

SCENARIO DEVELOPMENT FOR NIGER ENVIRONMENT BASED ON RISK AND EFFECT
ANALYSIS WITH DROUGHT, DROUGHT RESPONSE, AND POPULATION GROWTH AS DRIVERS

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Scenario development for Niger environment based on risk and effect analysis with drought, drought response, and population growth as drivers

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ABSTRACT

Niger is a landlock country located within the Sahara Desert and Sahel region. The region is subject to extreme climate conditions including heat waves, droughts and floods. Rapid population growth together with institutional incapacity and poor adaptive capacity can exacerbate the consequences of extreme climate. This paper develops four scenarios for the Niger environment based on risk and effect analysis with drought, drought response, and population growth as drivers. Scenario 1 (long-term drought, ineffective institution, rising population) would result in high risks of socioeconomic and environmental consequences as compared to scenarios 2 (long-term drought, effective institution, controlled population growth), 3 (highly variable climate, ineffective institution, rising population), and 4 (highly variable climate, effective institution, controlled population growth). However, with effective social and economic policies, these climatic and environmental conditions could be an opportunity for the country to develop and improve the living conditions of communities.

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LIST OF ABBREVIATIONS

BCPN	Bilan Commun de Pays du Niger
CCA	Cellule Crises Alimentaires
CNEDD-NDT	Conseil National de l'Environnement pour un Développement Durable-Neutralité en matière de Dégradation des Terres
CNEDD-PNS.....	Conseil National de l'Environnement pour un Développement Durable-Plan National Sècheresse
CNEDD-TCN	Conseil National de l'Environnement pour un Développement Durable-Troisième Communication Nationale
DNPGCA	Dispositif National de Prévention et de Gestion des Crises Alimentaires
IUCN.....	International Union for Conservation of Nature
PANA	Programme d'Action National pour l'Adaptation aux changements climatiques
PKRESMIN-EIESA-RE.....	Programme Kandadji de Régénération des Ecosystèmes et de Mise en valeur de la vallée du Niger-Etude d'Impact Environnemental et Social Actualisée Résumé Exécutif
RGP/H-RSSF.....	Recensement General de La Population et de L'Habitat Rapport sur la Situation Socioéconomique des Femmes
SNAE	Stratégie Nationale d'Accès à l'Electricité
UICN	Union Internationale pour la Conservation de la Nature

1. INTRODUCTION

1.1. Country overview

Niger Republic is a landlock country located in West Africa with 1 267 000 km² of landmass (CNEDD-PNS 2019). It is bordered by Libya and Algeria to the North, Nigeria and Benin to the South, Mali and Burkina Faso to the West, and Chad to the East (CNEDD-TCN 2016). Niger is the largest country in West Africa and the fourth largest on the African continent. More than half of its territory is covered by the Sahara Desert with the vast majority of its population (more than 80%) living in rural areas (Afifi 2011). The population of Niger was estimated at 17 138 707 people in 2012 (RGP/H-RSSF 2012). Colonized by France, it gained its independence in 1960 with French being the official language. The demographic makeup is diverse and is composed of different ethnic groups which include Hausa, Sonraï-Djerma, Tamashek, Fulani, Kanuri, Boudouma, Gourmantche, Tubu, and Arabs (CNEDD-TCN 2016). The culture and traditions are strongly influenced by Islam which is the main religion practiced by 99% of the population (Planification familiale au Niger 2012).

The fact that its territory is largely covered by the desert might be the reason why the population density is much higher in the southern parts of the country. Indeed, climate and environmental conditions have not only shaped the population density distribution, but they have contributed to influencing the land use pattern and species richness across the country as well. This leads to 75 % of the population living on only 40% of the territory (Planification familiale au Niger 2012). The W National Parc and many protected biodiversity reserves (Gadabéji, Tamou, Dosso) are located in the southern parts of the country (UICN-Parcs et réserves du Niger 2010).

The climate is characterized by two major seasons: the dry season between October and May and the rainy season from June through September (PANA 2006). Evapotranspiration is very high, ranging between 1700 and 2100 mm (CNEDD-TCN 2016). The amount of precipitation varies significantly across the country ranging on average between 700 mm and to almost 0 mm from south to north (see Figure 1). The soils are generally sandy or sandy clayey, and mostly poor in nutrients (Sivakumar et al. 1993). In terms of landcover, Niger is home to approximately 1,600 of plant species (PANA 2006). The fauna is also rich with 168 species of mammals, 512 bird species, 150 reptiles and amphibians, 112 fish species, and many invertebrates such as mollusks and insects (PANA, 2006). Domestic animals in the

north are generally composed of hardy animals which can withstand difficult climate and environmental conditions. These include camels, goats, donkeys; while sheep and cows are the most common domestic animals encountered in the southern parts of the country. In addition, the types of crops cultivated also vary: millet, sorghum, and cow pea cultivated under rainfall are mainly produced in the south. Irrigation agriculture which includes potato, onion, orange, watermelon, tomato, etc. is practiced both in the south and north.

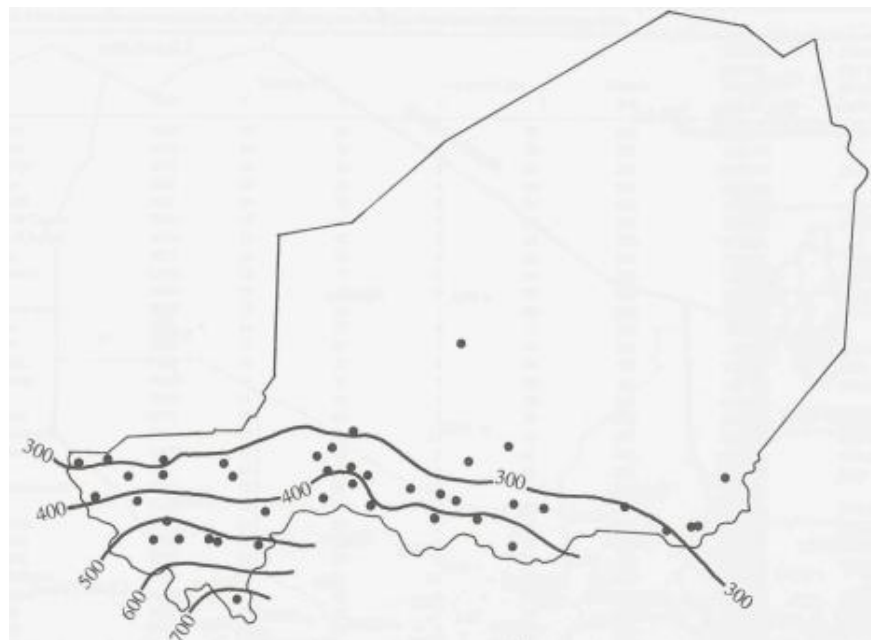


Figure 1: Average annual rainfall distribution in mm.
(Source: Sivakumar et al. 1993).

Beside agriculture and livestock farming, forest and fisheries are also practiced by communities in the Niger River, Komadougou, Lac Chad, and other water bodies. The rural sectors (agriculture, livestock, forest, and fisheries) contribute approximately 44% to the country's GDP, while the secondary (industries, mining) and tertiary (commerce, finances) represent respectively 20% and 33% of the GDP (CNEDD-TCN 2016). However, despite the rich potential in terms of natural resources such as uranium, oil, gold and coal, Niger is among the poorest countries in the World (CNEDD-TCN 2016).

1.2. Definitions

1.2.1. Definition of drought

The National drought mitigation center (<https://drought.unl.edu/Education/DroughtIn-depth/WhatisDrought.aspx> June 2021) defines drought from two different perspectives which include the conceptual approach and the operational approach. From the conceptual perspective, drought is considered to be an extended period of rainfall deficit with extensive damaging effects on agriculture. From the operational point of view, drought is defined based on the way it functions, including its starting and ending periods as well as its level of severity. It is a natural phenomenon which is typical to all climatic and weather systems (Ding et al. 2010). Drought is a recurring (Wilhite 2000) and slow-moving process with rippling effects that affects many economic sectors (Wilhite et al. 2007). Beyond its frequency of occurrence, three other distinctive elements characterize droughts: intensity, duration and spatial extent (CNEDD-PNS 2019). Compared to other natural disasters, drought may be considered as the one that is least understood which affects more people than any other natural phenomenon (Hagman et al. 1984). Droughts have significant impacts on environment, humans and their socioeconomic activities. These impacts include reduction of livestock, fishery and agricultural production, conflicts between resources users, land degradation and loss of biodiversity, etc. (Wilhite et al. 2005).

Despite the damaging effects and recurring nature of droughts, there is not a single agreed upon definition of the concept of drought. Zarch (2015) links drought to a deficiency of rainfall, particularly with respect to its distribution, duration, and intensity in relation to water availability and demand. Motha (2000) describes four types of droughts namely meteorological, agricultural, hydrological, and socioeconomic drought. Meteorological drought occurs when the amount of precipitation over a specified period of time is below a certain threshold resulting from rainfall deficit. Agricultural drought refers to a condition where there is a lack of enough moisture in the soil for crops, vegetation, etc. Hydrological drought relates to a shortage of water supply systems (aquifers, river drainage, etc.). Socioeconomic drought is related to the impacts of droughts on humans and their social and economic activities.

1.2.2. Definition of scenario

Since time immemorial, human beings have been interested in understanding what the future might look like (Durance and Godet 2010). Yet, it is almost impossible to escape from the challenge that our knowledge and experience are all about the past, while the decisions we make are all about the future (Ratcliffe 2000). Therefore, studying the future is not only about knowledge and facts, but it also considerably involves making conjectures (Ratcliffe 2000). Thus, developing techniques to expand the scope of our thinking could be of extreme importance. Scenarios represent a technique that can help achieve that purpose under different assumptions of future conditions (Mahmoud et al. 2009). However, scenarios are not designed to predict the future. They are built in order to understand how critical uncertainties might interact with one another and unfold in a surprising way (Bowman et al. 2012).

There are two main approaches to scenario building, namely the inductive and the deductive method (Bowman et al. 2012). The inductive method uses a bottom-up technique. It starts with available data and information that allow the scenarios to develop in a cohesive and incremental manner. The deductive approach on the other hand, utilizes a top-down strategy. It evolves through a broad framework of imposed plausible future outcomes and proceeds by refining them with data and information. The number of scenarios to build is such that it provides enough information and relevant plausible outcomes, without being too large in order to facilitate the implementation of subsequent decisions. Furthermore, the future might not necessarily produce a static and exact continuation of what happened in the past. For any given starting point, it might be possible to have several trajectories that may lead to different future outcomes (Mahmoud et al. 2009). That is why two to four scenarios are considered, each representing a clear and distinct future trajectory (Ratcliffe 2000).

1.3. Scenario baseline

This scenario analysis is carried out in a context where Niger Republic is facing multiple socioecological challenges. The current socioecological challenges and institutional response strategy represent the context and baseline from which the scenario analysis is developed. The socioecological challenges are partly related to its geographic position in the Sahara Desert and the Sahel (CNEDD-TCN 2016), a region highly prone to drought events as shown in Figure 2. Since the late 1960's, drought related crises have become increasingly frequent with severe consequences in terms of environmental

degradation and food insecurity for communities and livestock (CNEDD-PNS 2019). In addition to droughts, land degradation also represents a challenging issue. Each year, the Niger experiences a loss of thousands of acres of arable soils due to erosion at the expense of agricultural producers and livestock farmers (Afifi 2011). This situation often results in humanitarian crises such as conflicts, hunger, famine, and health problems that particularly affect women and children which constitute the most vulnerable segments of the population (CNEDD-PNS 2019).

