoning it in order to meet their food requirements. However, food aid alone is not enough to assist families' long-term recovery from natural disasters (Lentz & Barrett, 2013). Sadly, national assistance programs, including credits and food aid deliveries, are often poorly targeted resources and are late to arrive. Due to the limitations of the utility of these national-level coping strategies and deep-seated poverty, many rural households are not able to fully protect themselves against shocks, such as drought, and thus suffer significant reductions in well-being (Dercon, 2002; Kazianga & Udry, 2006).

Technological improvements and policy interventions are also able to assist rural areas cope with drought events. One of the main technological improvements is the adaptation of drought-tolerant crops. As well as promoting appropriate crop establishment methods through the public and private sectors, enhancing agronomic implementations that increase soil moisture levels and the development of suitable post-rain-season cropping systems are additional technological options that can assist farmers tackle problems caused by drought. However, there are major challenges associated with the national and local institutions capacity for researching and developing program implementation, especially in developing countries. For example, Pandey and Bhandari (2009) emphasized that there are no major Indian agencies that utilize

advanced analysis of drought impacts and its roots in all vulnerable zones. Establishing such research institutions and linking them with agencies that are actively engaged in drought management would promote overall drought management.

Therefore, there should be comprehensive policy interventions that would enhance the potential of farmers to better manage drought situations by utilizing more effective incomes, as well as consumption-smoothing measures. Improvements in rural infrastructure and marketing facilities, as well as the promotion of rural and agro-processing industries that provide farmers with a variety of sources to earn money, can have a major effect on decreasing the whole risk to income (Pandey & Bhandari, 2009). Sometimes, the impact of drought on farming systems and agricultural land use is so intense that its effects are observable on an international scale. Accordingly, there must be a number of coping mechanisms in order to deal with the impacts of drought on an international level.

Macro (international) level

According to Moran *et al.* (2006), drought has been a permanent international dilemma due to its significant effect on climate change, biodiversity, and greenhouse emissions which directly influence ALC. The effects of worldwide determinants are influencing agricultural policies across several countries in a similar way, and one of the relevant active factors includes an increasing recognition of climate change, and drought dynamics on a world wide scale (O’Meagher, 1998). There are many reasons that make the consideration of drought coping strategies crucial on international levels in terms of its effect on ALC. For example, in times of drought, recreational and tourism industries are seriously damaged because tourists do not want to travel to a country that is suffering from a severe water shortage. Shortages of certain goods result in the costly importation of necessary goods from outside of the affected area. Hence,

income decreases due to the drought, which may adversely affect the capability of a vulnerable country to conduct ALC prevention. Consequently, the more ALC increases in one country, the more it intensifies ALC in neighboring fields and regions surrounding it. Furthermore, the migration of farmers after drought, even to adjacent countries, which may also result in ALC, is considered an important reason for implementing drought coping strategies at a macro scale. In this regard, there are many active practitioners in drought at an international level.

Through the program “Emergency Relief and Rehabilitation”, the FAO cooperates with many stakeholders in order to identify food safety and family farm reactions. Moreover, programs conducted by Oxfam (Oxfam Emergency Response to Drought: East Africa Food Crisis) in Somaliland, Ethiopia and Kenya that respond to drought, are comprised of a combination of emergency aid, long-run deployment and prevention, and support to find the main cause(s) of severe drought. Providing food in exchange for work through “The World Food Programme: Food For Assets Program” makes it also possible for the poor and hungry to devote time and energy to take the first steps out of the poverty trap. This is the aim of WFP's food-for-assets programs. Drought risk management, comprising projects to tackle drought in Ethiopia, Zimbabwe, and Mozambique is another program that is conducted through the “United National Development Programme (UNDP)” at an international scale. Such collaboration among countries that have a long history of reducing the risks of drought and communicating with regional and international innovations can assist in the development of knowledge sharing in order to decrease adverse drought impacts. The above discussion demonstrates the fact that understanding the drivers that have led to ALC is useful to guide the appropriate targeting mechanisms to intervene with coping strategies for improvement (Ebanyat *et al.*, 2010).

Table 3 summarizes three levels of drought coping strategies that include micro (local), meso (national) and macro (international) scales.

