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RESEARCH PAPER

Effects of drought and their mitigation strategies in Yobe State, Nigeria

A. H. Gana[1,2*], M.A. Fullen[2], D. Oloke[2]
[1]*Department of Biological Sciences, Yobe State University, Damaturu, Nigeria*
[2]*Faculty of Science and Engineering, The University of Wolverhampton, Wolverhampton WV1 1LY, UK*

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Abstract. Drought is regarded as a natural phenomenon and its impacts accumulate slowly over a long period. It is considered to be insufficient precipitation that leads to water scarcity, as triggered by meteorological parameters, such as temperature, precipitation and humidity. However, drought mitigation has mostly been reactive, but this has been challenged by extreme events globally. Many countries and regions around the world have made efforts in mitigating drought impacts, including Nigeria. This study produced frameworks for drought amelioration and management as a planning tool for Yobe State, Nigeria. Drought coping strategies have also caused environmental degradation in Yobe State. Farmers over-harvest their farms, practice deforestation and over-exploit wild animals. Several efforts to mitigate the impacts of drought by the Nigerian Government have failed, thus this research adopts a bottom-top approach to mitigate drought impacts in Yobe State. Four validated drought mitigation and management frameworks were developed for Yobe State. The frameworks were evaluated pre-use through respondent validation. State officials and farmers believed that these frameworks will reduce the impacts of drought in Yobe State. The frameworks include social, economic, environmental impact mitigation and an Integrated Drought Mitigation and Management Framework. The proposed frameworks were designed and have advocates a paradigm shift, using both proactive and reactive measures.

Keywords: Drought; environmental degradation; polices; drought mitigation; framework

1. Introduction

Yobe State is one of the most severely affected by drought and is among the nine drought and desertification frontline States in Nigeria (Olagunju, 2015). Nigeria loses ~351,000 hectares of land annually due to desertification and southward movement of sand (Nwokocha, 2017b). According to Nwokocha (2017b) it is estimated that the southward movement of sand is ~0.6 km per year and Yobe State has lost ~25,000-30,000 hectares annually in the last decade. Drought in the north-east region plays significant role in increased desertification in the area (Musa & Shaib, 2010; Olagunju, 2015; Terhile, 2017). Farmers in Yobe State were chosen as the sample group due to their vulnerability to drought (Abdullahi et al., 2007). Among the six north-east States Borno and Yobe States are the most severely affected by desertification (Olagunju, 2015). Table 1 shows the States most affected by desertification in northern Nigeria. Some States in the north-west are also severely affected, including Katsina, Jigawa, Sokoto, Kebbi and Zamfara.

*Corresponding author. E-mail: A.hassangana@wlv.ac.uk; hassangana09@gmail.com
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Table 1. States affected by desertification in Nigeria

States	Geographic region	Rate of desertification	States	Geographic region	Rate of desertification
Sokoto	North West	Severe	Borno	North East	Severe
Zamfara	North West	Severe	Yobe	North East	Severe
Katsina	North West	Severe	Bauchi	North East	Moderate
Jigawa	North West	Severe	Gombe	North East	Moderate
Kano	North West	Moderate	Taraba	North East	Moderate
Kebbi	North West	Severe	Niger	North Central	Moderate
Kaduna	North West	Moderate	Plateau	North Central	Moderate

(Source: Olagunju (2015)).

1.1. Socio-economic effects of drought

Many studies have shown that drought has not been well documented and it appears that the magnitude and complexity of it impacts are increasing (Feyen & Dankers, 2009; Wilhite & Pulwarty, 2005). Droughts have different socio-economic effects on humans, which include lack of labour, decreased agricultural productions, diminished human health and increased prevalence of diseases. However, social characteristics also vary according to regions, traditions, cultures, households and individuals and adapting to impacts of drought depends on social responses (Wilhite et al., 2007). In many places, the impacts of drought can be diverse and its effects are either direct or indirect. Droughts have caused more environmental refugees in recent years than any other time in human history. This disaster has caused more deaths than any other natural disaster in the second half of the 20th century (Vicente-Serrano et al., 2012). Socio-economic activities and environmental degradation move simultaneously, for example, over-exploitation of natural resources due to an extreme climate event is an alternative coping strategy (Shiferaw et al., 2014). These activities include productivity loss, increased forest fire hazards, reduced water levels, increased livestock and wildlife mortality rates and damage to wildlife and fish habitats. Shiferaw et al. (2014) argue that exploitation of natural resources and habitat increases when there is reduced farm output, unemployment, famine and extreme events, such as drought and hurricanes.

Indirect impacts of drought include environmental degradation and reduced incomes, which affects livelihoods through the prices of both livestock and crops. Indirect effects of drought could be larger than direct impacts (Zimmerman & Carter, 2003). Droughts account for only 5% of natural disasters, but the total losses caused are ~30% compared with other natural disasters. In contrast, Keshavarz et al. (2013) stated that 22% of damage caused by natural disasters is from drought and 33% of persons affected by disasters were caused by drought. The socio-economic aspects include increased work load, decreased income, malnutrition, poor access to health services, migration, emotional impacts (depression and frustration), poverty, reduced life quality and conflicts over land and water resources (Alston & Kent, 2008).

1.2. Environmental problems in Africa

Agnew and Warren (1996) reported the seriousness of environmental changes in the Sahel. Many people have suffered from drought events in the 1980s, which produced millions of environmental refugees. However, there are differences between environmental problems and changes. Environmental problems also have two major aspects; impacts of people upon the environment and impacts of environment on people. Any change in physical environmental conditions can cause environmental problems (Batterbury & Warren, 2001; Olsson, 1993). Most environmental problems in the Sahel are also considered cultural and economic, as they are triggered and created by poverty. Despite peoples' lifestyles adjustment during droughts, people cannot withstand severe events.

During severe events, without assistance from outside (relief), people do not consider environmental conservation important, due to their struggle for survival. Msangi (2004) argued that if droughts are properly managed, environmental degradation will certainly decrease. However, drought triggers environmental stress and resource degradation. This occurs when people are trying to overcome severe drought events, thus placing pressure and demands on

resources, which in turn harms the natural environment (Ghai, 1990). Drylands occupy ~41% of the earth's surface and has a population of over 2 billion people (Prăvălie, 2016).

1.3. Importance of indigenous knowledge in drought mitigation

Eludoyin and Eludoyin (2017) defined indigenous knowledge as a local skill unique to a given place and culture. An important characteristic of mitigation practices among rural farmers is local or indigenous knowledge. It is important to integrate this knowledge into drought mitigation practises in places characterised by recurrent drought such as the Sahel which may also provide guide cause for mitigation of future droughts.

1.4. Need for national drought policy

There is a need to establish a national drought policy in order to serve as guidelines to oversee drought management in countries affected by drought (Wilhite, 2016). Oladipo (1993) proposed a national drought policy to help mitigate drought as the haphazard approaches in the 1970s and 1980s did not yield a productive outcome. If proper and comprehensive drought mitigation policy and measures are not in place, the impacts of drought will affect more people.