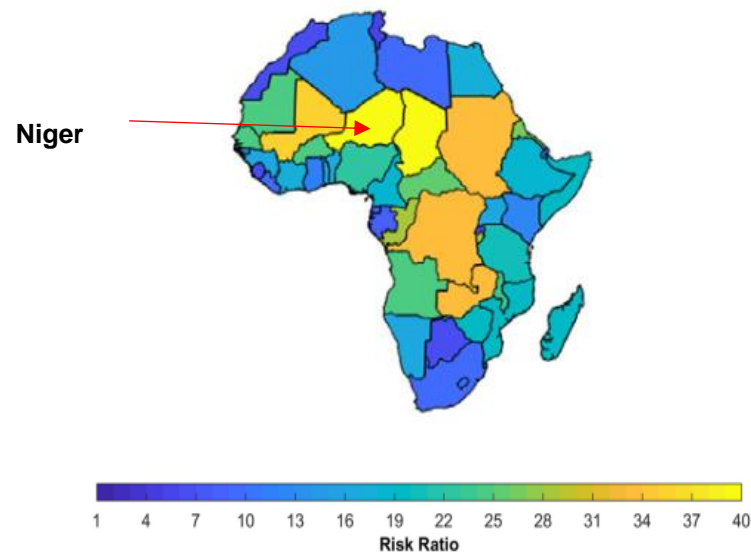


Figure 2: Illustration of the high drought risk of Niger. (Adapted from Ahmadalipour et al. 2019).

Despite being the largest country of West Africa, only 12% of its land area are actually fit for agriculture (PANA 2006). Agricultural, livestock, and fishing activities represent the main source of livelihood in which over 90% of people are engaged (Afifi 2011). This highlights the strong dependency of the country's economy on natural resources. Due to the continuous environmental degradation, rural farmers and livestock owners have lost their source of income and jobs, thereby making them vulnerable to poverty and hunger (Afifi 2011). This situation is pushing these people to flee and abandon their villages in order to search for alternative solutions of survival. Each year, thousands of families and individuals leave rural areas and embark on the perilous journey of migration both within and outside the country (Afifi 2011). However, the issue of refugees and migration due to climate and environmental degradation is not something only peculiar to Niger. It is a phenomenon equally observed across Sub-

Saharan Africa and at a global level (Epule et al. 2015). This phenomenon is expected to increase (Figure 3) as living condition continues to deteriorate.

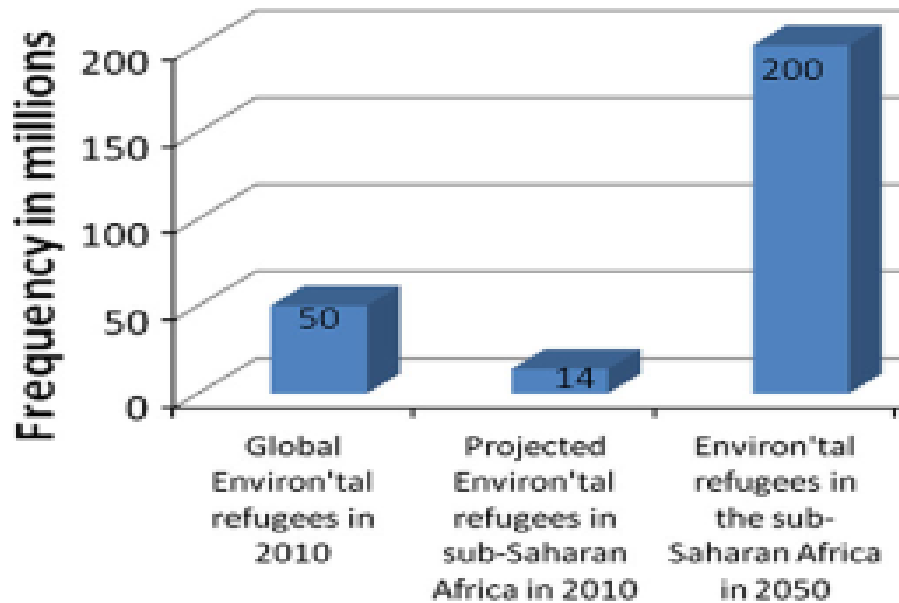


Figure 3: Trends of environmental refugees in Sub-Saharan Africa (2010 to 2050). (Source: Epule et al. 2015)

The environmental issues of Niger are not only related to natural factors such as droughts and land degradation. Human factors play a significant role in the crises as well. One of these factors include the exponential growth of its population. Niger has the highest fertility rate of 7.6 children/women in the world (Potts et al. 2011). From 11 million in 2001, the population has increased to 17 million in 2012; and by the year 2050 it is projected to reach 56 million people (CNEDD-PNS 2019). Table 1 shows the population growth trends from 1960 (the year of its independence) to 2020. It can be observed from this table that the global position of the country has changed from 93rd in 1960 to 56th in 2020. This exponential growth is substantially related to the social and cultural context which favors and promotes high fertility. In fact, the pronatalist mindset is such that the desire to have more children is even greater than what couples could actually have (Potts et al. 2011). Many view children as a gift and blessing from God rather than a social and economic burden. As such, God will provide for every human being He created. Of course, having more children might be considered as a blessing from a believing man perspective. However, they come with social and economic responsibilities too.

Table 1: Population growth trend of Niger from 1960 to 2020.

Year	Population	Yearly % Change	Fertility Rate	Global Rank
2020	24,206,644	3.84 %	6.95	56
2010	16,464,025	3.86 %	7.55	62
2000	11,331,557	3.61 %	7.70	68
1990	8,026,591	3.02 %	7.80	82
1980	5,989,004	2.93 %	7.75	85
1970	4,510,644	2.88 %	7.55	89
1960	3,388,764	2.77 %	7.40	93

(Source: Adapted from Worldometer: <https://www.worldometers.info/world-population/niger-population/>, June 2021)

Other reasons which might account for this pronatalist mindset could be the overwhelming poverty condition of families. Having more children, especially males, might be a potential source of free labor for livestock grazing and millet fields. However, the high population growth together with the heavy dependency of communities on environment for their livelihood contribute to increasing the pressure on natural resources (CNEDD-PNS 2019) especially when the population growth is not in pace with food production. The soils are increasingly losing their fertility while the population is growing exponentially. The continuous decrease in soil fertility (Table 2) and the imbalance between the population growth rate and food production may constitute further factors that exacerbate the social and environmental challenges.

Table 2: Illustration of decreasing yields for millet and sorghum.

Crop	Yield (kg/ha)		Trend
	1980- 1990	1991-2001	
Millet	402	381	-5.2%
Sorghum	301	188	-37.5%

(Source: Adapted from Stratégie de Développement Rural 2003)

The low level of literacy especially among rural people represent an additional contributing human factor to the environmental challenges. The national census conducted in 2012 (RGP/H-RSSF 2012) found that only 68.7% of male children have attended primary school against 57.6 % of females. In urban areas, these rates were found to be 80.7% and 77.6% against 44.9% and 37.1% in rural areas for male and female children respectively. This study points not only to the disparity of literacy rate between urban and rural areas, but it also highlights the inequality between males and females with respect to access to education. The low level of education might not facilitate the promotion of positive attitudes and behavior towards nature and natural resources. In fact, there are many community members who hold the view that natural resources are God-given assets. As such, people should have open and free access to them without any restriction (Tiffen and Mortimore 2002).

The overexploitation of forest resources constitutes another issue. Owing to the lack of access to electricity, firewood represents the main source of energy both in rural and urban areas (Peltier et al. 2009). The rate of use of firewood is more than the double of the rate of regeneration of natural vegetative cover (Potts et al. 2011). Urban sprawl is also contributing to exacerbating the pressure over forest and agricultural areas around urban and peri-urban areas. The uncontrolled expansion of urban and peri-urban areas due demographic explosion is causing forest and agricultural areas to be converted to residential areas (CNEDD-NDT 2018).

The endemic nature of drought to the environment of Niger contributes to the increase in frequency of dry periods in the country. Even during normal seasons of relative abundant rainfall, several localities across the country experience drought events that are responsible for structural deficit in agricultural production each year (PANA 2006). The precipitation pattern is becoming increasingly erratic. The rainfall is either too soon or too late, but rarely in the right amount for every farmer to produce enough food (Potts et al. 2011). Even in years of surplus, between 1 to 3 million people around the country still remain in food insecurity (CNEDD-PNS 2019).

The vulnerability of communities might also be related to the poverty trap and poor adaptive capacity as well as lock-ins in terms of agricultural techniques and equipment. More than 60% of the population live below the poverty line (BCPN-Bilan environmental 2002). This poverty results in the

inability of many to afford modern agricultural equipment and fertilizers in order to optimize their production and to be able to adapt to the changing climate and environmental context.

1.4. Research objectives

Faced with these social and environmental challenges, the government of Niger with the support of partners has put in place a response strategy to combat drought and its related consequences on communities and the environment. The strategy includes the adoption of different sectorial policies (forestry, fishery, agriculture, livestock, etc.) and the creation in 1998 of the DNP-GCA and that of CCA in 2002 (CNEDD-PNS 2019). The CCA is responsible for the coordination of food aid while the responsibilities of the DNP-GCA include contributing to reducing the vulnerability to food insecurity through the delivery of information, along with the coordination and management of operations of diverse actors (CNEDD-PNS 2019). The adoption of a national drought plan in 2019 and the creation of a ministry dedicated to humanitarian actions and disaster management in 2021 might represent the recent steps taken by the country that emphasize its determination to address the issue of droughts and other climate related disasters. The actions conducted so far through the DNP-GCA and CCA include direct food assistance to affected communities and land restoration actions through cash for work, cash transfer, loans, etc. (CNEDD-PNS 2019).

Despite these efforts and actions implemented, the issue of droughts and associated socioecological consequences still continue to persist and worsen. The resources needed to face these challenges are beyond the country's capacity (CNEDD-PNS 2019). Niger Republic is among the poorest countries of the world (CNEDD-TCN 2016). A large portion of the various restoration actions were made possible through loans and donations from international partners (CNEDD-PNS 2019). Drought events that occurred in the past have often resulted in food insecurity for many families across the country (CNEDD-PNS 2019).

With climate change, the challenges are expected to increase both in frequency and intensity. A study of climate indicators (CNEDD-PNS 2019) has identified the major climatic risks the country is likely to be exposed to due to climate change. These include an inter- and intra-seasonal variation of precipitation; the shortening of rainy seasons and fluctuation of sowing periods; increased frequency of droughts; and floods due to extreme precipitation. These risks are also corroborated by other findings of

the same study which show that between 1973 and 2013, the country has recorded 3 702 climate related disasters that have unfortunately caused the death of 10 625 people and approximately US\$3.259 billion of economic loss. This highlights the extent of damaging effects of natural disasters on communities and the country's economy.

Therefore, a scenario analysis of the major uncertainties and drivers is needed to assess the potential consequences of future droughts and other climate risks on the environment and communities in a context of climate change. This paper is intended to contribute to this purpose by developing scenarios for the Niger environment based on risk and effect analysis with drought, drought response, and population growth as drivers. On the one hand, the scenario analysis will provide a picture of how the drought related consequences would turn out under different population growth trends and response effectiveness. On the other hand, it can provide insights for decision making relative to climate risk preparedness so that future climate events will not automatically lead to environmental and food crises for communities in Niger.

1.5. Methodology

The scenarios are developed based on secondary data and information already available in the scientific literature. The information and data obtained are also supported by other sources which include country reports and official documents that are relevant for the scenario analysis. Four different scenarios are formulated and explored for the next 25 years which are:

Scenario 1: Long-term drought, ineffective institution, rising population

Scenario 2: Long-term drought, effective institution, controlled population growth

Scenario 3: Highly variable climate, ineffective institution, rising population

Scenario 4: Highly variable climate, effective institution, controlled population growth

Each scenario is then assessed with respect to the baseline and its specific drivers based on a qualitative analysis approach. The time period considered for long-term droughts is six months and above as suggested by Illston and Basara (2003). The controlled population growth is considered as 5 children per woman. This fertility rate is proposed based on studies that show that even with the adoption and implementation of policies to reduce the rapid population growth, the country will still experience a birth rate that will be above 4 children per woman in 2050. The plausible future social and environmental

implications of the interactions of these drivers is then analyzed over the next 25 years. The scenarios process is in addition enriched by inputs and thoughts from graduate students as part of their scenario building, policy, and innovation assignments for the North Dakota University class NRM 620 - Sustainable Scenario in Natural Resources Management.