[Table 3 near here]

DISCUSSION

As Figure 2 shows, ALC, drought, and coping strategies are in a reciprocal relationship and can have either a positive or negative influence on each other. This means that drought can impact ALC (Ostwald & Chen, 2006; Pandey & Bhandari, 2009; Dunn *et al.*, 2012; Keshavarz *et al.*, 2013; Udmale *et al.*, 2014) and in turn, be impacted by it as well (Fall *et al.*, 2009; Anya, 2012; Rudi *et al.*, 2012; de Mûelenaere *et al.*, 2014; Lasanta *et al.*, 2015; Bruun *et al.*, 2015). Also, the emergence of ALC and drought determines the use of coping strategies in order to reduce these phenomena at local, national, and international levels (Roncoli *et al.*, 2001; Wasilewski & Krukowsli, 2004; Pandey & Bhandari, 2009; Ebanyat *et al.*, 2010; Campbell *et al.*, 2011; Habiba *et al.*, 2012; Gray & Bilsborrow 2013). However, on the condition that the coping strategies, used by farmers and governments are inappropriate, ALC increases and drought in turn becomes more severe. Indeed, unsuitable coping strategies that are utilized by farmers may put their families under greater risk (Kenny *et al.*, 2008). Millions of poor people may become trapped deeper in poverty because of drought-induced income and assets losses which make the possibility of migration to more remote areas and result in farmland abandonment and ALC (Morduch, 1994). When farming households encounter subsistence and production losses in areas prone to high levels of vulnerability to climatic events such as drought, the socio-economic impacts may be much more significant due to the fact that majority of farming families live at basic livelihood assets (Roncoli *et al.*, 2001). The impacts would be even higher in the regions exposed to higher risk of drought and also in areas with the lack of availability of natural resources, where the total income loss may be less than areas with more natural resources. Moreover, according to farmers, an increase in irrigation frequency could be

another adverse effect of drought. Therefore, the farmers must use more water to irrigate the land and consequently, the cost incurred to farmers increases. Some of the farmers decide to abandon their land, migrate or sell their farm, and therefore, agricultural land use change occurs. This process may show the signs of indirect socio-economic impacts of drought on ALC, because food and livelihood security will not only affect the quality of life and increase farmers' vulnerability, but also put their health in danger.

[Figure 2 near here]

Considering the health aspects, the social impacts of drought can directly affect the health and quality of life and cause ALC. The consequences of drought usually appear in the agriculture sector, which then impacts farmer's lifestyle (Habiba *et al.*, 2012). However, production loss, which is often used as a measure of the cost of drought, is only a part, often a small part, of the overall economic cost. Severe droughts can result in starvation and the death of the affected population. Providing more resource for farmers to gain income via more improvements to rural infrastructure and marketing can play a significant role in decreasing the total income risk. Improvements to drought prediction and informing farmers about such forecasting can assist them to make efficient decisions regarding crop choices and input utilization (Abedullah & Pandey, 1998). Developing such institutional and policy interventions, accompanied by useful technologies, can have a great impact risk of income production. Even though, during the last decade, some progressions have been made and much remains to be explored in this regard (Pandey & Bhandari, 2009).

According to Figure. 2 there are different coping strategies at local, national, and international levels that are developed in order to deal with drought impacts on ALC and reversal effects. It is noticeable that all three levels intertwine with each other. This means that the strategies used by farmers in their farmland could make ALC either severe or weak, and could impact

731 governments' coping strategies at national or international levels. This means that the socio-
732 economic impacts of drought appear on a local scale, yet as the economy changes, it affects
733 regional and national scales alike (Figure. 2). In other words, not only impacting agriculture, but
734 drought effects other sectors like tourism, energy, health services, transportation, and ecosystem
735 services, mainly due to the water shortage problems that are a result of prolonged durations of
736 low levels of precipitation and extreme temperatures.

737 Although governments try to improve this situation by conducting different aid programs, there
738 is a lack of study on comprehensive understanding of drought features that can include the
739 vulnerability of farmlands and farming families at both local and national scales (Pandey &
740 Bhandari, 2009). Tackling drought only through traditionally accepted mechanisms, especially in
741 developing countries that lack funding and adapted policies, does not adequately mitigate the
742 increasing intensity of drought effects. This is mainly due to unknown effects of different coping
743 mechanisms, such as shifting subsistence patterns, migration, and the abandonment of farmlands
744 that all can result in ALC. These are usually caused by demolishing many traditions at a local
745 scale, especially when drought happens in shorter cycles. On the other hand, many aid programs
746 may cause more vulnerability to future droughts events by making households and communities
747 more reliant on government interventions or aid programs from charity organizations. Generally,
748 policies associated with drought management at regional and national scales are not suitable, and
749 in some cases, not feasible in many countries.

