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IT HAS BEEN WITH US IN ONE FORM OR ANOTHER: DROUGHT AND THE SAHEL CRISIS

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Abstract
Drought is a phenomenon associated with a deficiency in precipitation for a long period of time, usually a season or more. It is a prolonged abnormality of the natural climatic pattern. It may also differ greatly from one area to another. The study employed a systematic literature review involving the Preferred Reporting Items and Meta-Analysis (PRIMA) guidelines for review and analysis. Relevant literature was sought using a systematic document search procedure from a sophisticated database using the search string "drought impacts" OR "drought environment" OR "drought risk" OR "drought mitigation" OR "adaptation risk" OR "drought adaptation" OR "climate impacts" OR "drought smallholder OR "drought Sahel" OR "Adaptation ability". Keywords were searched in the title and abstract, including where otherwise indicated in the supplementary files. They include documents that were written in English and span the period from 1970-2020. The findings indicate that droughts, particularly in the 70s and 80s, have ravaged the Sahel region, and the Niger Republic in particular, resulting in socio-economic, physical, and ecological degradation, loss of biodiversity and loss of ecological stability, decline in surface water, reduction in water availability for irrigation, severe malnutrition, loss of livestock, decline in agricultural production, increased rate of unemployment, and severe food shortages.

Key Words: *Drought, Sahel, Agriculture, Impacts, Niger*

Introduction

The Sahel region in West Africa is well known for its devastating environmental problems, especially droughts and desertification, and came into international concern in the late 70s and early 80s when the zone was ravaged by a series of famines, droughts and desertification (Agnew and Chappell, 1999). Throughout the last decades, warnings of drought in the Sahel have been seen by many writers to be both extreme and persistent. Several climate researchers have observed a declining trajectory in precipitation in the 1970s (Lamb, 1974; Winstanley, 1973). The

concern for the people of the land arose in the early 1970s, and gradually the 'Sahel drought' became an international relief effort.

Drought is a complex climatic phenomenon characterized by a natural reduction in precipitation that results in negative impacts on the environment and human activities. Therefore, drought is a "climatic excursion involving a deficit of rainfall (meteorological drought) sufficient to cause water resources depletion (hydrological drought), adversely affects crops and livestock production (agricultural drought), causes severe disruption of the established economy (economic drought) and causes some ecological damage (ecological drought) in the affected areas" (Ovwasa, 2019). When droughts affect the well-being, livelihood, and lives of people, it is seen as a socioeconomic drought (Burton, 1998; Gautier *et al*., 2016).

Drought is a spreading threat that grows slowly, often over a period of several months, and can have a long-life cycle of several years for major events. The impact of drought has spread over a thousand square kilometres (Burton, 1998). Drought danger can be described as a state of dry conditions abnormality, resulting in a severe hydrological imbalance. The implications for humans include crop failure, water shortages for humans and livestock, and property damage. Overgrazing, bad farming practices, and improper soil management techniques do not in themselves cause drought, but often intensify the drought-related hazard (Burton, 1998; Epule *et al*., 2014).

Drought and associated famine occurred in Niger in 1883, 1903/1905, 1913/1915, 1923/1924, 1942/1944, 1954/1956, 1972/1973, 1968, 1982/1983 and the major droughts, which are regional and have been established statistically to have a 30-year cycle, occurred in 1883/1885, 1913/1915, 1942/1944 and recently 2005, 2008, 2010 and 2012 (Federal Ministry of Environment, 2006; United States Agency for International Development, 2017; Ahmed *et al*., 2018; World Bank, 2019). These 30-year cycle droughts are usually regional and cover the entire Sahel and Sudan climatic belts. The 10-year cycle droughts are usually localized, even in areas lying along the same latitude (FME, 2006). The impacts of drought have been documented in various literature (Seaman *et al*., 1978; Biellik and Henderson, 1981; O'Keefe, 1983; Kustner *et al*., 1984; CDC, 1985; Carnell and Guyon, 1990; Patel., 1994; FME, 2006; Chotard *et al*., 2010; Mason *et al*., 2010a; Ahmed *et al*., 2018).