2. SCENARIO 1: LONG-TERM DROUGHT, INEFFECTIVE INSTITUTION, RISING POPULATION

In scenario 1, the population of Niger is considered to grow exponentially. Institutions in charge of drought response including the central government are ineffective and do not possess the capacity and necessary resources to address long-term drought condition stretching up to 6 straight months. The occurrence of such a drought during the next 25 years could have severe consequences on the environment of Niger, its communities as well as their socioeconomic activities including agriculture, livestock, tourism, energy, fisheries, health, food security, tradition and cultural values, etc.

2.1. High risk of land degradation and desertification

The extended dry condition caused by the long-term drought could result in an unprecedented loss of land cover. A lack of rainfall can result in significant reduction of soil water content and subsequent increase in temperature and evapotranspiration (Choat et al. 2018). As the amount of water loss by trees becomes greater than their water uptake, they start to undergo a condition of water stress (Choat et al. 2018). This can subsequently lead to a widespread tree mortality due to drought (Wang et al. 2012). As the drought condition stretches over several months, the loss of vegetative cover has the potential to drive ecosystems to reach a tipping point and subsequent regime shift (Wang et al. 2012). The Niger environment may thereby reach a threshold beyond its current dynamics where damages as a result of massive destruction of its vegetation could become irreversible, triggering severe environmental degradation processes such as soil erosion and desertification.

The erosion and desertification processes might be exacerbated by rapid population growth. Over the next 25 years, due to low level of education, especially among women, birth control measures such as family planning might still not be widely practiced by families in Niger. With the highest fertility rate in the world (Goujon et al. 2020), chances are high that the population will double its current size by 2045. This might exacerbate the pressure over the environment and natural resources by imposing a resource need twice or much greater than the current demand.

The current trend of energy supply is less likely to guarantee a full coverage of the whole country that could satisfy the energy need of every citizen, particularly in rural areas. Approximately 12% of people in Niger had access to electricity in 2017 (SNAE 2018). It is unlikely that the energy access will

reach 100% by 2045. The vast majority of people might need to continue to rely on natural resources such as fuelwood as their primary source of energy. This constitutes another source of deforestation that could increase the pressure over forest resources already threatened by agricultural expansion.

In order to meet the needs of the exponentially growing population, more lands would be required for food production. Millet fields might increasingly shrink because they have to be subdivided among growing number of family members. Fallow periods will likely continue to decrease from year to year. Substantial land would need to be cleared for the conversion to new agricultural lands. Consequently, the agricultural expansion can potentially lead to increasing shrinkage of existing wooded areas (Jnr 2014). Continuous loss of vegetative cover as a result of agricultural expansion could further exacerbate land degradation and desertification. The loss of arable soils due to desertification could be far greater than the current rate of 100 000 ha/year.

2.2. High risk of loss of biodiversity

Environmental degradation can result in habitat destruction and fragmentation, especially as a result of increasing demand for land and other resources to satisfy the needs of the growing population. The prolonged period of lack of rainfall may lead to a situation of resource depletion where drinking water and forage may become scarce and difficult to find for wildlife species. This can trigger their migration outside the country while some might be trapped and eventually die due to hunger and thirst. The migratory movements could likely be towards the southern parts of the country. This is because the northern regions are much drier and wholly occupied by the Sahara Desert with few resources such as grass and surface water. With a drought condition, it is possible that some species will migrate to neighboring countries such as Nigeria, Burkina Faso, Benin Republic, etc. The toll on wildlife may be significant to the extent that by 2045 some species may go extinct or become extirpated from the country. These could include species such as dama gazelle, leopard, addax, lion which are currently on the IUCN list of species critically endangered of extinction (<https://www.iucnredlist.org/search> June 2021). The famous west African giraffe as well might have to abandon its habitat of Kouré region and migrate in order to survive.

Aquatic life might also be impacted. Due to the long-term drought condition, the waters of the Niger River can become shallower. In fact, the flows of Niger River could eventually stop as they once did

in 1985 around the capital city of Niamey (Andersen et al. 2006). Its tributaries might also dry up or become shallower as their waters and flow regime depend on yearly rainfall. Their waters might become warmer due intense exposure to sunlight. Substances such as dissolved oxygen is strongly dependent on stream water temperature (Beschta 1997). Water temperature also influences the composition and distribution of several aquatic organisms (Poole et al. 2001). Fish for example are ectotherms, they are highly sensitive to water temperature variation (Boltaña et al. 2017). As the river and its tributaries become shallower and warmer, fish and other temperature-sensitive organisms could suffer if their habitats become unsuitable (Poole et al. 2001).

Large mammals such as hippos and manatees could also be severely affected. They may also migrate, especially to Mali where the waters in the river tend to be much deeper and cooler. Species such as addaxes and west African giraffes can also be severely impacted. Consequently, the country may lose several of its wildlife and aquatic species due long-term droughts. The drought condition could drive these species to extinction or extirpation, visitors including school children might have to go to the Boubou Hama national museum where the remaining specimens may be kept for tourism or education purposes.

2.3. High risk of decreased soil fertility and food production

When the soils are denudated owing to massive tree mortality, they become exposed to different forms of erosion (Jnr 2014). Wind erosion will likely intensify, especially during periods of high winds and sandstorms, and has the ability to remove millions of soil particles and nutrients from agricultural lands and deposit them far away (Jnr 2014). Furthermore, intense evapotranspiration can cause dry and bare soils to change into crusts (Wildemeersch et al. 2015), thereby making it harder for crop roots to penetrate, and for rainwater to infiltrate. Poor infiltration will lead to increased runoff, making water erosion a serious issue with the potential to detach and carry along soil particles as well as nutrient contents through leaching (Jnr 2014). Additionally, poor infiltration of rainwater can significantly decrease the amount of soil moisture available in crop root zones (Wildemeersch et al. 2015). On another hand, wind and water erosion might jeopardize the Niger River and other surface waters. Millions of soil particles might be carried through wind and water erosion and deposited in these surfaces water bodies, which can cause them to silt up quickly and eventually dry up.

As the drought condition intensifies, soil biota could also be put at high risk of destruction. Organisms such as fungi, algae, and bacteria are essential for the degradation of complex organic substances required by crops for their development (Schinner 2012). For plants to be able to assimilate organic matters, they need the action of soil microorganisms to reduce these substances and make them available as nutrients (Schinner 2012). Soil microorganisms also contribute to creating a good environment for better seed germination and root system development which is highly essential for increased yields (Furtak and Gajda 2018). However, these beneficial functions of soil microorganisms to crop development and yield could be negatively affected by the occurrence of long-term drought events. Since long-term droughts can significantly decrease soil water content, moisture-sensitive microorganisms such as bacteria would not be able to thrive and maintain an appropriate population size in order to effectively contribute to crop development (Hueso et al. 2012).

The aforementioned degradation and pressure over the Niger environment might result in a drastic depletion of soil nutrients. The agricultural fields might not only increasingly shrink due to high demand, but they may become significantly poor in organic matter and moisture which are crucial for agricultural productivity. Yield can decrease substantially, and it might become harder for farmers to produce enough food to feed their families. Without adequate mitigation measures, agricultural yield might continue to decrease since the effects of long-term drought might be felt over several years. Continuous low soil productivity might result in a significant decrease in plant biomass which is essential in the context of the environment of Niger with low external inputs such as fertilizers. Aboveground and belowground soil organic matter such as crop residues and stubbles play an important role in nutrient cycles and soil fertility (Kumar et al. 2015). The vast majority of farmers in Niger may continue to depend on postharvest leftover plant biomass to maintain their farm's fertility. Low plant material can lead to low soil organic turnover and subsequent yield reduction. However, the consequences of long-term drought events might not only be limited to yield decrease. Their occurrence can also lead to a growing season with zero harvest because long-term droughts can cause crops to die from water stress before they reach maturity.

2.4. High risk of livestock mortality

Besides agriculture, livestock farming represents a second important activity of rural communities in Niger (PANA 2006). The occurrence of a long-term drought might cause severe damage to livestock. Challenging issues that herders might face include forage and water shortage. The extensive nature of the livestock farming system in Niger might compound the effects on livestock. The lack of rainfall could result in a situation where grass may not be able to grow and become abundantly available. Green tree leaves that serve as additional forage may not be available in abundance. Postharvest leftover crop residues that are important for both livestock and soil fertility might be insufficient to contribute substantially to livestock survival. The scarcity or depletion of these resources may lead to a situation where herders cannot provide their animals with enough feed. The drying up of surface water resources may cause an additional stress to animals in terms of difficulty to find drinking water.

Livestock might need to expand their grazing and browsing areas by traveling over longer distances and time to find forage and drinking water. The drought condition may be widespread across the country so that the few remaining places with forage were already exhausted before their arrival. Furthermore, traveling over long distances in quest of forage and water is not always an easy undertaking for weak livestock. It is expensive in terms of energy and time requirement. Cows for instance can use up to 30% of the energy from feed while searching for forage and water (MCDougald et al. 2001). Unfortunately, due to the drought condition, enough feed and water might not be available along their journey to offset this loss of energy. Without enough feed and water, hunger and water stress might take a huge toll on livestock with increased risk of diseases and mortality. Thousands of head of livestock may die as result without herders having the ability to prevent it.

Instead of watching powerlessly their livestock dying, herders might decide to sell parts of their livestock, especially the most vulnerable and weak ones in order to prevent their loss and generate some income that would allow them to purchase grains to feed their families. Unfortunately, it is less likely that the destocking could generate enough money. In times of food crises cattle and other domestic animals such as sheep and goats do not sell well. Their prices decrease drastically while cereal prices increase exponentially (Morton and Barton 2002). The money made out of this forced liquidation may not be enough to buy sufficient food for their families. As a result, both livestock owners and their animals might

suffer from hunger. However, the drought condition could be a boon for some. These include commercial farmers who managed to spare some grains before the drought occurs. They can make more profit out of the crisis by selling their grains at a higher price. This could also be an opportunity for them to make some investments from their cereal sales by purchasing livestock at a cheaper price.

2.5. High risk of economic crisis

Owing to the incapacity of the government to provide each citizen with good education, justice, jobs, and to promote sustainable behavior and use of natural resources, it is highly likely that the vast majority of Nigeriens may still have to depend on the environment for their livelihood for the next 25 years. With rapid population growth and poor environmental management, natural resources could undergo more overexploitation. Agricultural lands may degrade and become a highly expensive commodity due increased demand. With the soils being denuded due to loss of vegetative cover, their fertility and productivity could significantly decrease, thereby making them unfit for agriculture. Besides the cereal deficit, other vital resources such as drinking water could become a challenging issue. Additionally, irrigation and off-season agriculture might not be possible. Since these activities depend largely on surface waters, the long-term drought condition can be such that water is not abundantly available or accessible to grow crops.

In addition to farmers and livestock owners, fishermen might suffer as well. The Niger River and other surface water bodies such as Lake Chad and Komadougou might have their water levels significantly decreased or dry up totally. Fish productivity can decrease due to poor habitat condition. When communities such as farmers, herders, fishermen lose their means of living, they may not only become exposed to food insecurity, but they also lose their source of investment in small businesses to generate more income. Due to poor harvest and loss of extra source of income, they may not be able to purchase or afford other necessary items such as clothes, healthcare, marriage, education, etc.