750 It is important to notice that complex and multidimensional nature of droughts requires the
751 development of an inclusive framework by understanding the different impacts of drought as
752 well as sharing various coping strategies developed worldwide, the capacity of communities to
753 cope with future drought events and afterward, decrease the social, economic and environmental
754 effects related to this universal climate extreme. One good example of such an integrated

management program is the “Integrated Drought Management Programme (IDMP)”, which was developed in cooperation with the World Meteorological Organization (WMO) and the Global Water Partnership (GWP) in March 2013, aimed at assisting stakeholders worldwide through developing policies and guides for better management practices. This is achieved by providing compatible scientific data and sharing the most successful implementations and findings on a global scale for managing drought in an integrated manner. A compatible approach for drought management and its forecasting and monitoring, should be developed by making connections and combining new programs and activities with those that are already available around the world. Arranging useful guides and instruments for developing perfect and suitable policies and management plans associated with droughts should be added to such integrated approaches so that different countries and regions around the world can take advantage of them. Some significant impacts of such an integrated approach, in both the short and long-term, can be as follows:

- Improved potential for developing increased assistance in international sectors in response to current drought events;
- Providing an opportunity for poverty reduction by developing prevention strategies for the drought-prone areas;
- Further stakeholder participation through drought management networks for the development of policy and practices;
- Increased coping capacity of countries in order to tackle droughts that are rapidly increasing in speed due to climate change, and powerful strategies for tackling local as well as trans boundary consequences of drought;

- 777 - Cooperating and developing drought management organizations at regional, national, and
778 global scales (by introducing related professionals and successful institutions) and
779 sharing knowledge and suitable practices.

780 Future studies should focus on the possibility of developing integrated approaches in
781 drought prone countries while considering various challenges and opportunities associated
782 with such frameworks. This study also revealed that although there are significant research
783 projects carried out on different impacts of drought on ALC, further investigation is crucial
784 to understand ‘how ALC can affect the intensification of drought’. All these may help create
785 a better understanding of the mutual impacts of drought and ALC that is necessary for the
786 future development of measurements and coping strategies to mitigate the impacts of
787 droughts. Also, depending on the level of perception and awareness toward the risk of
788 drought, farmers would make certain changes to their livelihood patterns in order to cope
789 with drought issues. Therefore, identifying farmers' responses and their rational and mental
790 process to drought can help develop suitable measures and better decision-making to
791 decrease the amount of harm in the agricultural sector.

792 **CONCLUSION**

794 As discussed in this paper, ALC is a process in which land is changed from agricultural to
795 urban uses and varies in different countries in terms of intensity, trend, and drivers. In this
796 study, we explored several socio-economic and bio-physical impacts of drought on ALC.
797 The study showed that the effects of drought on human societies are multifaceted and
798 mutual. Drought is perceived differently since it varies according to socio-economic class,
799 age, ethnicity, gender, and education, as these factors determine households' vulnerability.

It is important to notice that the different impacts of drought are increasing because of climate variability and the strategies for drought management are urgently needed, leading to enhanced coping potential. These strategies must be scientifically well-developed and designed based on risk management and the mitigation of drought impacts. To achieve such effective drought management approaches, there is a significant need for the theoretical context of drought effects to be better understood and for coping mechanisms to be utilized at different levels, especially in relation to the agriculture sector as the most vulnerable sector to ALC. In this regard, there are useful experiences that are part of undertaking comprehensive and practical methods in different sectors within all the three levels, including local, national, and international. For tackling with droughts such approaches need to be largely shared, and wherever necessary, the capacity to utilize such approaches needs to be built-up and adapted (WMO/GWP, 2011). Such an integrated approach focuses on the governments' collaboration with different stakeholders in order to improve drought risk management implementations, decrease vulnerability, and construct resilience and coping capacity at all the levels in order to deal with drought incidents.

The adverse effects climate change that demand more effective and feasible coping strategies for droughts mitigation management. The strategies must be well-developed and elaborated based on risk management factors. To develop such effective strategies, there is an urgent need for a better understanding of the theoretical context of drought effects and its coping mechanisms applied at different levels, especially in relation with the agriculture sector as the most vulnerable sector to drought. Such an integrated approach should focus on close collaboration between governments and different stakeholders in order to mitigate drought impacts on ALC and vice versa, and minimize farmers' vulnerability and enhance

the resilience of their farming systems through applying effective and feasible coping capacity at different levels.