Documentation of the consequences of drought is complicated for a number of reasons. Numerous measures are used to capture and measure the onset, length, intensity, and end of droughts (Stanke *et al*., 2013). Drought conditions are sluggish phenomena that typically evolve over a prolonged period of time and lack highly visible and systemic impacts (Stanke *et al*., 2013). They may be geographically vast, affecting large regions, regardless of geopolitical/country borders, and may exhibit complex spatial patterns. The social impacts of drought can be slow to develop as they develop over time as the occurrence continues, and the impacts can last for years (National Drought Mitigation Centre, 2012; Stanke *et al*., 2013).

With agriculture having the largest share of GDP in Niger, research on the effect of drought on agriculture does not receive proportional interest. Generally,

there is still a lack of substantial research on the physical, ecological, and socio-economic impacts of drought in Niger. This study therefore, aim to provide an in-depth systematic review of the drought impact, and adaptation measures by farmers in Niger. The objective of this study is to examine the impacts of drought on agricultural production in Niger Republic.

Material and Methods

Study Area

Location, Position and Size

Niger, named after the Niger River, is a landlocked country located in West Africa (Yelboga *et al*., 2019). The country covers an area of approximately 1,267,000km^2 and an estimated 700km from the southernmost border away from the Gulf of Guinea (United Nations Development Programme, 2018). Niger is bordered by Libya to the northeast, Chad to the east, Nigeria to the south, Benin to the southwest, Mali to the northwest, Burkina Faso to the southwest and Algeria to the northwest. The largest portion of the country is found in the semi-arid Sahel belt and is characterized by a hot and dry climate. The northern part extends into the Sahara-desert (UNDP, 2018). In the extreme southern part, a tropical climate dominates at the edge of the river Niger basin. The terrain is dominated by desert plains and sand dunes, with flat terrain or grassland in the south and hills in the north. Rainfall is extremely variable year over year, both in terms of geographical intensity and frequency.

The population of Niger was estimated at 19.9 million as of 2016, with an annual average growth rate of 4% per year, one of the highest in the world. Niger is now in the group of low human growth, ranking 187 out of 188, and is a member of the Least Developed Countries Group. Average annual income is measured at US$427 per capita. The agricultural sector (agriculture, livestock, forests, and fishing) accounts for 44% of its GDP and is the primary source of jobs for 90% of the population. Production is highly dependent on minimal seasonal rainfall, rendering it especially vulnerable to natural disasters.

The country has three ecological zones based on rainfall level and agricultural productivity (USAID, 2014). The Sudan zone is found in the southern part of the country, bordering Nigeria. This zone remains the most suitable and fertile for agricultural production and receives an annual average rainfall of 800 mm, characterized by mixed cropping, pastoralism and irrigation. The Sahel Zone, covering the central part of the country from west to east, is an arid-zone and the most populated zone in the country. This zone receives 200-700mm of rainfall per annum (USAID, 2014) and is associated with thorny vegetation and acacia and favours livestock production. The Sahara Zone, which is described as almost entirely desert, recording less than 150mm of rainfall per annum (USAID, 2014) and does not support rainfed agriculture and favours pastoralism. The northernmost areas receive less than 150mm. The central belt of the country receives 200-400mm. The south and south-eastern areas receive 400-600mm. In the southwest, rainfall can exceed 600-800mm per season. Temperatures vary across the country and seasons. In April and May, temperatures reach up to 45°C and as low as 28°C-31°C during the wet season.