However, it might not only be the communities who might suffer from poverty as a result of loss of asset and income, but the government may suffer economically as well. Sectors such as tourism might be heavily impacted by long-term drought conditions. Many tourists visit the country because of its wildlife species such as hippos, addax, giraffes, etc. Due to the drought conditions these wild species might become extinct or migrate to new habitats outside the country by 2045. As a result, tourists might not be

interested in visiting the country. The loss of tourists would constitute a substantial shortfall for the country's economy as well as for individuals and businesses that depend on the tourism industry. Other sources of income that are essential to the country's GDP could also be severely affected. These include taxes from agriculture, livestock industry, fisheries, forestry, etc.

Another sector which might be the hardest hit by long-term drought is energy. With the occurrence of a long-term droughts, the objectives of the Kandadji hydropower program might not be met. The Kandadji hydropower project represents a strategic program for the country as it is aimed at optimizing the energy sector so as to reduce the country's reliance on Nigeria for its electricity supply; mobilizing the water resources sector; and promoting irrigation and fisheries activities (PKRESMIN-EIES-RE 2018). By 2045, the country should have its decades-old Kandadji dam project constructed and operational. However, the advent of long droughts can weaken the ability of the country to fulfill its ambition in terms of energy autonomy. With the severe drought condition, the water levels of the reservoir might become significantly low such that the dam cannot function appropriately and fulfill its purpose. This could represent a huge loss of income for the country's economy. Moreover, the ambition of becoming energy-self-sufficient may be jeopardized. The country might still have to continue to depend on Nigeria for the bulk of its energy supply. The cost of electricity might continue to be high, with a high risk of deleterious knock-on effects on the living conditions of consumers as well as on the ability of industries and the economy to develop. Other specific objectives of the project might not be reached as well. The 45,000 ha of irrigation (PKRESMIN-EIES-RE 2018) might not be possible. It might also be difficult to practice fishing and other recreational activities such as boating, water sports, tourism.

2.6. High risk of famine and hunger

The possibility that most of the sectors that are vital to the country's economy might be affected could make the consequences widespread, affecting many parts of the country. The economic crisis that can result from long-term drought events might undermine the government's capacity to address crucial issues such as providing health care, drinking water, education, paying salaries, etc. The consequences might be felt across entire social and professional groups including public and private. Across communities and groups, those at risk could be the low-income citizens and poor people representing more than 60% of the population (BCPN-Bilan environmental 2002). However, women and young

children that constitute the highly vulnerable segments of the population could be hit the hardest (CNEDD-PNS 2019). The inherent poor adaptive capacity represents another contributing factor that can exacerbate the stress on communities.

In times of crisis like droughts, communities in Niger often rely on traditional coping strategies such as kin support and community solidarity (Potts et al. 2011). However, when conditions become too hard and overwhelming, it might become difficult for communities to maintain these cherished social values. In these circumstances not everyone would be willing to give credit, share foods or provide support lest they expose themselves and their families. With the crumbling of social support networks keeping families and communities together in times of crises, people might be left alone with their problems, thereby increasing their vulnerability.

The difficult economic situation faced by the government and deterioration of sectors on which people depend for livelihood such as agriculture, livestock, forestry, and fisheries can lead to an unprecedented food crisis. The cost of living might become extremely expensive for communities. The scarcity of cereal such as pearl millet, rice, sorghum can cause their prices to increase exponentially to the extent that the vast majority of families may not be able to afford to buy food. People may become exposed to hunger and famine. As a result, their living and health conditions can deteriorate with different types of diseases starting to appear. These could include famine related diseases such as malnutrition, malaria, tuberculosis, HIV/AIDS, respiratory infections, diarrhea, and yellow fever (Stevens, 2004). The hunger and poor health conditions might result in the death of many people, particularly in rural areas where background poverty is already common. The rapid population growth is another factor that might exacerbate the crisis and subsequently increase the number of victims. As more people become hungry and sick, hospitals and other relief services may become overwhelmed. Thus, they may not be able to provide adequate support and healthcare to all those in need, thereby constituting an additional factor that can potentially increase the death toll.

2.7. High risk of “ecoviolence”

As the saying goes “a hungry man is an angry man”, food insecurity and poverty inherent to drought and resources depletion might exacerbate tensions over resources. When common pool resources start to shrink and become scarce, conflicts often arise due to intense competition (Soysa

2002). Access to and use of shared resources may become problematic between communities and individual users. Poor resource management and pressure due to population growth may come into play and escalate these tensions. These conflicts referred to by some as “ecoviolence” (Soysa 2002) may intensify and become widespread in Niger. Several factors can militate in favor of ecoviolence between resources users. First, due to drought-induced resource scarcity, people might be tempted to maximize their right and share over resources without due respect to customary and agreed upon rules of access. Drinking water represents a key resource that can easily spur tensions. The frequency of the conflicts might increase especially in the parts of the country with less available water sources and where both humans and livestock share the same water points for drinking. Villagers on the one hand might think that they should have priority access, while herders on the other hand might not hold the same opinion. This misunderstanding might lead to tense and often deadly confrontations between the two user groups.

Access to and control of grazing areas represents another challenging issue that could spawn conflicts. The control over the remaining grazing spots might pitch individual herders against one and another. Selfishness and the law of “the might makes right” could become the governing principles for access to these areas. As such, access to grazing areas can be denied to weak herders which can be a source of frustration and conflicts.

However, conflicts may also erupt between different communities such as livestock owners and farmers. These intercommunity tensions might be the most violent forms of ecoviolence in terms of injuries and loss of lives. Elements that contribute to these conflicts might include the diversity of ethnic groups that include Hausa, Zarma, Fulani, Tamashek, Kanuri, Toubou, and Arabs which make up the country’s population. People’s ethnic identity can often be an indicator of the type of socioeconomic activities they are engaged in. Hausa, Zarma, Kanuri tend to be traditionally sedentary and mostly practice agriculture as source of living while others such as Fulani, Tamashek, Toubou, and Arabs are generally pastoralists and nomadic. As such a conflict between a herder and farmer might not only set the two individuals one against the other, but it could also indirectly oppose the two different ethnic groups they belong to. Conflicts involving different ethnic communities might have the potential to spark and easily escalate with more casualties. Furthermore, past grudges and intercommunity rivalries may be still lingering and hanging in the social atmosphere. Therefore, competition over resources heightened by the

drought condition can stoke the fire or fuel the already tense relationship between herders and farmers. This can eventually drive communities into an interminable spiral of ecoviolence with increased risks of loss of lives and properties.

2.8. High risk of rural exodus and “ecorefugees”

In times of famine and hunger, communities in Niger generally depend on food assistance and support from the government and aid organizations (CNEDD-PNS 2019). Food assistance is important for these communities because it might prevent them from abandoning their villages and attempting to embark on the risky journey of migration and exodus. With food assistance, they may be able to keep their family structure and social relationship, maintain their culture and traditional way of life, and keep their children in school. Unfortunately, the government may lack the required capacities and resources to provide affected families with the adequate support they need in times of crises such as droughts (CNEDD-PNS 2019). With a rapid population growth, the number of drought-stricken families might be increased, and a large number of people might be in need of food assistance at the same time. The situation can be overwhelming for both the government and the donor organizations involved in addressing the crisis.

In such a context of high social vulnerability and ineffective response, the living condition might be extremely hard for families. Threatened by famine and diseases, people may be left with only two choices: staying with the potential risk of dying from starvation, or fleeing in order to survive. The decision to leave is nevertheless not always easy to take (Mounkaïla 2002). It means abandoning their homelands as well as their traditional way of life (Afifi 2011). Moreover, the departure might be permanent with an eventual breakup of family ties and centuries tight-knit social relationships. The uncertainty about how things might turn out at their destinations could be an additional source of anxiety and stress. Even so, many individuals and families might have to leave their villages because neither their environment nor the government is able to guarantee their survival. As such, communities may be forced to abandon their villages in droves in order to find better living conditions and opportunities. The longer and more severe the drought condition, the higher the risk for larger numbers of people that might leave their villages and become ecorefugees within their own country. However, some might travel abroad to neighboring countries such as Nigeria, Burkina Faso, Algeria, Libya, Benin Republic, etc.

For herders, the best destination might be places where they can find grazing areas and forage for their animals. Farmers on the other hand might prefer places where they will be able to practice agriculture including off-season irrigation activities. For both agriculture and livestock farming activities, the southern parts of the country might be the target destinations. Places such as Kollo, Say, and regions along the Niger River have already experienced influxes of refugees as a result of the droughts that occurred during the 1980's (Mounkaïla 2002). These places might experience a large number of immigrants again with the occurrence of long-term droughts. Larger cities such as Niamey, Maradi, Zinder, Tahoua, Dosso, Tillaberi, Agadez, and Diffa could also be target destinations. However, the younger among refugees may prefer to go to places where they can find more opportunities such as Europe and USA. Migrating to Europe and USA is a longtime dream for youth in Niger (Afifi 2010). The drought-triggered food crisis might be a push factor and a good opportunity for them to accomplish their dreams.

Drought-induced refugees might encounter different forms of challenges upon arriving at their destinations. These might include economic difficulties as well as sociocultural integration and acceptance challenges within their host communities. Having left their home and traditional way of life, they may now have to learn to live in a social and cultural environment that might be totally different from the one they were used to and to which they may not be prepared for. Differences in religion, ethnicity, and language, could be a factor that may not facilitate integration and acceptance by local communities (Omata 2019). Although some among local communities might view refugees as contributors and an opportunity for cheap labor, others in contrast often hold negative feelings and opinions about them (Chambers 1986). As such they may feel rejected, discriminated, or stigmatized by locals (Hamadou 2018). The negative feeling and discrimination may exacerbate the relationship and eventually spawn conflicts between refugees and local people who may view them as competitors. The conflicts and hostility may be exacerbated especially in areas where local communities are already suffering from poor job markets and scarce resources (Chambers 1986).

Due to the difficulty of integration, it may be harder for migrants to get jobs in order to be able to provide food and shelter for their families, thereby making them vulnerable to food insecurity and stress. Furthermore, since many of them might have left their villages without enough financial resources, the

expensive living conditions of cities might represent another factor that can exacerbate their condition of poverty. In order to survive, they might have to depend on food assistance from government or humanitarian organizations. When support and assistance are not enough to satisfy their needs, their living conditions can further deteriorate with a high chance of becoming exposed to various kinds of social evils. With poor healthcare and housing, they may become vulnerable to different types of diseases related to hunger and poor hygiene condition such as trachoma, scabies, malaria, and diarrhea (Prüss et al. 2002).

Consequently, instead of finding opportunities and better living condition in cities, they might instead find misery and a living condition much tougher than the one they fled from as a result of the long-term drought conditions. Their extreme poverty condition might push them to live in slums or illegally occupy public spaces. Their settlement in slums might represent a factor that can lead to a population increase within these areas, thereby exacerbating the pressure over community infrastructures (water structures, health centers, drainage systems, roads, etc.). Major cities such as Niamey, Maradi, Zinder, Tahoua, and Dosso could become overwhelmed with street dwellers and mendicants. Young children who were forced to abandon their school due to the drought conditions might be forced to beg in order to support their families. Women, especially girls may also be pushed into prostitution with a high risk of contracting diseases such as STDs. Moreover, due to their extreme poverty and loss of hope, they may be tempted to enroll in terrorist groups or engage in other forms of criminality such as murder, theft, and drugs.