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1079 **Table 1.** The effects of drought on ALC

Socio-economic impacts	Reference
Accelerate permanent ALC to urban use	Udmale <i>et al.</i> , 2014
Abandonment of farm land	Lopez <i>et al.</i> , 1988
Decline agricultural related sectors	Lopez <i>et al.</i> , 1988
Migrate	Kent, 2004; Mbilinyi <i>et al.</i> , 2013
Conflicts between agricultural and nonagricultural land	Wu & Irwin, 2008; Udmale <i>et al.</i> , 2014
New land regulations	Wu & Irwin, 2008
Increase in farmers' workloads	Kenny <i>et al.</i> , 2008
Reduces income and job opportunities	Kent, 2004
Poor rural health conditions	Anderson, 2009; Dean & Stain 2010
Increase costs to farm	Campbell <i>et al.</i> , 2011
Lower productivity	Bhattacharyya <i>et al.</i> , 2004
Decreases the availability of lands	Ostwald & Chen, 2006; Dunn <i>et al.</i> , 2012
Reduces investment in the agricultural sector	Lopez <i>et al.</i> , 1988; Habiba <i>et al.</i> , 2012
Bio-physical impacts	Reference
Wildfires	Keshavarz <i>et al.</i> , 2013; Lasanta <i>et al.</i> , 2015
Decreased soil productivity	Keshavarz <i>et al.</i> , 2013; Lasanta <i>et al.</i> , 2015
Soil erosion	Zhao <i>et al.</i> , 2008; Torres <i>et al.</i> , 2015
Soil salinity	El Kharraz <i>et al.</i> , 2012
Reduces groundwater quantity and quality	El-Sadek, 2010
Land degradation	El Kharraz <i>et al.</i> , 2012
Loss of vegetation cover	Zhao <i>et al.</i> , 2008; Torres <i>et al.</i> , 2015
Loss of biological productivity	Chazal & Rounsevell, 2009
Lowered water resources	Keshavarz <i>et al.</i> , 2013; Lasanta <i>et al.</i> , 2015
Reduced water quality	Keshavarz <i>et al.</i> , 2013; Lasanta <i>et al.</i> , 2015
Increased pollution and destruction of landscape patterns	Keshavarz <i>et al.</i> , 2013; Lasanta <i>et al.</i> , 2015

1081 **Table 2.** The effects of ALC on drought

Hydrological impacts	Reference
Water scarcity	Keshavarz <i>et al.</i> , 2013; Lasanta <i>et al.</i> , 2015
Reduces the volume of groundwater	El-Sadek, 2010
Low levels of water reserves in aquifers	de Mûelenaere <i>et al.</i> , 2014; Rudi <i>et al.</i> , 2012
Increases in extent and frequency of intensive floods	Rudi <i>et al.</i> , 2012
Climate impacts	Reference
Increasing the temperature	Fall <i>et al.</i> , 2009; Anya, 2012
Decreasing in precipitation	Adegoke <i>et al.</i> , 2007; Anya, 2012
Greenhouse gas emission	Hazell & Wood, 2012
Soil impacts	Reference
Decreasing soil fertility	Zhao <i>et al.</i> , 2008; Torres <i>et al.</i> , 2015; Bruun <i>et al.</i> , 2015
Loss of organic carbon in soil	Keshavarz <i>et al.</i> , 2013; Lasanta <i>et al.</i> , 2015
Soil erosion	Zhao <i>et al.</i> , 2008; Torres <i>et al.</i> , 2015
Soil salinity	El Kharraz <i>et al.</i> , 2012

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1083 **Table 3.** Drought coping strategies

Micro (local) level	Meso (national) level	Macro (international) level
Improve soil quality by adding organic matter into the soil	Comprehensive policy interventions	Emergency relief and rehabilitation
Holding rain water and distributing rain water into fields during the rainy period	Utilizing more efficacious incomes- as well as consumption-smoothing measures	Providing food in exchange for work
The diversification of crops in farmlands	Improvements in rural infrastructure and marketing facilities	Drought risk management
Utilizing different methods of water preservation	The promotion of rural and agro-processing industries	Communicating with regional and international innovations
Spraying plants with leaf fertilizer	Technological improvements and policy interventions	-
Thicker mulching	-	-