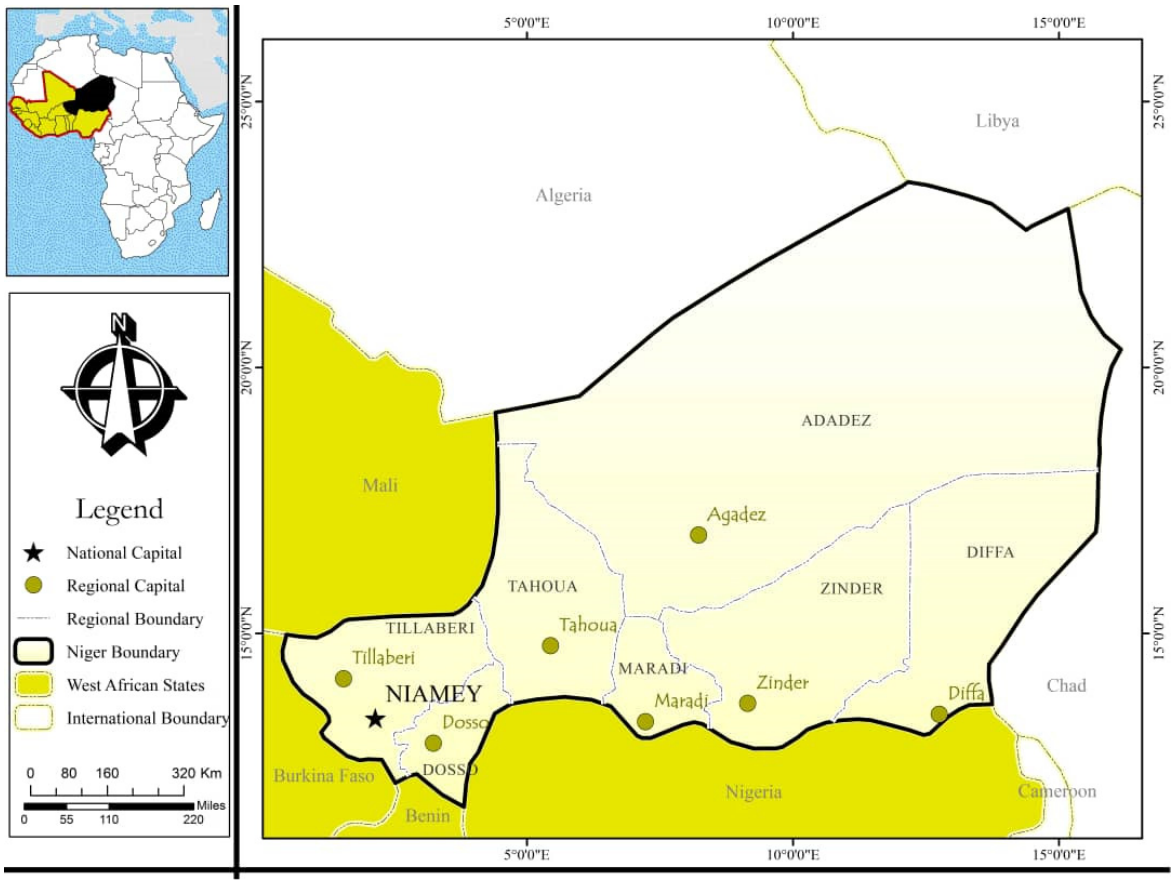

Fig. 1. The study area map

Methods

Systematic literature review aims to collect all pertinent information that matches the pre-specified eligibility requirements in order to address a particular research question. It employs integrated and systematic approaches to eliminate bias in the identification, selection, synthesis, and summary of studies (Moher *et al*., 2015). This, when done well, offers accurate results through which conclusions can be drawn and decisions taken (Moher *et al*., 2015). This review followed the Preferred Reporting Items and Meta-Analysis guidelines for review and analysis. The PRIMA methodology involves a framework to help researchers develop guidelines for planned systematic reviews and meta-analysis, providing them with a minimum collection of elements to be included in the procedure. The aim of the protocol is to provide the justification for the review and for the pre-planned methodological and strategic analytical approach before the implementation of the protocol and embarking on the review.

Search Criteria for Identification of Documents

Searching for relevant studies was conducted between 11th October and 22nd November, 2020. A comprehensive search of eight databases was conducted. The databases searched were Scopus, African Journal Online (AJOL), ProQuest, Elsevier, Research Gate, and Google scholar (Haby *et al*., 2016). The documents were obtained using the search

string "drought impacts" OR "drought environment" OR "drought risk" OR "adaptation risk" OR "drought adaptation" OR "climate impacts" OR "drought smallholder" OR "drought Sahel" OR "Adaptation ability". Keywords were searched in the title and abstract, including where otherwise indicated in the supplementary files. Results were imported into an excel spreadsheet and removed duplicates (Moher *et al*., 2015; Haby *et al*., 2016). The search was undertaken and evaluated by the author as per the eligibility criteria. The complete text of any potentially relevant document has been retrieved for further consideration. The author was precluded from the inclusion side, so there was some uncertainty as to its inclusion in place to ensure that no crucially significant articles were lost.