1.5. Critical appraisal of policies and efforts made by Nigerian governments to mitigate impacts of drought

As part of effort by the Federal Government of Nigeria (FGN) to combat the problems of desertification and drought, National Action Plan (NAP) was designed in 2005. The plan was designed to help implement the United Nations Convention to Combat Desertification Framework. Sectoral policies were also introduced in efforts to combat drought and desertification. These policies include the National Policy on Environment, the National Agricultural Policy, the National Environmental Action Plan (NEAP), State Environmental Action Plans (SEAPs) and the National Conservation Strategy. All these are to effectively implement the NAP (FGN, 2005). In 2005, the FGN (2005) developed a national drought forecasting and Early Warning Systems as part of an effort to mitigate drought through proactive measures, to facilitate effective drought mitigation measures. The FGN (2005) approved the provision of state-of-the art meteorological instrumentations in many locations to help forecast drought. Furthermore, the FGN (2005) upgraded the status of the Nigeria Meteorological Services to Agency. The FGN (2005) has according to the Constitution, annually reserved 2% of the national budget as ecological funds. These funds are disbursed to state governments after application and meeting the criteria of accessing the funds. They are also regarded as contingency funds, where states apply when the have severe environmental problems. Despite the ecological funds, funding remains an issue when it comes to ecological projects.

Nwokocha (2017) examined the challenges to effective implementation of drought and desertification strategies adopted by the government in the north-eastern states, including Adamawa, Bauchi and Gombe. The study chose those states considering that they have similar characteristics of drought and desertification. The findings identified challenges which include poor funding, escalated desertification activities by citizens, mismanagement of facilities by citizens, local communities not properly involved in the process, poor commitment from government staff and lack of awareness amongst local citizens (Nwokocha, 2017). The study did not identify which policies were implemented in these states. There are several policies identified by the Federal Government in the 2005 UNCCD report. Considering the choice of study area, it appears that Nwokocha (2017) did not use states severely affected by drought and desertification in the region. Adamawa, Bauchi and Gombe States are moderately affected by drought and desertification (Table 1). Table 2 shows how the Federal Government has taken steps to combat drought and desertification by introducing several policies; with implementing ministries and agencies.

Eludoyin and Eludoyin (2017) reported that drought mitigation should include policy, institutional, socio-economic, physical, community and individual efforts, which was based on review of different national policies. In contrary the Nwokocha (2017a) suggested that

agroforestry and awareness are remedies to drought in northern Nigeria. However, governments at all levels in Nigeria find it difficult to implement policies (Medugu, 2009; Nwokocha, 2017a; Olagunju, 2015).

Several policies and programmes have been implemented by the Nigerian Government to combat desertification. These include the Arid Zone Afforestation Protection in (1977), River Basin Development (RBDA) (1987) and the establishment of the Federal Environmental Protection Agency (FEPA) in 1987. All 36 states have also established State Environmental Protection Agencies (SEPA) following FEPA guidelines (Medugu, 2009). In 1999, the Department of Drought and Desertification Amelioration was created under the Federal Ministry of Environment. This was to help coordinate policy implementation and monitoring of mitigation strategies (Olagunju, 2015).

Despite these policies and programmes implemented by the government problems of drought and desertification has been aggravated over recent years (Medugu, 2009). The government has collected loans and sought partnerships with local and international organisations (Medugu, 2009). They have also received financial and technical support, capacity building and partnership from the Chinese Government, UNEP, Japan International Agency, UNDP, International Fund for Agricultural Development (IFAD) and the World Bank (Medugu, 2009). This might be because the problems are treated as sectoral issues, rather than using integrated approaches to help formulate suitable policies and strategies. Lack of political will, weak institutions and corruption are also linked to the lack of success (Nwokocha, 2017a; Olagunju, 2015). Failures of government in drought and desertification policies in Nigeria include neglect of indigenous knowledge, use of inappropriate technology, sectoral approaches, top-down approaches, lack of proper funding and inadequate awareness (Medugu, 2009).

The Nigerian government is among 11 countries that introduced the 'Great Green Wall for the Sahara and Sahel Initiative' (GGWSSI). According to Federal Ministry of Environment (FME) (2012), the project was initiated to combat desertification, by building a wall of trees across the Sahara and Sahel. The wall is expected to be 15 km wide and 7,775 km long from Dakar to Djibouti (Figure 1). The project also serves as ecosystem protection and means of sustainable development. FME (2012) Some of the project's achievements include public awareness on desertification, rehabilitation of ~1200 hectares of degraded land and improving the livelihoods of ~6 million people in some affected communities. However, there are some challenges, which include population growth, urbanisation, dwindling natural resources caused by anthropogenic activities (FGN, 2005). Jenkins (2012) also stated that socio-economic activities and infrastructure reduce drought impacts as affected individual would have alternatives.

2. Methodology

The study employed mixed methods to investigate impacts of drought in Yobe State. Questionnaire survey and Focus Group Discussion (FGDs) were used to obtain field information on drought from farmers and government officials. FGDs were conducted at different levels (Government and farmers). This has provided information on how drought affects human activities and the environment in Yobe State. Number of questionnaires distributed to farmers were 1,040, where 721 returned (69.3%) and 22 farmers participated in the FGD. At the government level, 5 directors and environment officer from Yobe State Ministry of Environment (MoE) with combined 110 years work experience participated during the FGD.

3. Results

Data were collected from farmers in Yobe State through questionnaire survey and Focus Group Discussion (FGD). The results show that most farmers have lost ~70-80% of their harvests. According to the survey results farmers believed that desertification has increased in the study area over the years. Farmers and officials from the Ministry of Environment believed that drought can be mitigated if farmers are support to be self-reliant. Farmers highlighted fertilizer supply,

Table 3. Policies established within the Nation Action Plan (NAP)

National Policy/Plan Strategy	Content of NAP-related objectives/activities	Implementing Ministries/Agencies	Actions
National Policy on Environment 1989 reviewed in 1999 and 2005.	Drought & desertification is a key prioritised area based on participatory process consistent with NAP	Federal Ministry of Environment as Lead Implementing Ministry, Other Line Ministries and Agencies such as Fed. Ministries of Agriculture, Finance, Water Resources, Education, Information, Energy Commission of Nigeria, and Nigerian Meteorological Agency (NiMET).	This policy deals with issues including biological diversity, conservation of natural resources, land-use and soil conservation, agriculture, water resources, forestry, wildlife and protected areas, mining and mineral resources, energy, education, science and technology, flood and erosion control and cross- sectoral issues of public participation.
National Agricultural Policy	Protection of agriculture against drought, desertification, soil erosion and flood. Protection and conservation of forests. Promotion of alternative sources of energy.	Federal Ministry of Agriculture as Lead Agency. Other Federal Line Ministries and Agencies (Environment, Water Resources, Women Affairs, Industries, Finance, Education, Science & Technology, Energy Commission of Nigeria) Nigerian Meteorological Agency (NiMET)	This policy should cover issues that deal with livestock, forestry, food production, and land and water resources, drought, desertification, soil erosion and floods and the Protection and conservation of forests; forest regeneration/ afforestation; ensuring water resources management, conservation and protection of the ecosystem and the promotion of appropriate farming systems.
National Environmental Action Plan (NEAP) and State Environmental Action Plans (SEAPs) started 1995 completed in 1998.	Overall Protection of the Nigerian Environment, Conservation of threatened flora and fauna species, Environmental education and awareness creation and reduction of resource use conflict among land users.	Federal and State Ministries of Environment as Lead Agencies, Other Line Ministries and Agencies (Federal Ministries of Agriculture, Education, Water Resources, Finance, Energy Commission of Nigeria, Women Affairs).	The National Environmental Action Plan was developed in order to help analyse, evaluate and discuss interdependence between the environment and Nigeria economy.
National Conservation Strategy	Conservation of forest, marine, fisheries, forage, wildlife and soil resources. Application of indigenous knowledge system in conservation of natural resources.	Federal Ministry of Environment as Lead Agency. Other Line Ministries and Agencies (Agric., Education, Women Affairs, Commerce, Industries.	This policy also deals with protection of important ecosystems in Nigeria, especially habitat wildlife.

irrigation, supply of improved seed (crop) and pest control (insects) as the main measures to mitigate impacts of drought in Yobe State.