3. SCENARIO 2: LONG-TERM DROUGHT, EFFECTIVE INSTITUTION, CONTROLLED POPULATION GROWTH

In scenario 2, long-term drought episodes are considered to occur in a context of effective institutional response and a controlled population growth. Although droughts have inherent environmental and socioeconomic consequences, with preparedness and adequate mitigation measures these effects can be minimized (Wilhite et al. 2005). Therefore, as the government of Niger and other organizations involved in addressing drought issues are prepared and well equipped with the necessary financial and technical capacity, issues such as food insecurity, diseases, ecoviolence, ecorefugees, and loss of economic assets including livestock and agricultural production would not be as dramatic as they used to be throughout the country's drought history. The ability of the government to adopt and implement policies that help control population growth represents another mitigating factor since less people would be affected as compared to the case of scenario 1 with exponential population growth.

By 2045, the Niger government should have fully operational its recently adopted drought plan. A taskforce may be composed of multidisciplinary actors including public and private actors from the fields of environment, economy, agriculture, livestock farming, fisheries, tourisms, energy, education, etc. The taskforce would have the capacity to make food and cereal reserves available in sufficient quantity that can provide food, water and other vital items to every affected family. With an effective communication platform in place, drought awareness information and other useful coping strategies can be provided to farmers, livestock owners, fishermen, etc. Adaptive policies can be adopted and implemented for the purpose of controlling the price of food and marketed cereals such as pearl millet, sorghum, cow pea, rice, etc. Other adaptive policies may be adopted that can help increase the literacy rate, especially among rural communities. In addition, decent jobs are available, and the vast majority of families are practicing birth control measures such as family planning. The advent of long-term droughts in Niger within these circumstances would result in moderate risks in terms of pressure over natural resources, famine and hunger, ecoviolence and ecorefugees. However, there are some challenges that might need to be overcome. Despite the government preparedness and capacity of response, the vicious cycle of the poverty trap along with technological and cultural lock-ins might be challenging issues that can undermine the government efforts and response efficacy.

3.1. Moderate risk of pressure over natural resources

Niger with the highest fertility rate in the world of more than seven children per woman (Goujon et al. 2020), succeeding in controlling the growth of its population would be one of the achievements that the country could make. Good socioeconomic policies can help the country to significantly reduce its exponential population increase. Research has shown that the lack of education among women is a driving factor for high fertility in Niger (Goujon et al. 2020). For example, between 2009 and 2012, the fertility rate was found to be 7.9 among women without education while this rate was 4.9 for those having secondary school level of education and above. Therefore, effective education policies might be one of the best options that can help the country to control its population growth. However, even within a context of low fertility, it will require several decades for the country's population to stabilize (Goujon et al. 2020). The world population prospects report (2019) suggests that Niger will be the only country that will still have its fertility above 4 children per woman in 2050. But even though the country might not be able to reach a demographic transition by 2045, measures that can facilitate access to education for all, especially women and rural people, may contribute to significantly reduce the high fertility rate. Therefore, reducing its current fertility rate of 7.1 to 5 by 2045 would be considered a significant achievement.

Having a decreasing population growth might have numerous advantages especially in times of crises such as long-term droughts for Niger. Population increase and resource demand are directly proportional (Balatsky et al. 2015). Although the ecological footprint of Nigeriens might increase with increase in lifestyle and level of economic development, the resource demand may reduce nonetheless as the country's population grows at a slower rate. Demand for resources such as agricultural land might continue to decrease and the current trend of conversion of 100 000 ha of forest areas would decrease significantly. Fallow periods would be extended to several years as farm fields would produce enough cereal that meet the needs of farmers. The increasing of fallow periods might contribute to facilitate forest protection and integrity. It might also contribute to soil health and organic matter turnover, thereby improving soil fertility and productivity.

Further benefits of a continuous decrease of the population grow rate might include the reduction of the demand for fuelwood. The construction of a hydropower plant might be a contributing factor to reduce the pressure over forest resources by providing energy to communities and industries at a lower

cost. Other forms of clean energy such as a solar energy system could be an additional option that can help the government achieve this objective. Today with the advancement of science and technology, solar energy systems are becoming affordable as well as increasingly cost-effective as compared to other forms of energy (Devabhaktuni et al. 2013).

The transition toward a solar energy system is advantageous for Niger in several respects. Owing to its geographic location, sunlight is available in abundance throughout the year. The minimum and maximum average monthly temperatures are between 16 and 42 °C across the country (Graef and Haigis 2000). Furthermore, a solar energy system might not be sensitive to certain extreme weather conditions such as droughts. For instance, long-term drought conditions may cause a significant decrease of the water levels in a dam reservoir to the extent that the dam might not be able to operate at full capacity. Flood waters subsequent to high precipitation might also lead to the dam structure's failure. It can result in power shortage and huge consequences in terms of damages to the plant infrastructure, creating an economic loss for the country and high cost of repair. Unlike the case of hydropower systems, extreme climatic risks might not be a big issue with a solar energy system. Moreover, solar energy systems can be adapted to different types of locations including collective and individual household levels, villages, and cities (Devabhaktuni et al. 2013). The durability of sunlight and its renewable nature are further compelling reasons that solar energy technology might be the best sustainable and reliable source of energy for the country for the future. Making this technology accessible and affordable might help the country meet its energy needs at low costs while protecting its fragile ecosystems.

Effective education and affordable energy might substantially contribute to facilitating government efforts to promote a new dynamic of mentality and behavioral change. The view that natural resources are unlimited gifts that has led to uncontrolled exploitation of forest resources might be abandoned. Education might help communities to understand the importance of protecting resources and the environment as a whole. Moreover, they may start to understand the importance of their contribution and responsibility as citizens and stakeholders to conserve natural resources for their own benefits and future generations'. When the government succeeds to convince people, especially rural communities, to shift from fuelwood to new ecofriendly and cheap energy forms, the rate of deforestation, land degradation and desert encroachment over agricultural productive lands might decrease significantly. The erstwhile

degraded areas might start to recover specially when accompanied with land restoration actions. The regeneration of land cover can contribute to the improvement of soil stability and quality, rainwater infiltration and subsequent reduction in runoff, water erosion and land degradation.

The recovery of the country's ecosystems might further contribute to the reduction of water and wind erosion which can prevent soil leaching and nutrient loss (Jnr 2014) as well as aggradation of the Niger River and other bodies of water. The protection of forested areas might also contribute to the improvement of habitat quality for the survival and persistence of wildlife species. Species that are threatened of extinction such as dama gazelle, leopard, addax, and lion (<https://www.iucnredlist.org/search> June 2021) might be able to thrive again and multiply to reach a viable population size. When the ecosystems recover and improve in resilience, drought events might result in moderate adverse effects. The improvement of ecosystems resilience and reduced pressure on natural resources due to controlled population growth might further facilitate post drought recovery of the environment and food production systems.

3.2. Moderate risk of famine and hunger

With adequate preparedness of various actors including communities involved in drought response and post-recovery, it might be possible to alleviate the consequences such that the occurrence of long-term droughts will no longer result in famine and food crises. Sectors that are essential for the livelihood of communities such as agriculture and livestock farming can be resilient and thereby be able to resist shock and quickly recover after the occurrence of drought especially with reduced human pressure over the environment and food production systems. This would contribute to minimize economic loss especially for farmers and livestock owners. There are several mechanisms that might help reduce the consequences of long-term droughts in order to prevent famine and food crisis in Niger. These could include implementing a monitoring and early warning system, designing appropriate mitigation measures, promoting a culture of self-reliance of individuals and communities at large. The self-reliance would entail a condition where communities have the capacity and required resources at individual levels. It may also include the willingness of individuals to help one another and join forces to work together as a community to overcome environmental disasters such as droughts.

Establishing a monitoring and early warning system encompasses a mechanism of collection and sharing of information and data so that decision makers and communities receive timely information about an emerging drought event (Wilhite and Svoboda 2000). The data and information include important parameters such as precipitation, temperature, evapotranspiration, streamflow, groundwater, soil moisture, etc. (Wilhite and Svoboda 2000). With accurate and reliable data and information, the government of Niger and its partners involved in drought response can map out strategies to identify all drought hot spots and the profile of vulnerable people within and across communities. The profiling process can take into account age, gender, and profession to check which groups within and across communities and professional groups are highly vulnerable to drought. The profiling and mapping of vulnerability might be an important step in that it can help the government determine the degree of vulnerability and the nature of specific needs to provide to different affected people.

Beyond the vulnerability assessment, the timing of drought information to farmers and livestock owners might be a matter of life or death. The timely provision of drought coping strategies might be a decisive factor that can significantly reduce the effects on their lives and properties. To this end, media and other communication mechanisms might play an important role. They can contribute to quickly convey and spread drought related information to every community and individual across the country. The communication system might need to consider the cultural and ethnic differences of communities. The communication of information in local languages might be an effective mechanism that could ensure the information is understandable and has reached every individual and ethnic group. The timely provision of information might not only be important to farmers and livestock owners, but it could be crucial for decision makers too. It can help them coordinate and prioritize their actions. When they receive information at the appropriate moment, they might be able to know where and when to preposition food reserves and cereal banks that can meet the needs of affected people.

Information and education might further contribute to trigger a change of attitude and behavior of communities with regard to the drought coping approach. Instead of continuing to solely rely on food assistance from the government and donors, they can learn how to become self-reliant in times of crises such as long-term drought. In view of their background poverty and vulnerability though, they might need the help of government and other organizations with this process. Without guidance and capacity

building, they might not be able to change by themselves. There are various ways through which guidance and capacity building actions can be provided to communities especially in rural areas where background poverty is rampant.

One of the important strategies could be education. Education can have the potential to change their mentality and behavior. Certain cultural practices might need to be changed in order to facilitate and improve communities' coping capacity. Such cultural practices include the traditional inheritance of socioeconomic activity. In other words, professions tend to be transmitted from one generation to the next. The ethnicity and family in which people are born can often reveal the profession they will most likely will be practicing. Another cultural practice includes the issue of taboo. It is a taboo for some ethnic groups to practice certain types of activities. For example, Zarma people are not encouraged to engage in the meat business. Many Fulani do not eat fish as such they are less likely to practice or engage in fishing industry. These taboos represent cultural lock-ins that might be a reason that prevent these communities to explore opportunities and sources of income beyond their traditional socioeconomic practices.

Although a shift from these cultural considerations is becoming noticeable, they nevertheless might constitute a factor that influences communities' and the country's economic potential. As such, these cultural practices and mentalities might need to be abandoned especially in a resource scarce and drought prone environment like Niger where communities have few coping options. With appropriate programs that can make education accessible and affordable, it might be possible to overcome these challenges. Once these lock-ins are broken, it might become much easier for communities and individuals to freely choose the type of job they want without fear or blame from the society. Once free to choose and succeed in these activities, there can be an increase in their coping options in times of crises.

Education, particularly for women, can be considered as an indirect strategy of promoting family planning policy. First, education has an influence on the age at which women get married in the Sahel. The higher the education, the older at which they get married (Ijeoma et al. 2013). Second, when educated, they could have more opportunities in terms of decision making, jobs and incomes in order to improve the quality of their living condition. However, more duties and responsibilities represent other factors that might limit the time people have to care for their children. Third, education might also be a mechanism that can allow Nigeriens to understand the challenges of their environment and the increasing

pressure over resources due to the exponential growth of population. This might convince some regarding the importance to practice birth control in order to promote their own socioeconomic wellbeing and environmental sustainability. Therefore, education can be the pathway for the country to promote social wellbeing while shifting toward demographic transition. With family sizes continuously decreasing owing to effective education policies, especially for women, what farmers produce could be sufficient to feed their families. They might be able to invest their excess agricultural production in other income generating activities such as small businesses which can contribute to improve their quality of life. Their food production could support them throughout the year without having to take loans during the lean season. They can also invest in the education of their children. Their children could have the opportunity to get a good education which in turn contributes to the overall wellbeing of their families.