Results and Discussion

Physical and Ecological Impacts of Drought

The Sahel region of Africa suffered a 20–40% decrease in rainfall from the middle of the twentieth century, constituting the highest and most prolonged shift in rainfall in any contemporary region of the world (Nicholson, 2001; Maranz, 2009). Le Barbe´ and Lebel (1997) studied rainfall in the Sahel region from 1950-1960 and observed that the drought of 1970-1989 was associated with a decrease in the number of rainy events, rather than a decrease in mean rainfall per event. Shinoda *et al*. (1999) studied the amount, frequency, intensity, and onset of the hourly rainfall in Niamey and compared extreme periods: the wettest 1950s, the dry early 1970s, the driest 1980s, and the relatively wet periods of the 1980s to early 1990s. The authors observed that for the two drought periods, the rainfall amounts, frequencies, and intensities decreased to 42, 55, and 75%. Drought conditions of the 1970s and 1980s were associated with reduced rainfall frequencies. Crop assessment in the Tillabéri region indicates that 217 out of 1,661 villages are at the risk of food insecurity (USAID, 2005b). The impacts of droughts and advection from the Sahara exacerbate high potential evapotranspiration, which leads to drying of inland drainage and significant losses in water reservoirs (Ogilvie *et al*., 2010).

Other physical and ecological impacts of drought in Niger include; loss of biodiversity and loss of ecological stability; soil degradation resulting in loss of soil fertility (Famine Early Warning Systems Network, 2014); remobilization of fixed sand dunes, increased frequency of dust storms (Samuel, 2016), and reduction in river flow, particularly the river Niger, which recorded zero flow in 1984 and 1985 at Niamey (Okpara et al., 2013). The decline in surface water and aquifer recharge of major river basins, particularly the watershed of eastern Niger, predominantly the Lake Chad basin and Komadougu Yobe, and the watershed of western Niger, dominated by the river Niger., reduction in municipal water availability, reduction in water available for irrigation, hence reduced food production, reduction in water quality due to concentration of pollutants that occur as a result of reduced precipitation, general lowering of ground water table, and drying up of shallow wells, thereby limiting access to water for animals and domestic use. Other physical impacts relate to bio-resources and consist of the following: impaired health of bio-resources, loss of plant and animal species, changes in species composition,

increased incidence of invasive species, increased insect and disease infestations, reduction in reproductive capacity of humans, plants and animals, increased stress on endangered species, destruction of habitats, reduction of recreational opportunities, etc.

About 338,180 hectares of the forest areas were lost because of droughts in 1968, 1973, 1977, 1985, and 2004 and some other human factors and climate variations. About 100,000 to 120,000 hectares of forest areas disappear every year (UNDP/GEF, 2005). Surveys of endangered wood species or likely to be lost by the National Agronomic Research Project in the departments of Diffa, Zinder, Maradi, Dosso and Tahoua also show the effect of decreased rainfall on the extinction of many woody species (Larwanou, 1998; Larwanou *et al*., 2006a).

Effects of Drought on Agriculture and Food Security

The cumulative impact of drought and a desert locust outbreak adversely affected Niger's grazing lands and crop production in 2004, culminating in a food security crisis in agro-pastoral and pastoral areas. In an average year, children in pastoral and agro-pastoral societies regularly face severe malnutrition levels that reach emergency thresholds, particularly in the Maradi and Zinder axis (USAID, 2005a). The joint assessment report by the government of Niger, the United Nations, World Food Program, USAID, Famine Early Warning System (FEWS NET) and Permanent Interstate Committee for Drought Control in the Sahel (CILSS) stated that 2.5 million people are food insecure and require food assistance. Livestock were also at the risk of starvation due to pasture scarcity, resulting in about 4.6 million metric tons of pasture deficit. In addition, there was a 223,500 MT cereal deficit, resulting in cereal scarcity and price inflation, exacerbating the impact of food security. There was a significant decline in cereal production compared to the five-year average from 2004, which affected about 10,000 villages. These are particularly manifest in the agro-pastoral regions of Maradi and Tillaberi, as well as the pastoral regions of Tahoua and Zinder (USAID, 2005a).