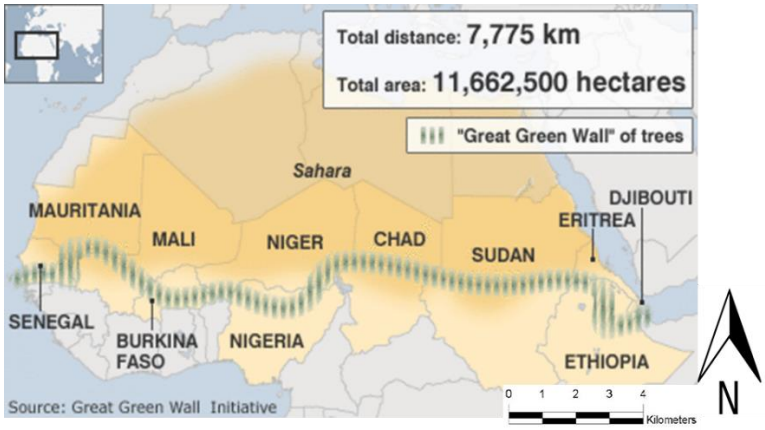

Figure 1. The Great Green Wall Project of the Sahara and Sahel (ITF, 2017)

3.1. Framework development

Based drought problems highlighted by State comprehensive drought mitigation and management is vital, thus this study advocates for holistic drought mitigation process. Sector frameworks were developed based findings from Hassan *et al* (2019). The sector frameworks were combined in a final framework ''Integrated Framework'. Both proactive (risk) and reactive (crisis) measures of drought mitigation were included in all frameworks. Possible mitigation and management strategies suggested by farmers, Ministry of the Environment officials and the literature were considered in the development of the frameworks. These strategies/measures would help provide alternative to stakeholders (farmers, communities, government and NGOs) as well as reduce cost of drought mitigation.

This research chose a 'bottom-top' approach, where farmers' suggestions were given priority. Stakeholders can choose to use the framework that will address their needs. For instance, any community, NGO and government can adopt any of the social, economic or environmental frameworks depending on their need. Preferably, all frameworks should be implemented. It is important that stakeholders should be responsible for drought mitigation and management, during and after implementation. However, in order to holistically approach drought mitigation and management, the final Integrated Framework is more suitable for implementation, as it combines management strategies for long-term mitigation. It is expected that government(s) should evaluate and then adopt the Integrated Framework.

3.2. Drought mitigation frameworks

These are measures/strategies taken to curtail the impacts of drought across Yobe State. All effects highlighted in the different sectors are expected to be mitigated using the measures or actions employed below.

a. Social impacts drought mitigation framework

These are possible measures to mitigate social effects of drought in Yobe State.

Awareness and education: Effective community and societal based awareness is important for drought mitigation. Most farmers know what drought is, and understanding it is very important to help reduce its effects. Educating farmers and people on how to prepare and manage drought before, during and after the crisis is crucial. Lack of clear consistent information affects drought mitigation (Buchanen-Smith, 2000). Awareness of when and where drought impacts will be more pronounced should be communicated to farmers and communities. Farmers should understand plantation and harvest period which is important for crop production during drought (Bodner et

al., 2015). Timely advice of types of crops to be used during a predicted episode should be communicated to farmers on time. As it will be difficult for some farmers to understand the cultivation process of the suggested crop, because most of them only stick to what they traditionally know. It is important involve stakeholders at all levels in the process if climate change adaptation and drought mitigation (Aakre et al., 2010).

Community response and structure: Farmers emphasised on community-based support systems as a means to respond to drought. Communities have responsibility to take actions to mitigate the impacts of drought. A community establishment should be created by community members, as a proactive strategy to support drought victims through a chain of leadership within communities. Willing community members should register a co-operative or association that will give them a platform, and provide opportunities for easy identification and serve as channels of intervention. The association can be tasked with collecting stipends from members during 'bumper harvests' to serve as insurance. These stipends can be given either in cash or kind, before or after drought. All cash crops contributed can be sold at lower rates to members during and after drought. Associations can venture into business with the capital or collateral provided to increase profitability, low risk businesses are suggested. Communities will be more viable and self-reliant if such structures are in place. This is also similar to a project introduced by the World Food Programme in Kenya. Farmers were asked to establish such an association to serve as a platform for invention and other drought mitigation programmes to improve their self-reliance (WFP, 2018).

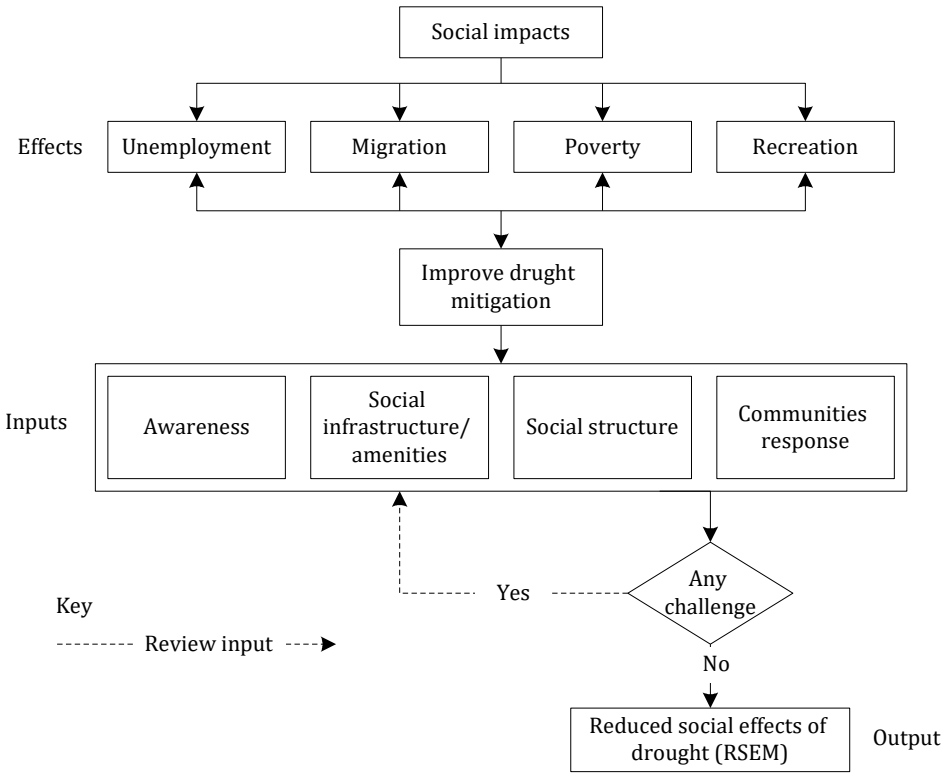

Figure 2: Social impacts mitigation framework

Social infrastructure and amenities: Most farmers highlighted that social infrastructure and amenities are vital to reduce the effects of drought. This includes proper water supply, good roads, alternative jobs and social support. Although having these and other infrastructure is not expected to solve the problems of drought, it is believed that these will reduce human suffering and induced environmental degradation (Eludoyin & Eludoyin, 2017). It is envisaged that however, these opportunities will make farmers self-reliant and create other commercial

opportunities. Figure 2 is a flowchart that shows social impacts drought mitigation framework. This shows the process to following in mitigating the impacts of drought.

b. Economic Impacts Drought Mitigation Framework

These are measures to mitigate economic effects of drought in Yobe state. These include:

Research and expertise: Research into drought (e.g. weather forecasting, drought modelling, cloud seeding, water management and improved crops) are important mitigation tools, in both the short and long-term. Research can provide up-to-date information of conditions within the State. This will also provide opportunities to discover water efficient seed varieties, animal feed and socio-climatic changes. Expert input in the process of drought mitigation is very important and can provide the most feasible approach to address to drought problems, for instance advising on agroforestry and crop rotation. These can also be addressed through collaboration efforts between academic institutions and communities. Experts will help communities improve their practises, which will also provide opportunities for research. They can also monitor people/communities progress both socially and environmentally, based on the practise.

