Journal of Economics and Sustainable Development
Volume: 05 / N°: 01 (2022), P86:-106
ISSN : 2661-7986 EISSN: 2773-2606

The impact of Climate Change on Food Security and Health, Case of Algeria

Rachida Kaabache[*], Brahim Badaoui

Department of Economic sciences, Faculty of Economic, Commercial, and Management Sciences, University of Bejaia, 06000 Bejaia, (Algeria),
charira779@gmail.com
University of Abelhamid Mehri, Constantine 2, (Algeria),
brahim.badaoui@univ-constantine2.dz.

Received:28/12/2021 ***Accepted:04/02/2022*** ***Published:02/03/2022***

Abstract:
Global warming, as a modern issue faced by humanity, is following a pace considered to be the fastest since the last ten thousand years. It is caused by climate fluctuations, but also human activity; exposing the world population to food insecurity, famines and transmissible diseases… Particularly in the developing world, where populations are already living in a precarious situation. Our country witnesses its effects through lower precipitations, which can affect its water capacities and the agricultural production volume, with a direct impact on its food security. A situation causing the food bill to rise constantly in order to guarantee food availability for its population. Therefore, the solution could be the implementation of a new agrarian policy, enabling a sustainable management of its existing resources. That may revive an agriculture that is still suffering from the negative effects of colonization. Throughout this article, we will try to discuss the impact climate change has on food security and populations' health, while highlighting the importance of the agrarian policy as a way to tackle the issue.
Keywords: Climate Change, Food Security, Health, Agrarian Policy, Algeria.
JEL Classification: I12 ; Q180 ; Q540.

[*] ***Corresponding.***

Introduction

The FAO (Ghounini, 2015) describes Nutritional and Dietary Security (NDS) as a priority to any country in the world. It is insured only if every individual is able to acquire a suitable food supply with no social or economic constraint. Hence, the ability of a person to obtain food and choose it freely, in accordance to their preferences, beliefs, in sufficient quantities, and at any time of the day, with no distinction of age, gender or social class… (Bricas & Conaré, 2019; Hulse J. H., 1995; Latham, 2001; Rastoin, 2010). It must also be reinforced by the establishment of both health and hygiene monitoring institutions, whose ultimate purpose is to allow individuals to support their needs (Padilla, 2009) in order to achieve a goal defined by Rastoin (as cited in Kaabache R. , 2018) as the ability to be active and healthy.

Besides, NDS expresses a country's aptitude to satisfy its population's needs relying on domestic production or imports while avoiding budget imbalances. The absence of arable soil could constitute an obstacle to NDS some countries defy by resorting to acquire assets from reliable exports in other domains. As in the case of Singapore, which produces none of its food supply but imports it using its export revenues. Indeed, during 2015, the country's imports exceeded 296.745 Bs USD with 4.106% of food, against 350.506 Bs USD of exports including 75.820% of manufactured products (Hulse J. H., 2008; Sherbrooke, 2021).

However, NDS faces the threat of climate change (CC), one of the factors that pose a risk to food availability (Torquebiau, Tissier, & Grosclaude, 2015). Since it is responsible for the increase of the frequency and intensity of extreme climatic events (droughts, floods, cyclones…), affecting the availability of water resources, ecosystems, arable land… and making it the main reason for production and agricultural markets instability (actu-environnement.com, 2019).

Therefore, it is possible to consider using the implementation of agrarian structures, as well as animal husbandry and agricultural production processes as a tool in the fight against CC, with the aim of insuring both sustainable food availability and a healthy condition for the population.

Our article is centered around the impact of CC on both Food Security (FS) and populations' health (PH). It illustrates how joining the sustainable management of natural resources to the choice of adequate agrarian policies can play a major role in the fight against CC. Particularly in Algeria, a country that suffers from the effects of both drought and desertification.

In this context, we introduce the following principal question:

What role does the agrarian policy play in the improvement of FS and PH?

In response to this question, two hypotheses are put forward, namely;

1. CC poses a risk to FS and PH.
2. The implementation of an adequate agrarian policy may constitute a sustainable mechanism to fight CC.

Through this article, we seek to improve the state of the Algerian population's FS, as well as its health condition by changing the agrarian structure, which can later be used as a prevention agent contributing in the reduction of health expenditures on the long term. Therefore, we chose to opt for a methodological approach based on three main goals.

Firstly, discuss the repercussions CC may have on FS and PH, in order to highlight the risk CC constitutes for food availability and its impact on human health. Secondly, depict the environmental situation in Algeria, by setting out the three main extreme phenomena of floods, drought and desertification and the way they act negatively on food availability. Thirdly and finally, highlight the cost of these extreme natural disasters, and introduce the sustainable management of the already implemented agrarian structures as a way to alleviate the consequences of CC and create a resilient agriculture.

1- Climate Change and its impact on Food Security and Health

CC could be described as a variation of the climate state, observed through the analysis of obtained statistics on the oscillation of the climate's physical characteristics along a period of ten years or more. Besides, according to the United Nations Framework Convention on Climate Change (UNFCCC), it is caused either by the variability of the climate or human activity (Van Diemen, 2019).

In 1824, Jacques Fournier was the first scientist to draw attention to the effects of global warming on the planet. Nevertheless, it took more than a century for a thesis on the subject, by the physicist Gilbert Plass, to be validated in 1940 (Sokona, 2018).

In fact, after WWII, industrial development resulted in an unprecedented economic growth (Mahi, 2011), causing harm to the atmosphere as a result of hazardous discharges released into nature and affecting entire ecosystems. Such a chain effect can be observed as atmospheric changes act on the biodiversity, which in return alters agricultural systems, affecting food availability and human health. Therefore, FS ad PH become vulnerable (Melgar-Quinonez, 2018).