In past decades, they were associated with outbreaks of locust, drought and famine (Sendzimir *et al*., 2011). However, within this period, human mortality rose from 2.7 to 7% (USAID, 2005a; 2005b). These associated impacts of famine have frustrated several internationally funded projects to fight food insecurity and support afforestation. Tougiani *et al*. (2009) stated that reforestation programs failed with only 20% of seedling survival rate and enhancing intensive agriculture did not bolster food security or income. Socio-economic impacts of drought

Niger is presently affected by extreme and chronic poverty and remains vulnerable to drought, which exacerbates the impact of malnutrition (Ogilvie *et al*., 2010). However, about 65.9% of the population in Niger are living below the poverty line of US 1.25 per day, which is among the highest in Africa (World Bank, 2009; Ogilvie *et al*., 2009). Drought exacerbates the impact of malnutrition, whereby one in every five is acutely malnourished in the Tahoua and Maradi regions. Similarly, in Maradi, 19.5% of global acute malnutrition was found and 2.9% of severe acute malnutrition, and 6,000 children under five were acutely malnourished in 2004, and on average, two deaths per day were recorded. A study conducted by Africa Riskview reported

that about 570,000 people are directly affected by the drought, particularly in the central and south-western Niger. The impact of the drought in 2016 was much less than projected and also compared to the historical drought trend and impacts. In 2016, about 1.3 million people were directly or indirectly affected by the drought in Niger (Africa Riskview, 2016).

In phase 3 and above of the Cadre Harmonisé exercise, it found that about 330,000 people were in severe food insecurity in 2016. And this is expected to rise to 750,000 in 2017. More so, "According to the analysis, three départements, namely Bani Bangou in northern Tillabéri, Mayahi in eastern Maradi and N'Gourti in the Diffa region, could fall into crisis due to the effect of a depletion of stocks, poor terms of trade between livestock and cereals, and the impact of civil insecurity on markets and humanitarian access" (Africa Riskview, 2016). More so, the recent 2010-2018 drought led to the substantial loss of crops and livestock in Niger, especially around Dosso, Birni N'Gaoure Fakara, Falmey, Garankedey, Golle, Gorou Bakassam, and Harikanassou (Tiepolo *et al*., 2018). Similarly, in 2016, a lot of people were affected by the drought in the Zinder region. Tanout had 204,000 people affected, Mirriah 125,000 people affected, Takieta 89,000 people affected, Magaria 77,000 people affected, Damagaram Takaya (29,000) départements (Africa RiskView, 2016). In Dosso départements, about 13,000 people are affected by drought and 34,000 people are affected in Tillabéri (FEWS NET, 2014; Africa RiskView, 2016). Other socioeconomic impacts include: increased unemployment rate, reduction in agricultural activities and agricultural production, increased rural-urban migration, particularly movement of people away from drought-stricken areas, higher frequency of resource use conflicts, severe food shortages and food insecurity due to massive crop failure, increased mortality rate, aided by limited or no access to medical supplies, worsening poverty levels, increased environmental refugees, and worsening poverty levels.

Impacts of Drought on Livestock Production

Livestock contributes to 35% of Niger's agricultural GDP (Kamuanga *et al.,* 2008). Niger has a population of 9,214 million herds of cattle (Nkonya et al., 2016). "The livestock management system is primarily pastoral, with 26 and 38% of households working in pastoral and agro-pastoral production systems. The average size of the herd is 11 and the maximum size is 122 livestock. The cows account for 40% of the herds. However, the productivity of livestock is low. The average daily milk production per cow in Niger is only 1.4 litters. This is comparable to the overall average of 1.6 litters per day per local cow breed in the Sahel region "(Desta and Coppock, 2002; Nkonya *et al*., 2016).

Drought incurred great loss of livestock, especially during the drought periods of 1968-1973 and 1977-1985 (National Adaptation Programme of Action, 2006). The 1977-1985 drought was reported to have destroyed about 50% of the entire livestock in the country (NAPA, 2006). However, in 1974, about 21.92% of the goat losses were recorded and 5.04% of the ovine breed. The trend in livestock losses continues as a result of the striking impacts of drought. For instance, in 1984 the losses were 33%goats, 35% ovine breed and 19% camel (NAPA, 2006).