Sustainable irrigation practise: this measure has been emphasised in both the assessment (survey and FGDs) and other many studies (e.g. Abubakar & Yamusa, 2013; Eludoyin & Eludoyin, 2017). Sustainable irrigation practise is one of the most effective strategies to curtail the impacts of drought, especially in rain-fed farming regions and it will help reduce harvest loss. It will also improve revenue generation for the State through taxation of produce sold in markets. The emphasis on adopting sustainable irrigation practise is very important to avoid depletion of water resources, water pollution and increased soil salinity. Water catchment areas can be identified in the State for project initiation (pilot project). This can also be carried out in different phases, depending on what crops grow best in different parts of the State. Training farmers on how to properly irrigate is important in order to reduce risk of improper irrigation practises.

Modern irrigation infrastructure should be provided to farmers. This equipment can help reduce water wastage and environmental degradation. However, irrigation alone cannot solve drought problems and supporting strategies should be included. Sustainable irrigation practise is important, because it assists water efficiency, uniformity and reduces contamination. Producers should evaluate their farming system, as every farm would have techniques suitable to them. Irrigation scheduling, soil and crop properties, improved irrigation technologies and managing surface irrigated fields are some sustainable irrigation practise measures (Waskom, 1994). Other pollution management measures include salinity management, crediting nitrate in irrigation, limited irrigation, landing levelling, managing application and determining leaching hazards (Waskom, 1994). Application of all these measures requires expertise and training for the project to succeed. If Yobe State opts for irrigation as a mitigation measure, then feasibility studies should be conducted (analyse soil fertility and salinity risks). If such measures are not employed, there is the possibility of increasing land degradation. Irrigation requires accessible water for it to succeed and the hydrogeology of the State has shown the potential to irrigate using ground-water (Dawoud & Raouf, 2009; Musa, 2011).

Fertilizer supply: During the FGD with farmers they emphasised their need to have access to fertilizers. Providing affordable inorganic fertiliser would improve growth and reduce harvest delays and showed that usage of fertilizer increase yield. Long gaps between rainfall events in a season cause much crop damage. It is important to educate farmers on proper timing and quantity of fertiliser applications. Inappropriate timing and quantities can diminish fertiliser efficiency. Organic fertilisers can be improved and used to reduce environmental effects of fertiliser application. Inorganic fertilisers need water in order to penetrate into the soil. According to Yobe rainfall data there is rainfall every year despite the general decrease.

Supply of improved seeds: Farmers emphasised their need to access improved crop seeds that can withstand or resist drought, to help reduce their harvest loss and increase harvest yield.

Collaborating with State and Federal Agricultural Research Institutes, universities and various Ministry of Agriculture (Federal and State) will help produce improved seeds through

Pest control: It is important that controlling pest invasions is given priority. For exotic insect pests, establishing classical biological control should be a priority, particularly in perennial or stable habitats. Types of invading pests should be identified across the State and the most suitable environmentally-friendly pest control techniques should be adopted. Both FGD sessions established that pest control is vital in the State.

Access to market: In order for farmers to be more self- reliant it is advisable they diversity their sources of income to reduce risks of drought shock. They should be trained and be given opportunities to access markets with their farm produce.

Establishing food reserves: food reserves are important both before and during drought. Establishing and managing food reserves slow increases in food prices during drought and play vital roles in supplying areas critically in need (Abubakar & Yamusa, 2013). Government or communities can create programmes where after every harvest, farmers can sell some of their crops to the reserves, where during drought food can be subsidised. Collaborating with the Federal Food Reserves of the Federal Ministry of Agriculture will increase the efficiency and scope of food reserve programmes.

Loans/insurance: Farmers strongly agreed that loans or insurance can mitigate drought shock during and after events. Providing loans and insurance to drought victims (farmers) will serve as a safety net. Providing enabling environments through approved platforms can allow access to loans from either commercial banks or government agencies, especially during extreme events. The loans can support farmers' diversify and provide opportunities to access mechanised equipment.

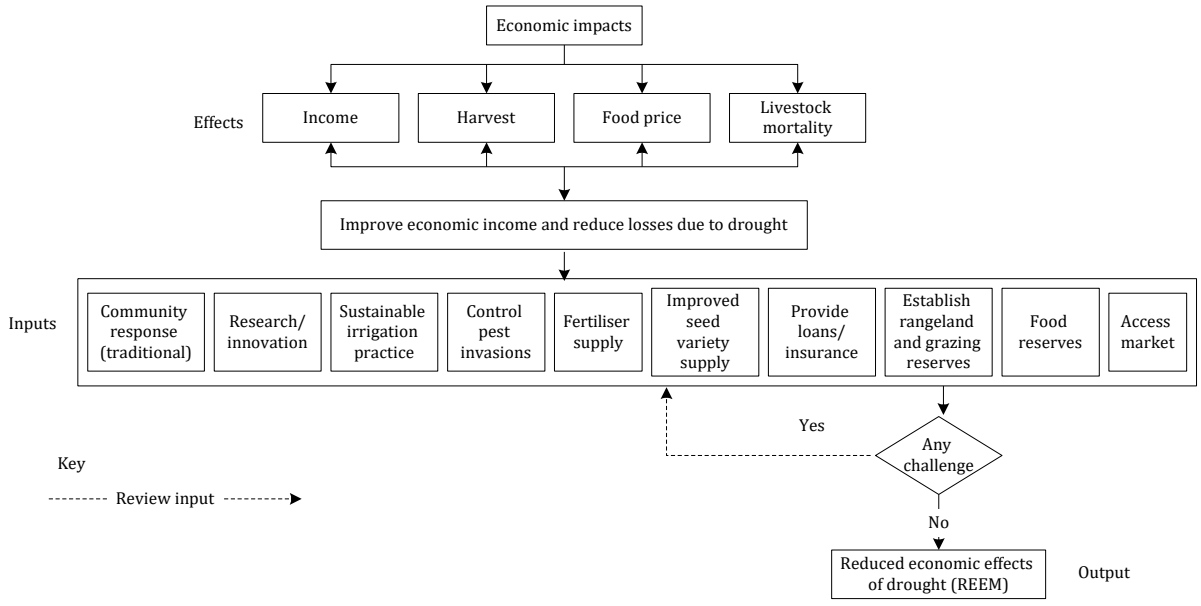

Figure 3. Economic Impacts Mitigation Framework.