With adequate education and guidance, communities may be able to know where to get information and how to interpret the information by themselves. Farmers can learn how to improve soil fertility, practice proper tillage and cropping techniques, and maximize productivity. They may be able to know which variety of millet, sorghum and other cash crops to grow that are best adapted to their soil condition. In years of abundant rainfall, they may be able to produce food more than their family needs. The excess production can then be traded to buy livestock or invested in other forms of activities. Though it may be possible that severe droughts can result in zero harvest, they might still be able to survive through the reserves from their previous year cereal production. Furthermore, with the help of the government, it might be possible to optimize agricultural production by promoting irrigation agriculture especially along the Niger River and other perennial and seasonal water sources. In places where surface water is not available in abundance, such as the northern parts of the country, the government can support communities by facilitating access to ground water and fertilizers to allow them to grow crops.

Livestock owners on the other hand can learn several drought coping strategies. One of the great challenges for them might be how to share shrinking resources such as water and forage without the risk of conflict. This challenge might be overcome through sensitization with the support of government and non-profit organizations. They can help in creating a condition of good relationship with farmers. The promotion of friendly relationships with farmers can facilitate their access to and use of postharvest leftover crop materials as additional fodder for their animals. Another important strategy might be to

sensitize and convince livestock owners to shift from extensive to intensive livestock farming. Though not every herder might be able to afford it, the government can help them through the transition process by providing incentives such as providing lands, fertilizers, tax alleviation and access to irrigation water. Unlike the rainfed forage, the irrigation system can give them a control over the timing and quantity of water needed to be supplied that would allow them to grow enough feed. By growing fodder in addition to naturally available forage, they might have enough feed available for their animals and make reserves in case a drought occurs

Providing livestock owners with guidance on how to manage fodder within a context of drought prone environment might also be important to help them navigate drought conditions. For example, they may be trained on how to ration feeds in drought periods. This can be helpful especially when feed might become scarce and expensive due to the drought conditions. The gradual decrease in the quantity of feeds would allow livestock to gradually adjust their feeding habits and adapt to the drought condition without major harm (McDougald et al. 2001). Another coping technique includes the reduction of time and movement of livestock in search for forage. The reduction insofar as possible can help them economize their energy and thereby their feed requirement.

Destocking constitutes another technique that herders can use to adjust their livestock numbers in accordance with the availability of fodder. It can contribute to reduce the pressure over the remaining feed stocks (Gill and Pinchak 1999). Instead of watching their animals dying from lack of forage and dehydration, they may trade part of their stocks and generate income. To that end, herders might need operational guidance. The government can provide them with knowledge on how to carry out the destocking process. Knowledge of gender ratio and the age range that can be marketed without the risk of jeopardizing their stock capital might be of extreme importance. Furthermore, the appropriate timing to conduct the destocking process might also be crucial because some herders may be reluctant to sell their animals. They might be tempted to wait and see, hoping that the situation will return to normal, until it is too late. When destocking is not conducted at the appropriate time, the drought condition may irreversibly affect their animals to the extent that they may become very weak or succumb. When animals become too weak, it would be hard for them to make substantial income out of their sales. Also, information about market and price of food items might also help to decide when to conduct the destocking. Since food

prices tend to increase in drought periods (Morton and Barton 2002), market information can allow them to maximize their sales and be able to purchase food and other necessary items for their families.

With the implementation of an effective early warning system and improved self-reliance, drought events would result in moderate food crisis and famine. The self-reliance and capacity building might help communities to get out of the vicious cycle of poverty traps and be able to resist shock including droughts. Families that might still need assistance can easily get it as the government and institutions involved in drought response are well prepared and have set up effective mitigation measures. These include the availability of a permanent drought task force with technical and financial ability to respond quickly and provide support wherever necessary. The measures could also include effective communication and coordination of actions of various actors. Other measures might include the control by the government of cereal prices and market dynamics to prevent price hiking and gouging usually inherent to drought periods. Improvement of the literacy rate, breaking taboos and cultural lock-ins that do not promote positive behavioral change and sustainable development might be of high importance in building communities' self-reliance. Sensitization programs might be provided to communities including fishermen to encourage them to learn and practice multiple types of activities instead of relying only on fishing as their source of living. By so doing, when drought occurs, they may still be able generate income and provide food for their families.

Equity, trust and transparency might be crucial for successfully conducting assistance operations. The equity relates to aiding communities without any form of discrimination in terms of religion, gender, political affiliation, or ethnicity. Trust on the other hand includes the fact that some communities might think that certain relief agencies, especially international organizations, are foreign agents and spies. As such they may be reluctant to open up and provide accurate information. For example, they may refuse to give the exact income or number of children, thinking that they may be used against them such as influencing the adoption of family planning and tax raising policies. The lack of trust can make some communities and oftentimes government officials to refuse assistance even though they might be in a dire need, thereby worsening their living condition. The food crisis that occurred in 2005 can be an illustrative example where certain government officials initially denied the problem. The denial and poor handling of the crisis had contributed to exacerbate the situation, especially in regions such as Maradi (Cornia and

Deotti 2008). However, in times of crises such as droughts, this information and data might be crucial in determining the type and amount of needs to provide to affected families. In order to insure trust, government and relief organizations need to be transparent. A good communication strategy and inclusion of traditional and religious leaders in the process might be helpful in building trust and transparency.

3.3. Moderate risk of ecoviolence and ecorefugees

With the government adequately prepared and communities becoming increasingly self-reliant and resilient, the advent of long-term droughts would result in moderate ecoviolence and ecorefugees. Increasing literacy rate, self-reliance and controlled population growth would result in less pressure and competition over natural resources. Individuals and communities would have the opportunity to learn to adapt to their changing environment and to prepare for extreme events such as long-term droughts. With people becoming educated and aware, they might start to understand the importance of settling their disagreements in a peaceful and civilized way rather than using violence. They may start to know and recognize the rights of each other as legitimate stakeholders with respect to access and use of common pool resources such as water, land, grazing areas, and fuelwood.

Democratic values and sustainability ideas may start to prevail which then helps govern the relationship between resource user groups and further helps define the extent and limit of rights as well as responsibility with respect to sharing and protecting resources for the benefit of all. Furthermore, resource users particularly livestock owners and farmers can finally understand that it is past time to abandon violent methods of conflict resolution. The awareness and education can allow them to understand that violent ways of conflict resolution are not durable and do not contribute to a peaceful relationship between communities. Instead, they only contribute to tear their relations, shed blood, stoke hate and anger, and grievances that often lead to a vicious cycle of endless retaliations. Rather than using these backward methods, they may start to resort to jurisdictions to settle their disagreements. They may be able to establish mechanisms to have their voices heard as well as to build strong social relationships that promote values such as solidarity, and selflessness.

Farmers and herders might see each other as friends and partners rather than opponents and competitors for resources. Their friendly relationship and partnership might contribute to create a social

environment where eventual disagreements and conflicts would be moderate. Furthermore, the culture of good relationship might incite different resource users to support one another in times of droughts.

Individuals and communities who might need assistance can easily get support through the government and fellow community members. People in need may not necessarily have to abandon their villages and become ecorefugees in order to get support. Since the government and institutions involved in providing relief are prepared with technical and financial capacity, they can easily reach and bring assistance to people in need.

4. SCENARIO 3: HIGHLY VARIABLE CLIMATE, INEFFECTIVE INSTITUTION, RISING POPULATION

Under scenario 3, the climate condition is considered to be highly variable which includes variation of the amount of rainfall over time and space across Niger. This scenario might result in different outcomes including events such as droughts, floods, and seasons of adequate rainfall. Within a context of ineffective institutional response and rising population, these variations of climatic condition might lead to diverse consequences over the environment and communities as well as their socioeconomic activities. The consequences might include moderate risk of land degradation and loss of biodiversity, famine and hunger, ecoviolence and circular migration during years of droughts. It might lead to conditions of high risk of flood with potential socioeconomic loss, increased number of ecorefugees, and damages to infrastructures in years of excessive rainfall. The climate variability might lead to conditions in which the rainfall amounts are just right for the country's environment, species and production systems to thrive, thereby facilitating social and economic development.

4.1. Moderate risk of land degradation and loss of biodiversity, famine and hunger, ecoviolence and circular migration during years of droughts

4.1.1. Moderate risk of land degradation and loss of biodiversity

The variability of climate might lead to the occurrence of flash and short-term drought events with adverse effects on the environment. An increase in the frequency of flash and short-term droughts may trigger a slow onset of tree mortality. The loss of vegetative cover due to tree mortality might cause soils to become barer and harder as a result of high temperature and evapotranspiration. It might further lead to a self-reinforcing environmental degradation which may be exacerbated as dry spells become long and frequent. This may push the environment of Niger beyond its resilience threshold whereby damages to its ecosystems may become irreversible. Agricultural and forested areas may be lost to erosion and desert encroachment.

The continuous population growth, on the other hand, constitutes a threat especially to forested areas. These areas might have to be converted to new agricultural fields in order to meet the growing demand for food. In regions where land is limited to expand agricultural fields, the need for new land might have to be offset through reduced fallow periods, agricultural land fragmentation that may lead to

poor soil condition and yield reduction. The demand for fuelwood may also spike due to increasing population, adding more pressure over forest resources. The increasing pressure owing to population growth together with poor resource management may lead to habitat destruction and fragmentation. When habitats are destroyed and fragmented, this might undermine wildlife species ability to survive and thrive.

Overall, these consequences may be considered as moderate. This is because they only occur due to flash and short-term drought conditions which may be less severe as compared to long-term drought conditions. Despite the population growth, the pressure over resource use might be less when ecosystems recover quickly after flash and short-term droughts. Also, the impacts on soil fertility might not be significant due to the ability of environmental conditions to restabilize after short-term and flash droughts.

4.1.2. Moderate risk of famine and hunger

The occurrence of short-term droughts within a context of institutional failure (including both government and communities' incapacity to address crises due to low adaptive, financial and technical capacity) and rising population may lead to food insecurity especially in rural areas. The poor adaptive capacity of rural communities may increase their vulnerability to hunger and famine. Poor hygiene conditions inherent to poverty might facilitate the spread of infectious diseases such cholera and trachoma. The lack of alternative source of income to rely on in times of crises represents another compounding factor that might exacerbate the stress over communities.

The ability of communities to produce enough food may become challenging especially for the most vulnerable segments of communities which include children, women, and elderly people. The lack of capacity and preparedness of government and institutions (including at the local and individual level) involved in addressing drought crises might worsen the impacts over communities. The insufficiency of technical and financial resources may make it harder to reach and provide support for every affected community. If people can no longer receive the help they need, this can expose them to death. People in rural areas who cannot fend for themselves such as women and children might be the segments of the population which may be hit the hardest. Because of the poverty cycle, adaptive capacity and resilience are also low at the local and individual level leading to increased risk of famine and hunger. However,

although the consequences may be widespread, they may not be as severe as in the case of scenario 1. Following short-term and flash drought periods, agricultural and livestock farmers may still be able to produce. The ability to produce as soon as the drought condition is over may further contribute to prevent substantial income and economic loss reducing the risk of famine and hunger.

4.1.3. Moderate risk of ecoviolence and circular migration

The increasing environmental degradation and overexploitation of resources due to exponential population growth may cause resources such as fuelwood to be scarce. The resource scarcity may constitute a factor that can easily spur tensions and conflicts between communities competing for access and control of resources such as water, grazing areas, and agricultural lands. Even trivial arguments or misunderstanding might fuel past grudges and conflicts. However, when drought conditions are over, ecosystems may be able to recover, and resources may become available again. This might contribute to reduce the competition over resource and the risk of ecoviolence.

The eventual tensions between resource user groups and inadequate assistance from the government and relief organizations may push some families to leave their villages. Unlike in the case of long-term droughts, short term droughts may not cause these displaced families to settle in their host localities. They may still return to their respective villages as soon as the drought condition is over. This circular migration is already a common practice in Niger as a drought coping strategy (Mounkaïla 2002). During the lean season and food shortage as a result of drought, circular migration allows communities to travel to other parts of the country where they may find food and other resources in order to survive. Although communities may be likely to return back to their villages after drought periods, some may settle permanently within their host localities especially when droughts increase in frequency and intensity.