Table 1: Impacts of Drought on Livestock and recommended Mitigation Measures

S/No	Aspect	Impacts of Drought	Proposed Mitigation Measures
1.	Livestock Health	▸ Increased susceptibility to disease ▸ Increased spread of diseases to other animals ▸ Reduction in reproduction ▸ Increased mortality ▸ Increased predation ▸ Reduced weaning weights resulting in less healthy calves/lambs ▸ Decreased lactation (milk production) ▸ Decreased disease resistance of animals	▸ Ensure disease control ▸ Emergency culling of livestock populations to reduce disease transmission and starvation ▸ Move livestock to areas with greater forage availability ▸ Dead animals shall be burnt immediately to avoid decomposing and spread of diseases to the rest of the herds ▸ Ensure availability of water ▸ Provide fodder banks
2.	Rangeland Productivity	▸ Reduced availability of livestock feed ▸ Reduced availability of water at livestock watering points. ▸ Increased competition of livestock with wildlife population for rangeland resources ▸ Rangeland degradation	▸ Promote livestock feed conservation methods ▸ Supplement surface water with underground water resources at watering points. ▸ Control restocking rates to aid forage recovery. ▸ Promote carrying capacity
3.	Economic returns to the Pastoralist	▸ Reduction in market weights of livestock ▸ Increased need for supplemental feeding and watering ▸ Reduced market prices ▸ Increased post-drought market prices	▸ Promote alternative livelihood ▸ Provide low interest credit facilities to support off-farm economic activities
4	Herdsmen/farmer conflicts	▸ Reduction in livestock folder ▸ Reduction in animal and crop products ▸ Increased clashes among resource owners/user ▸ Encroachment on rangelands ▸ Encroachment on agricultural lands	▸ Establish cattle routes ▸ Encourage rational utilization of shared resources ▸ Establish conflict resolution mechanism ▸ Establish storage silos ▸ Establish clear ownership/rights

Adaptation Strategies to Drought

Agriculture, due to its intrinsic exposure, is highly vulnerable to environmental change, especially climatic disasters such as drought (Lei *et al*., 2016). Climate change could increase the likelihood and severity of drought (Intergovernmental Panel on Climate Change, 2012) and thus generate greater risk to crop yields. Considering that even the most comprehensive mitigation measures cannot avoid additional drought impacts (IPCC, 2007; Esham and Garforth, 2013), therefore, it is important to recognise and assess the potential adaptation strategies to drought and its related climate extremes in Niger (Smit and Skinner, 2002; Howden *et al*., 2007; Lei *et al*., 2016).

The purpose of the adaptation measures should be to increase the system's capacity to withstand external shocks or changes. It is important to evaluate the adaptation strategies of farmers in order to provide knowledge that can be used to develop policies that improve adaptation as a tool for managing a variety of risks associated with agricultural drought. Despite the devastating impacts of drought in the Sahel region and Niger in particular, agricultural activities continue to exist through several adaptation options to manage the environment as well as the impacts of drought (Ahmed *et al*., 2019).

Table 2: Adaptation measures and mechanism behind each option that offsets the potential negative impacts of drought

Adaptation options	Measures/strategies	Mechanism to overcome the impacts of drought
I. Improve resiliency and adaptive capacity	(1) strategizing of local and regional adaptation plan (2) enhance drought monitoring and early warning systems (3) sustainable planning and coordination (4) innovation and technology	Improve the efficiency of adaptation strategies and mechanisms. Ameliorate the adverse effect of drought Enhance effectiveness of adaptation measures Enhance the efficiency of adaptation steps and lower costs.
II. response to changes in water availability	(5) technology and water use efficiency (6) enhance soil moisture holding capacity (7) water metering	Improve water supply and availability Increases water use efficiency Enhance sustainable water utilization
III. Response to drought	(8) planting drought resistant variety (9) crop insurance against drought	Enhance the effectiveness of agronomic water use Reduces financial damage/ economic loss to farmers
IV. Response to increased irrigation requirements	(10) change in crops and cropping patterns (11) soil water conservation practices (12) develop drought resilient crop (13) enhance crop diversification	Reduce financial damage to farmers Minimize crop moisture demand Mitigate the impacts of drought Improve farmers income