Insurance for farmers will provide alternative support to withstand drought shock. If possible, it will help them establish other sources of income, instead of selling their livestock and resorting to environmental degradation. Australia has introduced insurance for drought victims and it proved successful for proactive drought mitigation. These are actions and strategies that would be in place for farmers before drought events. Figure 3 is the flowchart of the Economic Impacts Drought Mitigation Framework.

Grazing reserves: Creating grazing reserves for farmers rearing livestock with proper infrastructure will serve as sources for animal feed before, during and after droughts. Daily Trust (2018) reported conflicts between farmers and herdsmen. Educating farmers and herdsmen on the importance of destocking and using grazing reserves will reduce such problems. Fertile lands within the State can be used to establish grazing reserves for pastoralists, thus reducing over-grazing of marginal land and environmental degradation. Proper infrastructure should be provided within the reserves, for example, water supply and fences to restrict livestock movements. Using fertile land will require significant amount of rainfall to maintain the reserve.

c. Environmental Impacts Drought Mitigation Framework

These are measures to mitigate impacts of environmental drought effects in the State.

Afforestation and reforestation: Establishing and restoring forests is important to reverse environmental degradation and provide habitats to affected organisms. This can also be done by empowering local farmers to grow seeds in nurseries and be given incentives. This has worked in some communities in north-west Nigeria, as part of efforts to combat desertification (FME, 2012). Forest ecosystems provide numerous environmental services, including reducing soil erosion and desertification and increasing soil organic carbon content. However, reforestation requires proper management and sustainable environmental law enforcement to improve forest protection. These measures have yielded positive results in other countries.

Crop rotation and timing: For proper soil management and land use, crop rotation and timing are vital. Crop rotation usually helps maintain soil fertility and serves as an alternative if there is no access to improved seed varieties. Timing of planting is important, as improper timing can exacerbate drought impacts. These techniques improved soil fertility in semi-arid region in Kenya (FAO, 2018). Engaging farmers in these practises will stress the importance of environmental stewardship.

Conservation of water resources: Maintaining and managing water resources in the State is important for water security and will enable the implementation of many drought mitigation measures (e.g. irrigation, grazing reserves and afforestation). Conserving both surface and subsurface water resources will reduce water pollution and habitat disturbance.

Woodlot establishment: Many people fell trees as a drought-coping strategy to reduce income shock. Establishing woodlots for fuel-wood will reduce this pressure. These woodlots can be established in different parts of the State, to allow access to many people. This will also reduce risks of wildlife habitat loss. Lack of access to electricity, cooking gas and cooking fuel/kerosene leaves people with no option, but to cut down trees for energy in their homes for cooking and heating during the cold season. However, some people use trees as timber for construction. Thus, woodlots will provide alternative sources of fuel-wood for energy and construction.

Reduce hunting of wildlife: Preventing wildlife vulnerability and extinction is very important in current environmental conservation measures. Farmers often resort to hunting during drought. However, effective and managed hunting is commendable as a conservation measure. According to MoE official problems of illegal hunting and poaching of wildlife is a major issue in the State and there is no proper law enforcement to prevent these activities.

Land use management: Bush burning, overgrazing and over-harvesting have been some of the major environmental threats in the State. Proper land use management will improve land use, reduce land degradation and desertification. Improper land management will increase the risks of desert encroachment in communities, which render farmlands infertile for harvest.

Law enforcement: This strategy would play a vital role in reducing environmental degradation in the State. Officials from the Ministry of Environment emphasised proper law enforcement, especially regarding deforestation and poaching. However, for the law to be implemented and

enforced, alternative sources of energy and means of livelihood are needed. The Environmental Mitigation Framework is presented in Figure 4.

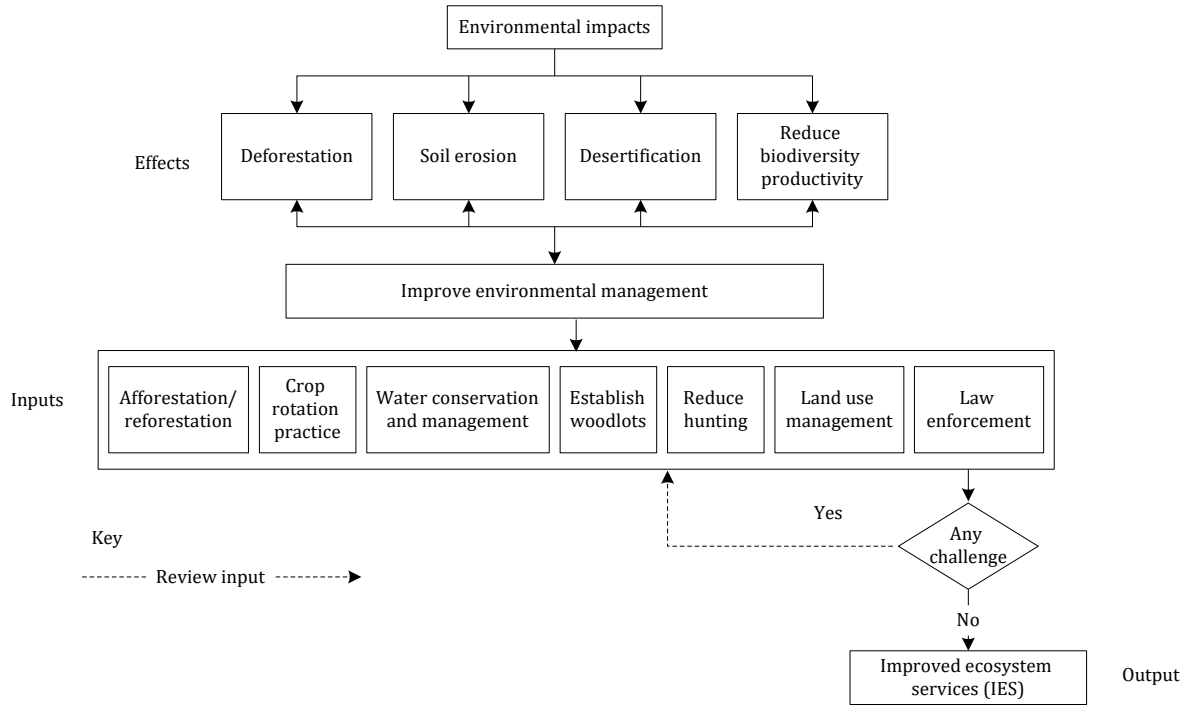

Figure 4. Environmental impacts mitigation framework

Communities and government can sign a commitment agreement where both parties will ensure that they play their part in drought mitigation programmes. This will also reduce negligence by both parties.

3.3. Sector frameworks implementation

Some major steps need to be taken to implement the Frameworks (Table 3). All the frameworks should be implemented at community levels. Implementing the Integrated Framework will assist proactive processes of drought mitigation in Yobe State.

Table 3. Sector frameworks implementation process

No. steps	Strategies	Actions
1	Identify areas that need intervention	Needs assessment should be conducted before, during or after drought to identify areas that need intervention. This is to help reduce the cost of implementation and ensure areas of need are covered.
2	Community structure	All communities that need intervention must have a platform or structure for easy intervention and support. This will make it easier to educate and provide support.
3	Awareness	Step 3 is to educate farmers on the need for the projects and how they can maintain them. Every strategy requires the provision of farmers education.

3.4. Drought management strategies

These are strategies to mitigate and manage drought in the State, and should prioritise proactive measures.