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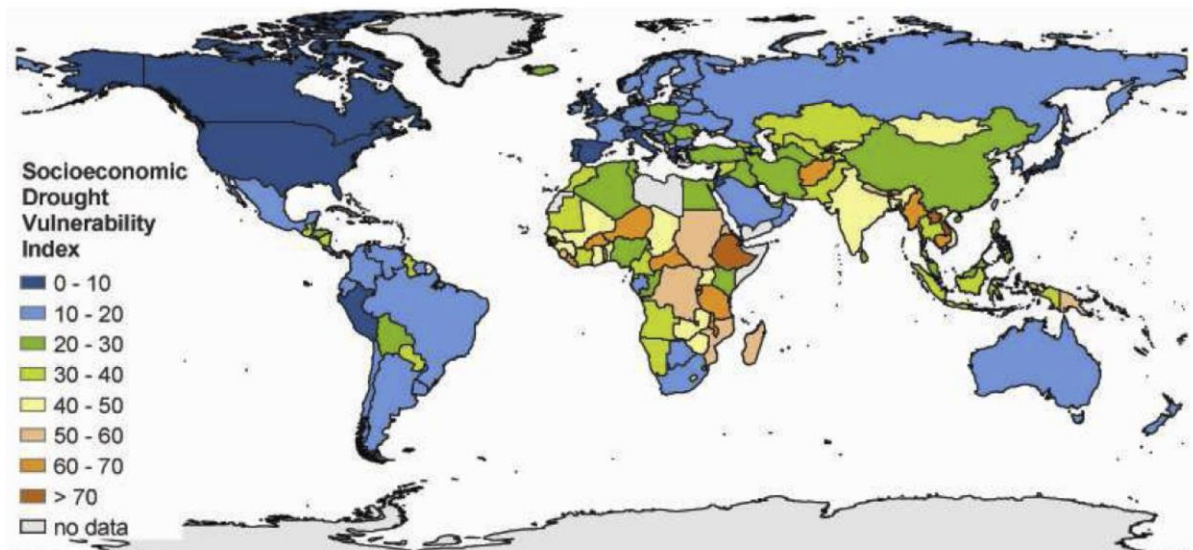
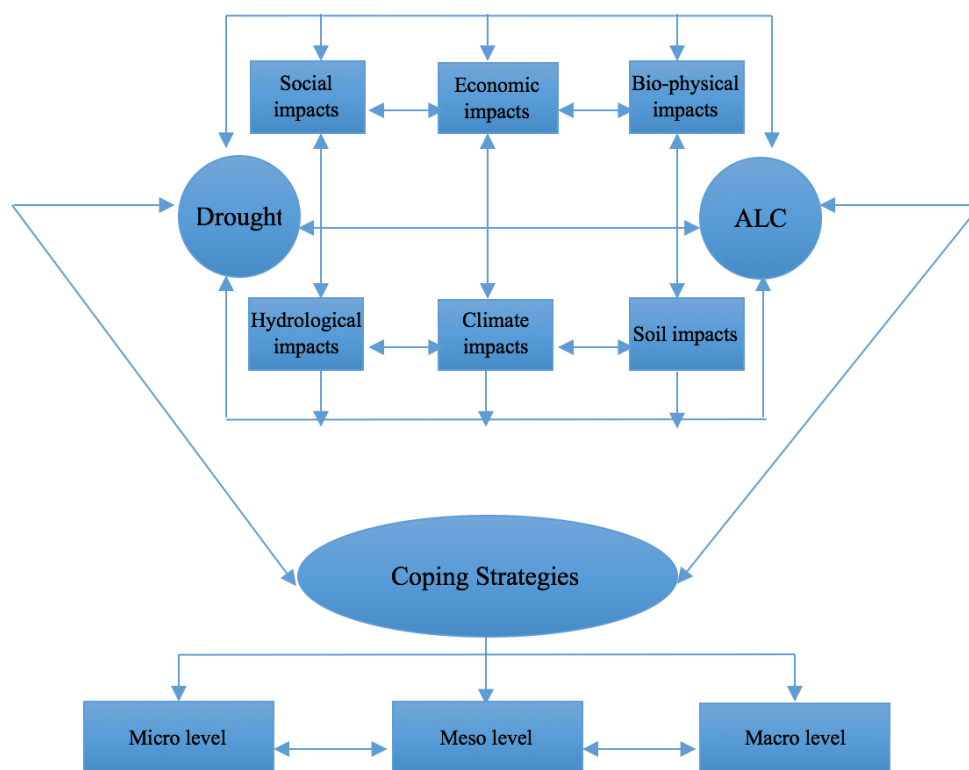


Figure 1. Socioeconomic Drought Vulnerability Index according to the crop diversity of each countries and their dependency on agriculture to provide income and employment (Adapted from Eriyagama *et al*, 2009)

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1092 **Figure 2.** Conceptual framework of drought impacts on agricultural land conversion

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