Adopted from (Iglesias and Garrote, 2018)

Drought Crisis and Strategic Adaptation By Farmers

Negotiating the Rain

Rainfall varies in intensity and duration (during the wet season) in the Sahel and Niger in particular. The characteristics and distribution are erratic and inconsistent from the end of May to mid-October, with a long dry spell around July and a false finish in September (Mortimore and Adams, 2001). Therefore, the three major farming operations are: "planting (which peaks very early), weeding (which is done three times during the season), and harvesting (which divides into early millet and cowpeas, at the first peak, and sorghum, late cowpeas, and groundnuts, at the second peak" (Mortimore and Adams, 2001). At this juncture, there is a sharp decline in labour and manpower, which is determined by the number of people in the family, their age and sex, as well as the resources available for hiring labour from outside. This condition might vary from year to year depending on the size of the farm and labour availability. Consequently, the problem faced by farmers goes beyond an uncertain one. Drought crisis (when a lot of farm labour is wasted) and the need for technological versatility to negotiate rain every year (Mortimore and Adams, 1999; 2001).

Managing Biodiversity

There is, however, a vast array of evidently degraded natural vegetation in areas with less than 400mm of annual rainfall than would be predicted. Economic development in Niger serves as a significant case study on how certain policies and institutions could lead to land degradation and strategize farmers on how to sustainably utilize land resources and maintain biodiversity. Land use/cover change (LUCC) revealed that a total of 6.12 million hectares of land had experienced LUCC and shrubs and grassland accounted for a large share of the change. Beyond the desert, 19% of the land had experienced LUCC. Crop land expansion is responsible for 57% of the deforestation. Management of land and biodiversity as a result of LUCC is estimated at USD 0.75 billion in 2007, which is about 11% of the 2007 GDP of USD 6.773 billion and 1% of the 2001 value of ecosystem services (Nkonya *et al*., 2016).

Economic trees are preserved and provide income for the farmers (Cline-Cole *et al*., 1990)," and the practice of discriminatory protection on cleared farmland has been recognised in Niger (Joet *et al*., 1998). In times of famine, the routine use of foods (apart from medicine, fodder, and construction materials) derived from natural vegetation is extended dramatically in hungry households (Mortimore, 1989). Biodiversity, therefore, is both a recognised and a managed resource "(Mortimore and Adams, 1999, 2001).

Working the Land Harder

The geometric growth of the population in both rural and urban areas of Niger results in agricultural intensification, which brings about changes in land use and land cover. As Mortimore and Adams (2001) pointed out, such population changes are accompanied by land transformation from woodland or grassland to farmland and the conversion of natural woodland to farmland. The expansion of farmland and agricultural intensification have led to land degradation. Other strategies involve intercropping for land maximization and diversifying crops against drought and the impacts of pests and diseases (Adams and

Mortimore, 1997; Mortimore and Adams, 1999).

Integrating Animals

Livestock populations recovered very rapidly from high mortality in the early 1970s and again in the early 1980s. In Niger, a lot of livestock is raised by farmers who own land or farmers who keep livestock, as well as specialized and typically nomadic pastoralists. As Mortimore and Adams (2001) pointed out, all own, or aspire to own livestock in basically predominantly agricultural areas. Livestock are kept as a storehouse for savings, a reserve for unexpected, self-reproductive assets, a source of income and nutrients for the soil in the form of manure. Similarly, they can help with intensive crop production through nutrient recycling, decomposition of plant residues, and manure (Mortimore and Adams, 1999; 2001).

Livelihood Diversification

In order to reach the optimum inputs of farm labour during peak times, a strategic waste of potential farm labour is needed at other times. Additional income sources are both tried and required to minimise the risk of crop failure (Mortimore and Adams, 1999; 2001). However, Ibrahim (1996) stated that (as a result of rainfall variability), and in the most rural parts, it merely reinforces the need for livelihood options. The first phase in diversifying is channelling efforts from the farm into livestock ownership (Mortimore and Adams, 1999; 2001). Off-farm livelihood diversification basically includes sales of assets, trade and craft, remittances, sales of labour, and migration. These activities provide extra income for households. Off-farm livelihood diversification is usually associated with mobility from rural areas to zones of commercial activities within the country and or outside Niger, especially temporary migration to Nigeria (Mortimore and Adams, 1999; 2001).