Early Warning Systems: These can be established to generate timely information and build needed capacities prior to drought. Providing drought Early Warning Systems in Yobe State will mitigate both drought impacts and reduce direct environmental degradation. Reliable

information is a major parameter for adequate Early Warning Systems which can be achieved by having infrastructure to support the systems. Establishing weather stations within all LGAs in the State with advance drought forecasting tools are integral to Early Warning Systems. This is important to improve prediction of drought onset, cessation, duration and distribution. The Yobe State Government can share data with the NiMET. This research has identified both socio-economic and climate parameters to project and assess drought impacts in Yobe State including harvest output, livestock mortality, migration due to harvest losses, water levels, rainfall, temperature and humidity.

These parameters can be used to develop a drought projection and impact tool. Sowing and harvesting time can be projected and assessed with proper Early Warning Systems to reduce harvest losses. The Nigerian Government is improving Early Warning Systems by providing well equipped weather station in drought and flood affected areas (FGN, 2005). These are signs of failed government efforts in implementing drought proactive mitigation policies, as much necessary infrastructure is not available in the State. Early Warning Systems should be integral parts of decision making and drought mitigation (Wilhite, 2005).

Preparedness: Having Early Warning Systems should be complimented by proper action plans. Proper planning measures are necessary before, during and after events, to enable speedy recovery. Community and individual resilience can be achieved with prepared action plans. Expected vulnerable areas of potential drought impacts and their extent can be identified with proper preparedness measures.

Communication: Effective Early Warning Systems and preparedness require adequate communication systems. Communication gaps and inconsistency can be the difference between mitigating extreme drought impacts and having major losses (Wilhite, 2016).

During the FGD some officials raised concerns on the problem of communication gaps between farmers, residents and government. For example, the problems of deforestation were communicated to people, but remain a problem in the State. In order to have adequate communication there is a need to have structures that can channel information from the government through regions, local governments and communities in the State. TV, radio stations and the internet, social media provide important communication tools. Increasing awareness and educating people on drought can help bridge communication gaps. This is important because of cultural and religious barriers; some people will not believe information provided (West et al., 2008), especially weather forecasts. The conflict between science, culture and religion are major challenges to achieving effective communication. These problems can be addressed through consistent public awareness via community and religious leaders.

Social welfare*:* Farmers strongly agreed that social welfare can mitigate the effects of drought in the State. This action can only be taken by governmental organisations, because it is expensive. Providing social systems that support drought victims without financial repayment will decrease both poverty and environmental degradation. Severely affected farmers can be prioritised for this type of support (Eludoyin & Eludoyin, 2017; Jenkins, 2012; Wossen et al., 2017).

Relief materials: Supplying relief items during and after drought has been the major action taken by the State Government; but has proved unsuccessful. Shifting to proactive measures is expected to be more effective. Some of the major challenges of using relief are timely intervention and quantity. Most interviewed farmers never received relief or support. Most relief items usually arrived late and were insufficient for the affected people. Transportation and accessibility can also pose problems for delivering relief and social amenities and infrastructure play vital roles.

Water management: Having an effective water management strategy is essential. Water management should be regulated by government agencies to minimise waste and create awareness of the importance of water conservation. The water management strategy should

include projection of population growth and water needs. Rain harvest provides important water management tools and irrigation to encourage water stewardship.

Drought mitigation task force: Government find it difficult to treat drought as multi-sectoral issues. In order to treat and properly implement drought mitigation in Yobe State, a task force should be established by the State Government. The task force should bring together experts (from various government agencies and academic institutions), policy and decision makers', representatives of community, platforms and traditional leaders. The task force should also assist in proper interpretation and dissemination of information and help reduce drought mitigation costs.

3.5. Drought policy as part of the framework

Drought policy is an essential part of the Integrated Drought Mitigation and Management Framework, but requires political will for implementation. The Framework can be adopted without it being a policy, but this will limit its effectiveness. MoE officials recommended that the Framework becomes Government policy if it proved successful. The framework should be further reviewed before adoption as government policy.

3.6. The Integrated Framework

The Integrated Framework comprises of *inputs* and *outcomes*, whereas the sector frameworks have *effects*, *inputs* and *outputs*. It is referred to as an Integrated Framework as it comprises only the outputs of all the sector frameworks. The Integrated Framework can only be implemented if the other three sector frameworks are implemented. Understanding the three frameworks will provide clear knowledge of the Integrated Framework.

Input 1: these are the outputs of the Socio-economic and the Environmental Frameworks and drought management through Early Warning Systems. All sector drought effects are addressed in the three sector frameworks. The Integrated Framework uses the outputs from the three sector frameworks to mitigate and manage drought impacts.

Input 2: these are proposed strategies used in the Integrated Framework, which will help achieve the desired outcomes. It comprises of policy, drought mitigation task force and implementation challenges.

Outcome: the final outcome of the Integrated Framework is to achieve sustainable drought management that will improve living conditions, achieve productive communities and improve environmental conditions that can help communities cope with future extreme weather events. This is a long-term outcome which can only be achieved by consistency in drought mitigation actions and management.

Implementing the integrated framework means that holistic and the most suitable measures of drought mitigation are considered. In order to have sustainable drought mitigation and management that secures both environmental quality and socio-economic growth, implementing the Integrated Framework is vital. The whole process can be achieved by reviewing and evaluating the measures during and after implementation. If there is the intention to make it a policy, then challenges should be addressed. The robustness of the Framework determines its level of achievement. However, to achieve mitigation management, reviews, monitoring, evaluation and research into drought problems is recommended.

3.7. Importance of implementing the Integrated Framework

Implementing the Framework for drought mitigation and management is challenging. Taking only some of the strategies within the Framework to combat drought impacts would not yield expected results. For example, farmers believed that irrigation, relief and water supply or afforestation would mitigate drought. However, integrating the complete Framework strategies would be more effective in combating droughts. The framework will assist in providing drought

contingency plans before, during and after droughts. The use of satellites and other remote sensing technologies to project and monitor drought would be vital. It is important to have both short and long-term drought management due to *resource* and *cultural* constraints. There are numerous challenges and constraints related to implementing the Framework, including: infrastructure, resources, planning and expertise.

The presence of adequate infrastructure will support implementation, including technologies and experts at weather stations. Some strategies are capital intensive, this is one of the reasons the frameworks are split. Expertise is required in order to implement some of the strategies, for example, irrigation through sustainable practises and drought prediction. Without proper and timely planning, even after implementing the Framework, success would not be achieved. This could be due to poor timing and intervention. It is recommended that communities and NGOs can use any of the sector frameworks.