4.2. High risk of flood with potential socioeconomic loss, damages to infrastructures, and increased number of ecorefugees in years of excessive rainfall

Over the next 25 years, the climate variability might result in seasons of excessive precipitation with high risk of floods. The consequences on communities and their properties may be severe. Diverse factors might contribute to exacerbating these effects. Due to poverty, many residents may not be able to afford adequate housing. The cost of construction materials of good quality is beyond their purchasing power. The poverty condition might continue to compel communities to continue to build their houses with

materials such as mud without due consideration to construction standards. These mud houses may not withstand high precipitation events especially if they become frequent with longer duration. Houses may collapse under intense rainfall, leaving the owners homeless. Beside losing their houses, they may also lose their lives and source of income. The excessive rainfall may cause flooding especially in places located along the Niger River. The damages resulting from the unprecedented flood of 2020 may still be fresh in people's minds. Floods of this nature may occur again with high risk of damages to irrigated crops such as rice.

Heavy precipitation may also cause substantial loss to livestock owners. It may lead to livestock mortality. The incapacity of livestock owners to build adequate shelters to protect their animals from severe rainfall represents a threat that might increase their vulnerability to death and diseases. Severe rainfall may cause both irrigation and livestock farmers to lose their source of income. Those who do not possess other alternative sources of income may become exposed to food insecurity. The poverty condition of families and their poor hygiene and sanitation might be exacerbated by floods and facilitate the spread of infectious diseases such as cholera and malaria.

The economic loss might include damages to infrastructures as well. Large amount of financial resources invested by the government and donors to construct roads, dams, and other public infrastructures might be at risk. These infrastructures, especially roads and dams, may be damaged or destroyed as a result of floods, thereby making the huge financial resources invested in their construction go in vain. Beside the financial resources invested for the construction of these infrastructures, further expenses and time may be required to rebuild or repair the damages as a result of floods.

The unpreparedness of government and population growth constitute other factors that might compound the adverse effects of floods. The failure to adopt and implement adequate urban development policy may continue to exacerbate the uncontrolled urban sprawl and settlement in flood-prone areas. The settlement in floodplains is moreover exacerbated by the increasing demand for housing as a result of rapid population growth. In addition to the use of mud as construction material, the construction of residential houses in flood-prone zones may increase their vulnerability to floods. Despite the danger involved, some communities may still continue to live within these areas. Reasons accounting for this might include the difficulty to abandon their homes and neighborhoods with which they might be familiar

for generations. Even buyouts and incentives provided by the government to encourage people to leave flood-prone areas may not be effective or even counter-productive. As soon as flood waters recede people may start to reoccupy their previous spaces and homes. Furthermore, flood victims may continue to be poorly tracked. The lack of a reliable database makes it difficult to identify victims that have previously benefited from buyouts and incentives. This may encourage dishonest people to return and reoccupy their places so they may continue to benefit from buyouts and incentives as much as they can. By so doing, these people continue to expose themselves and their families to floods. They may suffer the same loss and damages again and again anytime flooding occurs.

Poor response strategies together with the lack of willingness of communities to adapt and abandon flood-prone areas might represent a challenge that needs to be overcome in order to effectively address the issue of flooding in Niger. Hundreds of thousands of people may continue to be impacted by floods for the next 25 years. The incapacity of the government to provide housing and shelter to flood victims might force them to continue to occupy public spaces and buildings such as classrooms, mosques, etc. As such, the advent of floods may not only affect communities and their properties, but it may also adversely affect education, transportation, religious practices, etc. Those who cannot find shelter and support might be exposed to homelessness, hunger, diseases, and social vices.

Furthermore, excessive rainfall might negatively affect soil quality. The soils in flood prone areas are mostly sandy (Rabani et al. 2021). These may become saturated and waterlogged due to high precipitation. Therefore, instead of contributing to improve agricultural productivity, the saturation and waterlogging of sandy soils may reduce their productivity, thereby leading to decreased yields. However, the high precipitation may be beneficial to the fishing industry. Extended and intense rainfall may cause the Niger River and other water bodies to overflow and fill up their flood plains. The large bodies of water thus created may provide a conducive environment for aquatic organisms to thrive. Fish may be able to develop and multiply, thereby representing a boon for fishermen to increase their catches and generate more income.

4.3. Rainfall amounts just right for the country's environment, species and production systems to thrive, thereby facilitating social and economic development

Owing to climate change, conditions might be such that rainfall will be abundant over the next 25 years which would allow the vegetation to grow and degraded lands to recover. The resulting increase of biomass may contribute to improve soil fertility and productivity. Farmers would be able to grow different varieties of crops and produce enough food that will meet the needs of their families. They may be able to sell the excess agricultural production and invest in other forms of income generating activities such as livestock, and commerce. Women might also be able to produce cash crops to generate income and support their families. Livestock owners might not have to travel over long distances to graze their animals. Forage may become available in abundance around multiple areas in the country. The availability of abundant grass and water might contribute to create the conditions for their herds to thrive and multiply. They may also be able to diversify their sources of income by selling parts of their stocks and invest in agriculture and other types of businesses.

Furthermore, the rapid population growth might not represent a big issue. The increase in livestock and agricultural productivity might be enough to meet the increasing demand for food. The risk of famine and food insecurity may no longer constitute a threat to communities. In addition, the government response strategy would be of less relevance since families may become self-sufficient.

Competition between resource users especially farmers and livestock owners may significantly decrease. Resources might be sufficient for each user group to satisfy their needs. The decrease of competition may contribute to reduce the risks of ecoviolence. Peace and security might increasingly prevail across the country. The number of ecorefugees would also decrease as a result of reduced ecoviolence and food insecurity. The capacity of communities to produce sufficient food may contribute to prevent them from abandoning their villages and embark on the risky journey of migration. Communities might be able to continue to live their traditional way of life and maintain their social relationships. Keeping communities within their villages might facilitate the education of their children and increase their chances of success.

5. SCENARIO 4: HIGHLY VARIABLE CLIMATE, EFFECTIVE INSTITUTION, CONTROLLED POPULATION GROWTH

In scenario 4, the climate conditions are considered to be highly variable like in the case of scenario 3. However, in contrast with scenario 3, the institutional response is effective, with the technical and financial capacity to address crises such as droughts and floods. This entails the ability of the government to curb the rapid population growth to a controlled level of 5 children per woman on average. Under this scenario, the climate variability might result in three different outcomes. These outcomes include flash and short-term droughts due to rainfall deficit, floods as a result of excessive precipitation, and adequate amounts of rainfall that would create conditions for farmers and livestock owners to optimize their productivity. Owing to the effective response strategy and controlled population growth, the occurrence of short-term and flash droughts and floods over the next 25 years might result in low risk of adverse effects on the environment and communities. The conditions of abundant rainfall might be an opportunity for communities to improve their wellbeing, and for the country to embark on the path of social and economic development.

5.1. The occurrence of floods, short-term and flash droughts might result in low risk of adverse effects.

The ability of the government to bring the rapid population growth under control could be an effective way of reducing the pressure on the environment due to increasing demand for land, water, wood, etc. The adoption of measures and policies such as family planning and the promotion of positive behavior and attitude towards the environment and natural resources might constitute a factor that can facilitate environmental protection and resource conservation. To that end, education and sensitization on the value and contribution of ecosystems and species to communities' wellbeing might be of great importance. Education may allow Nigeriens to understand that socioeconomic activities such as agriculture and livestock farming hugely depend on the quality of their environment. When communities are educated and become aware of the contribution of nature to their social and economic wellbeing, they may no longer constitute a threat to species and their habitats. Instead, they may participate as citizens with interest and responsibility in protecting their natural environment and contributing to restoring degraded lands and ecosystems.

The resulting effects on the environment from the occurrence of short-term and flash droughts might not be significant. The culture of good relationship with the natural environment together with community participatory actions might create conditions that allow former degraded lands and ecosystems to regenerate, and the rate of desertification to be reduced. In fact, it might be possible to reverse the desertification process through actions such as tree plantations to revegetate formerly degraded lands through programs such as the ambitious Great Green Wall, a program involving more than 20 countries of Africa; and intended to regreen the entire width of the African continent, an area of about 8,000 km of length (The Great Green Wall: <https://www.greatgreenwall.org/about-great-green-wall>). Research might be conducted to test the feasibility of rewilding threatened forested areas through the introduction of missing species to facilitate their recovery. Further environmental management actions might be the abandonment of extensive and rudimentary agricultural practices which might be among the major threats to forest areas. The conversion to an intensive system through the use of fertilizers and mechanization might be an effective strategy to protect the remaining wildlife species and forest areas from being fragmented and converted to agriculture.

Beyond contributing to protecting the environment, the conversion to intensive agriculture may also improve communities' food security. The government can support farmers by making modern agricultural equipment available and affordable for them. This might contribute to increase their cereal production. Other best practices might include crop rotation, and intercropping. With crop rotation, farmers may be able to alternate crops with different root systems, thereby maintaining and improving soil fertility and productivity. Intercropping on the other hand might represent another strategy to cope with flash and short-term droughts. It can allow farmers to grow different crop varieties that can be harvested at different times to reduce their risk of loss of harvests. Farmers may grow for instance pearl millet that requires 3 to 4 months and cowpea with much shorter time requirement. In this manner, even with the occurrence of droughts they may still be able to harvest those crops that grow quickly. The promotion and facilitation of accessibility and affordability of drought resistant crop varieties with low water requirements for rural farmers might contribute to increase their food production as well. Conservation tillage techniques might also help maintain soil quality and increase yield.

The empowerment of farmers can help improve their resilience to droughts and reduce their vulnerability to hunger and famine. Similarly, the effects of short-term and flash droughts may be mild or less significant with empowerment and support programs from the government. These support programs include the ability to produce supplemental feed to cope with drought conditions. Unlike in the case of long-term droughts, there would be no need for destocking. The number of livestock that might be affected may be small and the extra feed that livestock owners produce by themselves would suffice to help their animals navigate short-term and flash drought periods. As such both farmers and livestock owners may be able to maintain or improve their economic and social conditions. In 25 years, these farmer and livestock owners may develop enough adaptive capacity and cooperation to the point where the communities are able to build resilience on their own.

The institutional capacity would also imply the ability of the government to regulate access and use of shared resources such as water, grazing areas, and wood. Although sharing resources might be challenging, it is not expected to result in conflicts or tensions between users. The consequences due to short-term and flash drought conditions might not lead to resource scarcity or depletion like in the case of scenario 1 with long-term drought and pressure due to increasing population. The fishing industry and irrigation agriculture might not be severely affected as well. There might exist enough water in the Niger River and other water sources to guarantee sufficient drinking water for communities and livestock. The available water resources would also allow irrigation farmers and fishermen to continue to practice their activities. Furthermore, the capacity of the government to provide support for those who might suffer losses due to droughts may create the conditions that would prevent communities to leave their villages and become ecorefugees within and outside the country.

In years of excessive rainfall, the resulting flood would be less disastrous because the government and communities are well prepared. Although damages to infrastructures such as dams and roads may be hard to prevent, the impacts on houses might be significantly mitigated. The design and implementation of programs and housing estate policies might be of great importance in this regard. Urban development may be carried out in such a way that new houses are built according to the designed master plan for urbanization. However, it might also be important to convince people to move from flood

prone zones along the Niger River to safer and secured areas. It might also be important to control urban sprawl and prevent any further housing and land development on floodplains.