Criteria for Evaluation of Adaptation Options

Some of the adaptation options to drought identified include; soil management, dry planting (Binne in Hausa), crop diversification, irrigation, adopting drought resistant varieties, sales of labour, remittances, introducing new crops and fodder bank with succulent and palatable grasses. The evaluation of adaptation options was based on (Ebi *et al*., 2011) in his study of smallholder adaptation to climate change in Mali. The authors devised criteria for evaluation of adaptation options. The interaction was between USAID, the contractors and agricultural experts from the Mali government. However, the identified adaptation options to drought were evaluated based on their effectiveness in addressing the impacts of drought, costs, and feasibility; the degree to which assistance would be required; and the adequacy for addressing the impacts of drought.

Table 3: Evaluation of adaptation options in Niger

Adaptation option	comment	Assistance required?	Assistance	Time-scale	Effectiveness of the adaptation option	cost	feasibility	Adequacy for current situation
Soil management Plough, use of simple tools Such as long handle hoe (Ashasha in Hausa) manure application.	Traditional ecological knowledge	Could be achieved at household and or community level	Very low	Short-term	Medium	Very low	Medium	Medium
Dry planting (Binne in Hausa)	Traditional ecological knowledge	Could be achieved at household and or community level	Very low	Short-term	Medium	Very low	Medium	Medium
Crop diversification	Greater use of intercropping where appropriate. More use of crop rotations to break pest cycle	Could be implement at household and community level with technical assistance	Low	Short-term	Very high	Very low	high	Medium
Irrigation, flood plain, Fadama For dry season production	Training may be needed	Technical assistance strongly needed	Very High	Medium-term	Very high	Very high	Very high	Very high
Variation in cropping pattern	Traditional ecological knowledge	Could be achieved at household and or community level	Very low	Medium-term	Very high	Low cost	Medium	Medium
Adopting drought resistant crop varieties on a pay-at-harvest basis	Drought and heat tolerant varieties will be needed	This could be implemented at household and community level with financial assistance	High	Long-term	Medium	Very high	Medium	Medium
Sales of labour (on or off-farm labour to generate income)	No training required, unless otherwise on skilled based labour	No assistance is required unless on skilled basis	Medium	Medium-term	Medium	Very low	Medium	Very high
Sales of assets, livestock, farm produce	No training is required	Could be achieved at individual, household and community level	low	Short-term	Medium	Medium	Very low	Medium

Migration	Require knowledge of the target destination	Basic information and guidance for the target destination with financial assistance	Very-low	Short-term	Medium	Low	Medium	Medium
Remittances	Money in form of cash and or kind to ameliorate the impacts of drought	Support and prayers from family and technical assistance for transactions	Low	Medium-term	High	Low	Very-high	Medium
Introduce new crops (Such as sesame) and early maturing (cowpea called Dan arba'in in Hausa)	Need markets for new crops and technical support	Research is required	Low	Long-term	High	High	Low	High
Fodder bank with succulent and palatable species	Substantial education on protection and allow for natural regeneration	Community could implement with extension services and financial assistance	Very high	Long-term	Very high	Very high	Very high	Very high

Source: Ebi *et al*. (2011)

Conclusion

Drought is a creeping phenomenon widespread naturally and a common part of the environment, affecting every continent and nearly all countries, but the impacts are worsened in delicate environments like the Sahel. It should not be treated as simply a natural phenomenon. Rather, drought is the product of the relationship between a natural event and the demand imposed on biodiversity, water resources, and ecosystems by social beings. These structures will greatly worsen the impact of the drought by inefficient use of natural resources. The effects of drought are varied; they cascade through the economy and may continue for years after the end of the time of deficiency in precipitation. Impacts are also referred to as primary or indirect effects. Compared to the high number of communities and different sectors of the economy threatened by the drought, its geographical scale and the complexity of assessing ecological damage make it difficult to determine precisely the economic costs of the drought.

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