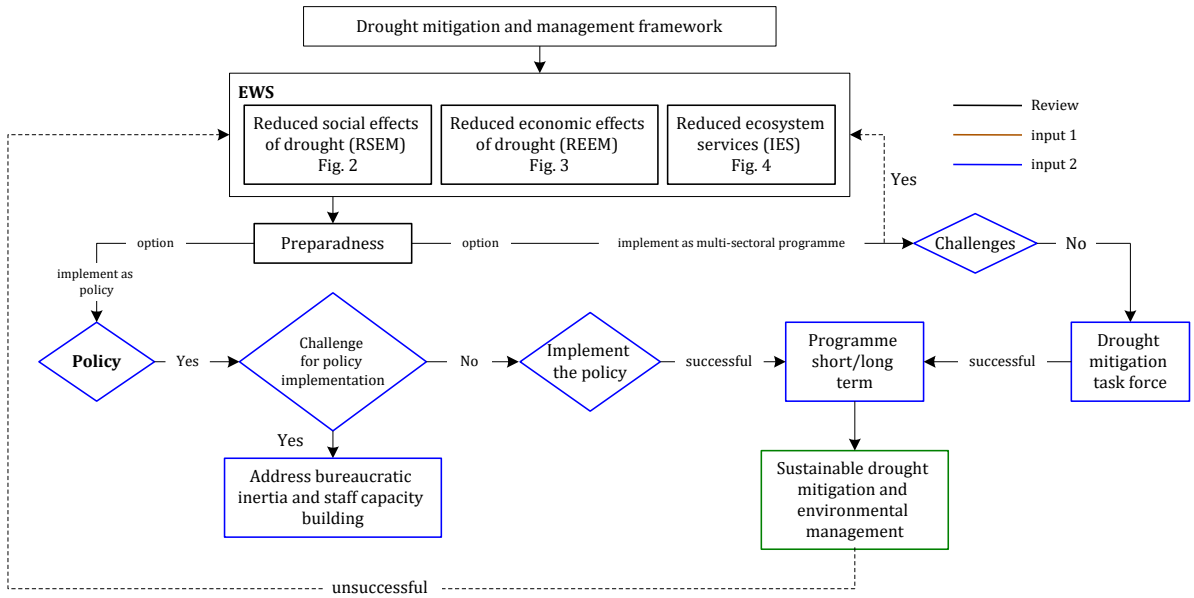

Figure 5. Integrated Framework.

3.8. Framework evaluation process

In order to assess the robustness, transferability and workability of the frameworks, a before-use evaluation was conducted. This was done to assess the extent to which effects of drought can be mitigated in Yobe State. Participants from the Ministry of Environment and farmers were invited to evaluate the proposed frameworks. The frameworks were presented in the form of flowcharts, with detailed descriptions given to the Ministry of Environment officials. For the farmers, the sector frameworks were presented for evaluation, whereas officials from the Ministry of Environment were requested to evaluate all the frameworks.

4. Conclusion

Studies have shown that drought research is important, especially in regions with extreme climate variability (HMNDP, 2013; Mishra et al., 2015; Mishra & Singh, 2011; Wilhite, 2005). This research reviewed the literature on the effects of drought. Generally, drought has received insufficient global attention, thus affecting the mitigation measures (HMNDP, 2013). In Nigeria, Shiru et al. (2018) suggest that drought has been increasing in Nigeria and particularly in Yobe State. In Nigeria, there have been several policies and efforts, but most failed to address the impacts of drought. The Nigerian Government needs to change its approach and improve efforts to mitigate the impacts of drought. Lack of political will, corruption and weak institutions caused the failures of many policies and strategies. Other factors that negatively affected government policies' implementation in the study area (Yobe State) include insufficient funds, bureaucratic processes and capacity. Different measures have been undertaken to mitigate and manage the

impacts of drought. Some Sahelian countries have not focused on providing safety nets to farmers in the region (Shiferaw et al., 2014).

The research collected data on the impacts of drought in Nigeria, with emphasis on Yobe State. The results showed that drought has negatively affected many farmers in Yobe, of which most solely relied on agriculture for their livelihoods, often most of their harvests and livestock have been lost. Farmers in the State find it difficult to afford basic necessities. Farmers often migrate and leave their families behind, very few were able to move with their families. This is affecting their way of life and making them more vulnerable to future droughts.

Drought is a major challenge to many communities and farmers in Yobe State. Most farmers in Yobe State have no alternative measures to reduce drought shock, as farming is their sole source of income and is extremely challenged by severe droughts in the State. Their means of coping with drought is through improper agricultural practises that cause land degradation. Farmers stated that their major problem is rainfall, which they said has been inconsistent in recent years. Droughts in Yobe State have led to mortality of livestock, severe harvest losses and pest invasions.

Predicted climate-related events will increase in the future, thus, drought mitigation is vital to avoid humanitarian crises. This research argues that drought management in Nigeria needs to be proactive to reduce costs, and impacts on communities and the environment. Stakeholders and governments need to step up to reduce drought impacts, as traditional and reactive measures are not working at community levels. It is believed that the frameworks proposed would assist drought mitigation and management in Yobe State. Hence, if the proposed frameworks are implemented, they could reduce farmers' drought shock by improving their living conditions and thus reducing poverty. At the same time, the application of the frameworks will reduce excessive environmental degradation and improve environmental management in Yobe State.

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References

Aakre, S., Banaszak, I., Mechler, R., Rübbelke, D., Wreford, A., & Kalirai, H. (2010). Financial adaptation to disaster risk in the European Union. *Mitigation and Adaptation Strategies for Global Change*, *15*, 721–736. https://doi.org/https://doi.org/10.1007/s11027-010-9232-3

Abdullahi, A. B., Iheanacho, A. C., & Ibrahim, A. (2007). Econometric analysis of the relationship between drought and millet production in the arid zone of Nigeria: A Case Study of Borno and Yobe States. *Journal of Agriculture and Social Sciences*, *2*(3), 170–174.

Abubakar, I. U., & Yamusa, M. A. (2013). Recurrence of drought in Nigeria: causes, effects and mitigation. *International Journal of Agriculture and Food Science Technology*, *4*(3), 169–180.

Agnew, C., & Warren, A. (1996). A framework for tackling drought and land degradation. *Journal of Arid Environments*, *33*(3), 309–320. https://doi.org/https://doi.org/10.1006/jare.1996.0067

Alston, M., & Kent, J. (2008). The Big Dry: The link between rural masculinities and poor health outcomes for farming men. *Journal of Sociology*, *44*(2), 133–147. https://doi.org/https://doi.org/10.1177/1440783308089166

Batterbury, S., & Warren, A. (2001). The African Sahel 25 years after the great drought: assessing progress and moving towards new agendas and approaches. *Global Environmental Change*, *11*(1), 1–8. https://doi.org/https://doi.org/10.1016/S0959-3780(00)00040-6

Bodner, G., Nakhforoosh, A., & Kaul, H.-P. (2015). Management of crop water under drought: a review. *Agronomy for Sustainable Development*, *35*, 401–442. https://doi.org/https://doi.org/10.1007/s13593-015-0283-4

Buchanen-Smith, M. (2000). Role of Early Warning Systems in Decision-Making Processes. In *Journal of Chemical Information and Modeling*.

Daily Trust. (2018). *Pastoralist-Farmers Conflicts and the Search for Peaceful Resolution*. https://www.dailytrust.com.ng/pastoralist-farmers-conflicts-and-the-search-for-peaceful-resolution.html

Dawoud, M. A., & Raouf, A. R. A. (2009). Groundwater Exploration and Assessment in Rural Communities of Yobe State, Northern Nigeria. *Water Resources Management*, *23*, 581–601. https://doi.org/https://doi.org/10.1007/s11269-008-9289-x

Eludoyin, A. O., & Eludoyin, O. M. (2017). Drought Mitigation Practices, Ch. 19. In S. Eslamian & F. Eslamian (Eds.), *Handbook of Drought and Water Scarcity, Vol. 3: Management of Drought and Water Scarcity* (pp. 391-403.). Francis and Taylor.