The unprecedented flood that occurred in 2020 should serve as a lesson for the government and communities with respect to the risks involved in living on floodplains. The tens of lives which have been lost and socioeconomic losses suffered in 2020 might have been avoided had appropriate measures been taken. There exist several strategies that may help the government achieve this. One of these strategies includes providing incentives to families already living in these areas. The incentives might be in the form of property buyouts for residents located within flood-prone zones and their resettlement in safer areas. In order to prevent people from returning back to their former places, measures might need to be enforced to deter those who may be tempted to do so. The measures can include sanctions such as fines, foreclosure, demolition, etc. that would prevent people who previously benefited from buyouts to abuse from the buyout program. In areas where buyouts might be expensive, flood structures such as levees, floodwalls, and dikes, can be built to protect communities and their properties.

Further important measures would be resolving the issue relating to the high cost of land procurement and construction materials. The vast majority of Nigeriens live in rural areas (PANA 2006) where poverty is rampant. Their poverty condition may not allow them to afford building materials and adequate housing that can protect them against floods. In order to improve their resilience to natural disasters such as floods, it might be important for the government to adopt policy and strategy to increase communities' income and wellbeing. Promoting education and creating job opportunities can allow Nigeriens to afford decent housing. Other incentive measures include the reduction of taxes, subsidization of construction materials and equipment as well as land granting for housing development to facilitate the resettlement of flood victims in safer areas. An insurance system might also be helpful in securing communities and their properties. Although many might be reluctant to due to religious reasons, programs may be designed to sensitize and encourage communities to enroll. The insurance system may be particularly helpful with regard to highly expensive infrastructures such dams, large public and private buildings. Floods can cause damages to these infrastructures such that the cost of their repair may be exorbitant and unfordable especially for individual owners. The insurance system may facilitate their repair, reconstruction, or pay for damages as a result of flood events.

In addition to top-down measures and policies, bottom-up actions and behaviors at community, household and individual levels might substantially contribute to the improvement of preparedness and post-disaster recovery. Instead of waiting for support and guidance from the central government, communities in Niger can self-organize themselves to overcome disasters. To that end, social capital might be a substantial asset and contributing factor. Social capital represents a costless mechanism that can help overcome crises (Rayamajhee and Bohara 2019). Several social values that can contribute to build and maintain a strong social capital already exist on ground. These include cooperation, solidarity, and participatory actions. The promotion of these social values may help people to work together as a community to overcome crises such as droughts and floods without the central government being necessarily involved.

5.2. The abundance of precipitation might spur social and economic development

Over the next 25 years, the climatic variability may be such that abundant precipitation will create the conditions that would allow the environment of Niger and its food production systems to flourish. Livestock and agricultural farmers would be able to maximize their productivity. Abundant water might be available in the Niger River and other bodies of water that would allow aquatic species, especially fish to reproduce and multiply for the fishing industry to prosper. All the major sectors of activity such as agriculture, livestock, fishing, forestry, tourism, industry, and businesses may be flourishing, allowing communities to become self-sufficient and be able to optimize their profits. Food and other necessary items may become cheaper and abundantly available across the country. The issue of hunger and famine may no longer be a threat to communities, and belong to the past. Dispersed and divided families due to food insecurity may now start to reunite as food becomes more available. People may also return back to live in their villages and sociocultural environment.

The ability of communities to produce enough food and become self-sufficient may be an opportunity for the government to focus on sectors of social and economic development. The financial resources that would have been spent for providing support and food assistance can be invested in sectors such as education, health, clean water and sanitation. This would contribute to the improvement of the living condition and the literacy rate of communities. Other aspects that would need to be addressed include the issue of social justice and gender equality. Women represent more than 50 %

(RGP/H-RSSF 2012) of the population. Their access to education, jobs, and responsibility is often limited due to traditional and cultural considerations might be among the stumbling blocks for the country' s social and economic development. Beside addressing the inadequacy of food production with respect to population growth, empowerment of women through equal access to education, jobs, and responsibility might contribute to the improvement of families' wellbeing and the country's economic development.

However, in order for women to be able to own and run private as well as public institutions, appropriate sensitization programs might need to be conducted and directed especially towards their male counterparts among whom many hold the opinion that the house and kitchen are the appropriate places for women. Therefore, in order to be successful, it might be important to combat this belief and demonstrate through these programs that the success of women is a success for the family and for the society as a whole. The adoption of policies that promote women, democracy, and culture of merit and excellence might facilitate the process towards social justice and gender equality.

6. SCENARIO SUMMARY

Table 3 represents a summary of the various scenarios analyzed and their related risk level on communities and the environment of Niger. The risk level associated with the major human and environmental effects for each scenario is characterized as very high, moderate, and low depending on the degree of severity of drought, population growth trend, and effectiveness of institutional response. The major contributing factors to each risk level are in parentheses.

Table 3: Scenarios with level of risk related to major human and environmental effects.

SCENARIOS	SCENARIO 1: <i>Long-term drought, ineffective institution, rising population</i>	SCENARIO 2: <i>Long-term drought, effective institution, controlled population growth</i>	SCENARIO 3: <i>Highly variable climate, ineffective institution, rising population</i>	SCENARIO 4: <i>Highly variable climate, effective institution, controlled population growth</i>
Major human and environmental effects	Level of risk and severity of effects due to interactions of drivers of each scenario on Niger environment, communities and their social and economic activities (major contributing factors are in parentheses).			
Land degradation, desertification	Very high (Tree mortality, erosion, resource overexploitation)	Moderate (Reduced pressure over resources, education)	Moderate (Less severe droughts such as flash and short-term droughts)	Low (Reduced pressure over resources, education, sensitization, intensive production system, soil conservation)
Pressure over natural resources	Very high (Extreme poverty, exponential population growth, heavy dependence on natural resources)	Moderate (Decreasing population growth, education, access to decent jobs, sustainable energy)	Moderate (Ability of ecosystems to recover after flash and short-term droughts)	Low (Reduced resource demand, education, intensive production system)
Loss of biodiversity	Very High (habitat destruction, fragmentation, resource depletion, loss of landcover)	Moderate (Decreasing population, environmental protection and conservation)	Moderate (Ability of ecosystems to recover after flash and short-term droughts)	Low (Reduced pressure over resources, position relationship with nature, protection and conservation of species)

Table 3: Scenarios with level of risk related to major human and environmental effects (continued)

SCENARIOS	SCENARIO 1: <i>Long-term drought, ineffective institution, rising population</i>	SCENARIO 2: <i>Long-term drought, effective institution, controlled population growth</i>	SCENARIO 3: <i>Highly variable climate, ineffective institution, rising population</i>	SCENARIO 4: <i>Highly variable climate, effective institution, controlled population growth</i>
Major human and environmental effects	Level of risk and severity of effects due to interactions of drivers of each scenario on Niger environment, communities and their social and economic activities (major contributing factors are in parentheses).			
Decreased soil fertility, food production	Very High (Tree mortality, loss of landcover, loss of nutrients, erosion, soil incrustation)	Moderate (Resilient ecosystems, improved soil stability and quality)	Moderate (Ability of environmental conditions to restabilize after short-term and flash droughts)	Low (Empowerment of farmers, conservation tillage techniques,)
Livestock mortality	Very High (scarcity/depletion of forage and water)	Moderate (Early warming, communication, equity, trust, transparency, destocking, supplemental feed, self-reliance)	Moderate (Ability to produce after short-term and flash drought periods)	Low (Self-reliance, intensive livestock production, production of supplemental feed)
Economic crisis	Very High (Loss of income, poverty trap, high cost of living)	Moderate (Institutional support, resilience of production systems, alternative source of income)	Moderate (Reduced periods of droughts and ability to produce after short-term and flash droughts)	Low (Education, protection of environment and production systems, increased productivity)
Famine, hunger	Very High (Loss of income background poverty, poor adaptive capacity high cost of living, selfishness, lack of support and solidarity)	Moderate (Community solidarity, self-reliance, food assistance, early warning, equity, trust, transparency)	Moderate (Reduced periods of droughts and ability to produce after short-term and flash droughts)	Low (Modern agricultural techniques, increased food production, support from the government)

Table 3: Scenarios with level of risk related to major human and environmental effects (continued)

SCENARIOS	SCENARIO 1: <i>Long-term drought, ineffective institution, rising population</i>	SCENARIO 2: <i>Long-term drought, effective institution, controlled population growth</i>	SCENARIO 3: <i>Highly variable climate, ineffective institution, rising population</i>	SCENARIO 4: <i>Highly variable climate, effective institution, controlled population growth</i>
Major human and environmental effects	Level of risk and severity of effects due to interactions of drivers of each scenario on Niger environment, communities and their social and economic activities (major contributing factors are in parentheses).			
Ecoviolence	Very High (resource scarcity/depletion, conflict and intense competition over resources)	Moderate (Resilience, education, peaceful settlement of conflicts, good relationship, solidarity)	Moderate (Reduced competition over resources following droughts when resources become available again)	Low (Less competition over resources, regulation of access and use of resources, self-reliance)
Rural exodus, ecorefugees	Very High (Poverty, lack of support, deterioration of social values and relationships)	Moderate (Technical and financial capacity to provide food assistance and support)	Moderate (Reduced human displacements due to less severe drought conditions. Only circular migration)	Low (Self-reliance, increased food, available resources for all)
Flood with related consequences	Not Applicable	Not Applicable	High (severe precipitation, poverty, poor construction material, inadequate housing)	Low (Incentives to promote adequate housing, increased living conditions, solidarity)
Socioeconomic development	Low (Extreme poverty, loss of income, food insecurity)	Moderate (Self-reliance, resilience, education, alternative source of income)	Moderate (self-reliance of communities, short period of droughts, reduced competition and ecoviolence)	High (Increased productivity, reduced conflicts, promotion of education/knowledge, social justice)

7. CONCLUSION

The geographic position of Niger contributes to its exposure to frequent climatic disasters. Analyses have shown that the country is highly likely to experience intense and diverse climate related disasters which include long-term, short-term, and flash droughts due to rainfall deficit, and floods due to excessive precipitation. These disasters can have adverse effects on the environment and communities across the country. This scenario analysis for Niger environment was to highlight the nature and magnitude of some of these consequences. Scenario 1 represents the worst-case scenario with its effects being magnified due to increasing demographic pressure and institutional failure. With respect to scenario 2 which would result in moderate effects compared to scenario 1 with its severe impacts such as high risk of land degradation, hunger and famine, ecoviolence, ecorefugees, loss of biodiversity, etc. Scenario 3 may lead to moderate effects, or may offer an opportunity for socioeconomic development, depending on the climate variability. Scenario 4 represents the best-case scenario with low effects due to effective institutions controlling and balancing population growth with food production. With adequate precipitation and policies, this scenario would be an opportunity for Niger to embark on the journey of social and economic development.

Whatever the climatic outcome might be, the environmental context should not be considered solely as the hinderance for the development of Niger and the justification for the condition of poverty of communities. Human factors might be the foremost reason. Although its position within the Sahara and the Sahel region might be viewed as a challenge, it might be possible to develop and improve the living condition of communities with appropriate socioeconomic policies. As Smith (1950) said: “whatever the soil, climate, or extent of territory of any particular nation, the abundance or scantiness of the annual supply [output] depends on the skills, dexterity, and judgement of its labor”. Therefore, the abundance of natural resources is not the panacea for all the challenging issues of Niger. The quality of human resources and the capacity to address the climatic and environmental challenges are also fundamental for the country’s development. Though drought events may not be avoided, their effects can nevertheless be mitigated.

Effective policies that promote development may include a balance between population and economic growth, social justice, promotion of education, and the development of adaptive strategies to

use available resources as an opportunity and a boon for development. A particular focus might need to be put on women's education and promotion as essential contributor to social and economic development. Until Niger will be able to invest in and to value knowledge, and to consider social justice, equity, and merit as a governing principal, it might be hard for Nigeriens to get out of the current condition of poverty and embark on the journey of socioeconomic development in particular and sustainable development as a whole.

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