FAO. (2018). *Conservation agriculture in Kenya: beating drought and poor harvest. Helping women farmers reach markets - sustainably*. http://www.fao.org/fao-stories/article/en/c/1100298/?utm_content=bufferb2499&utm_medium=social&utm_source=linkedin.com&utm_campaign=buffer

Feyen, L., & Dankers, R. (2009). Impact of global warming on streamflow drought in Europe. *Journal of Geophysical Research: Atmospheres*, *114*(D17), 17–34. https://doi.org/https://doi.org/10.1029/2008JD011438

FGN. (2005). *Committee for the Review of the Implementation of the Convention (CRIC). Combating desertification and mitigating the effects of drought in Nigeria, National Report on the Implementation of the United Nations Convention to Combat Desertification in Countr*.

FME. (2012). *Great Green Wall for the Sahara and Sahel initiative. National Strategic Action Plan*. Federal Ministry of Environment. https://www.fao.org/3/av139e/av139e.pdf

Ghai, D. (1990). The social dynamics of environmental changes in Africa, Whydah Africa Academic Science. *Newsletter*, *21a*, 1–8.

Hassan, A. G., Fullen, M. A., & Oloke, D. (2019). Problems of drought and its management in Yobe State, Nigeria. *Weather and Climate Extremes*, *23*(January), 100192. https://doi.org/10.1016/j.wace.2019.100192

HMNDP. (2013). *International Conference Centre (CICG)*.

ITF. (2017). *The Great Green Wall for the Sahara and the Sahel*. http://internationaltreefoundation.org/the-great-green-wall-for-the-sahara-and-the-sahel/

Jenkins, K. L. (2012). *Modelling the Economic and Social Consequences of Drought under Future Projections of Climate Change* [University of Cambridge]. https://doi.org/https://doi.org/10.17863/CAM.16425 Abstract

Keshavarz, M., Karami, E., & Vanclay, F. (2013). The social experience of drought in rural Iran. *Land Use Policy*, *30*(1), 120–129. https://doi.org/https://doi.org/10.1016/j.landusepol.2012.03.003

Medugu, N. I. (2009). *Nigeria and the advancing Desert*. Environmental Synergy World Press.com.

Mishra, A.K, Sivakumar, B., & Singh, V. (2015). Drought processes, modelling, and mitigation. *Journal of Hydrology*, *526*, 1–2. https://doi.org/10.1016/j.jhydrol.2015.03.054

Mishra, Ashok K., & Singh, V. P. (2011). Drought modeling – A review. *Journal of Hydrology*, *403*(1–2), 157–175. https://doi.org/https://doi.org/10.1016/j.jhydrol.2011.03.049

Msangi, J. P. (2004). Drought hazard and desertification management in the dry lands of southern Africa. *Environmental Monitoring and Assessment*, *99*, 75–87. https://doi.org/https://doi.org/10.1007/s10661-004-4002-x

Musa, H. D., & Shaib, B. (2010). Integrated remote sensing approach to desertification monitoring in the crop-rangeland area of Yobe State, Nigeria. *Journal of Sustainable Development in Africa*, *12*(5), 236–250.

Musa, K. (2011). *Groundwater occurrence in Damaturu and its environs Yobe state, north eastern Nigeria*. Ahmadu Bello University Zaria, Nigeria.

Nwokocha, C. O. (2017a). An Appraisal of the Strategies Implored by Government to Combating Drought and Desertification in the North-East Geo-Political Zone, 2004-2014. *Review Pub Administration Manag*, *5*(205), 2.

Nwokocha, C. O. (2017b). The Challenges Facing the Effective Implementation of Drought and Desertification Policy in North-East Geo-political Zone of Nigeria. *Arts and Social Sciences Journal*, *8*(4), 289. https://doi.org/DOI: 10.4172/2151-6200.1000289

Oladipo, E. O. (1993). A comprehensive approach to drought and desertification in Northern Nigeria. *Naural Hazards*, *8*, 235–261. https://doi.org/https://doi.org/10.1007/BF00690910

Olagunju, T. E. (2015). Drought, desertification and the Nigerian environment: A review. *Journal of Ecology and The Natural Environment*, *7*(7), 196–209. https://doi.org/https://doi.org/10.5897/JENE2015.0523

Olsson, L. (1993). On the Causes of Famine: Drought, Desertification and Market Failure in the Sudan. *Ambio*,

22(6), 395–403. https://doi.org/https://www.jstor.org/stable/4314110
Prăvălie, R. (2016). Drylands extent and environmental issues. A global approach. *Earth-Science Reviews*, *161*, 259–278. https://doi.org/https://doi.org/10.1016/j.earscirev.2016.08.003
Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B. M., & Menkir, A. (2014). Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options. *Weather and Climate Extremes*, *3*, 67–79. https://doi.org/https://doi.org/10.1016/j.wace.2014.04.004
Shiru, M. S., Shahid, S., Alias, N., & Eun-Sung, C. (2018). Trend Analysis of Droughts during Crop Growing Seasons of Nigeria. *Sustainability*, *10*(3), 871. https://doi.org/https://doi.org/10.3390/su10030871
Terhile, A. (2017). *Desert encroachment and security challenges in North East Nigeria*. University of Calabar, Nigeria.
Vicente-Serrano, S. M., Beguería, S., Gimeno, L., Eklunh, L., Giuliani, G., Weston, D., Kenawy, A. El, López-Moreno, J. I., Raquel Nieto, Ayenew, T., Konte, D., Ardö, J., & Pegram, G. G. S. (2012). Challenges for drought mitigation in Africa: The potential use of geospatial data and drought information systems. *Applied Geography*, *34*, 471–486. https://doi.org/https://doi.org/10.1016/j.apgeog.2012.02.001
Waskom, R. W. (1994). *Best Management Practices For Irrigation Management*. Colorado State University Cooperative Extension.
West, C. T., Roncoli, C., & Ouattara, F. (2008). Local perceptions and regional climate trends on the Central Plateau of Burkina Faso. *Land Degradation & Development*, *19*(3), 289–304. https://doi.org/https://doi.org/10.1002/ldr.842
WFP. (2018). *How Farmers in Kenya Are Beating the Effects of drought.*
Wilhite, D. A. (2005). *Drought and Water Crises*. CRC Press. https://doi.org/https://doi.org/10.1201/9781420028386
Wilhite, D. A. (2016). Drought-management policies and preparedness plans: changing the paradigm from crisis to risk management. In *Land Restoration: Reclaiming Landscapes for a Sustainable Future* (pp. 443–462). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-801231-4.00007-0
Wilhite, D. A., Svoboda, M. D., & Hayes, M. J. (2007). Understanding the complex impacts of drought: A key to enhancing drought mitigation and preparedness. *Water Resources Management*, *21*, 763–774. https://doi.org/https://doi.org/10.1007/s11269-006-9076-5
Wilhite, D., & Pulwarty, R. (2005). Drought and water crises: lessons learned and the road ahead. In Donald A. Wilhite (Ed.), *Drought and Water Crises: Science, Technology, and Management Issues*. CNC Press, Taylor & Francis.
Wossen, T., Abdoulaye, T., Alene, A., Feleke, S., Menkir, A., & Manyong, V. (2017). Measuring the impacts of adaptation strategies to drought stress: The case of drought tolerant maize varieties. *Journal of Environmental Management*, *203*(1), 106–113. https://doi.org/https://doi.org/10.1016/j.jenvman.2017.06.058
Zimmerman, F. J., & Carter, M. R. (2003). Asset smoothing, consumption smoothing and the reproduction of inequality under risk and subsistence constraints. *Journal of Development Economics*, *7*(1), 233–260. https://doi.org/https://doi.org/10.1016/S0304-3878(03)00028-2