1-1- Climate change and Food Security

Torquebiau (as cited in Seltzer, Lasserre, Granojean , Auber, & Fourey, 1946) refers to CC as one of the factors that constitute a risk for agricultural

production, since it is responsible for the increase of extreme climatic events' frequency and intensity, that is drought, floods, hurricanes… In fact, climatic variability can be responsible for the reduction of farm yields and food availability, consequently leading to a risk of food insecurity in the countries affected by this phenomenon (Gitz, 2016).

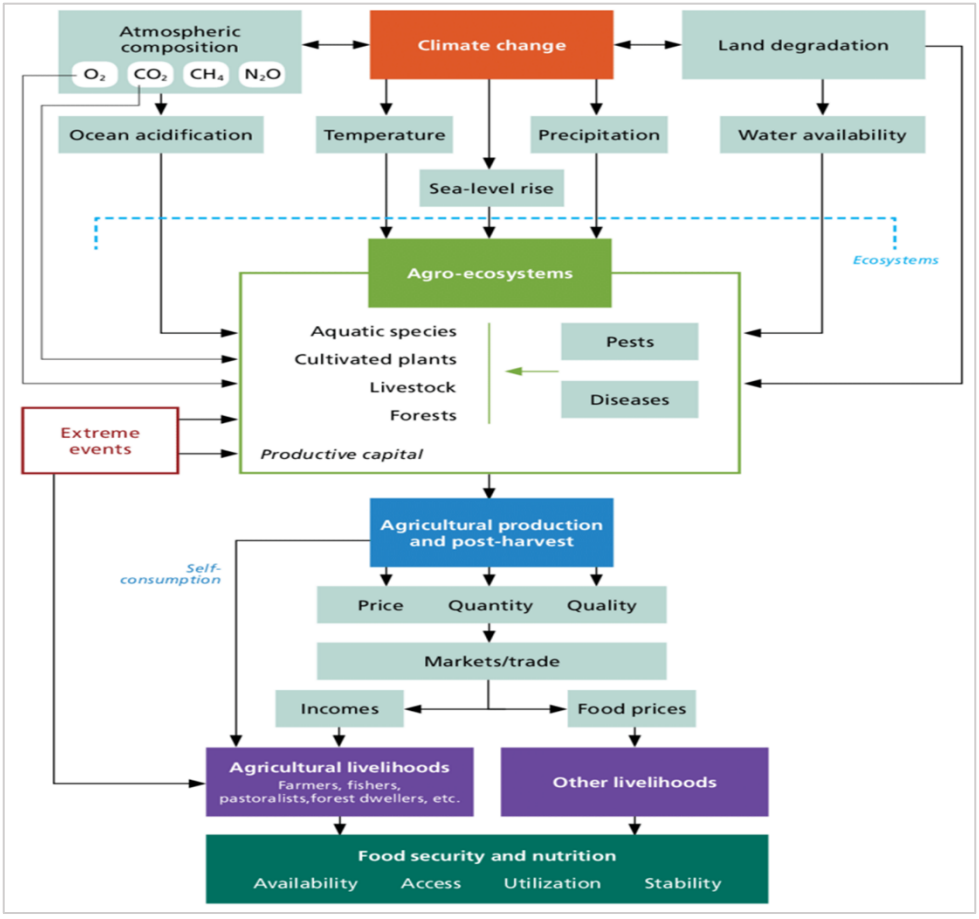
Currently, more than 40% of the population in Southern Madagascar is undergoing a situation of food insecurity, with 14,000 adults and 500,000 infants under the age of five (5) suffering from acute malnutrition. A situation caused by four (4) consecutive years of the most damaging drought the country has witnessed in forty (40) years, which led to the decimation of food-producing cultivations due to CC. Besides, both the UNICEF and the WFP expect the number of victims to double if not quadruple, depending on the areas by the end of the current year (2021), as a result of the hunger gap occurring between the months of October and December (UNICEF, 2021).

According to Torquebiau (2015) and IPCC predictions, the Global FS will soon be facing the threat of CC, as temperatures will continue to rise, affecting the world's agricultural production, and will be mostly noticed in the tropical regions where cereals (wheat, maize, and rice) are mainly produced. This is due to the correlation between temperature rise and cereal yield; thus, productivity decreases for each +1 to 2°C for wheat and maize, and +3 to 5°C for rice. In addition to the availability of fresh water that will be affected by droughts, reducing the productivity of farmlands and causing food scarcity. The damages will be more ravaging for the families that are already suffering from difficulties to access either the land or agricultural inputs (households supported mainly by women), risking to turn an existing poverty into an acute one and lead to climatic migration. As a result of such a situation, agricultural products exports will be affected, causing the increase of their prices on the international market (OECD, 2011). Therefore, threatening the FS of populations living in vulnerable countries.

A reading of the following Diagram No 1 offers us a better understanding of the different factors related to CC, through which it can constitute a threat to FS. It illustrates the way CC can impend the availability of water resources as well as agrosystems through climatic variability, demonstrated by precipitations and temperature variations, in addition to the proliferation of pests, causing the appearance of certain illnesses (zoonoses). Furthermore, it shows how CC can influence nature's balance and pose a risk to the survival and growth of vegetal (plants, trees…) and animal (terrestrial and aquatic) species. Consequently, it can damage the production ability and lead to both an insufficient and unsatisfactory agricultural offer, which may be fatal to small-scale producers who survive thanks to a subsistence agriculture, as

well as the consumers whose purchasing power can't follow the price fluctuation on the market.

Diagram 1: **The Effect of Climate Change on Food Security**



Source: FAO, 2016. In (Gitz V., 2016)

1-2- Climate Change and Health

Morand & Waret-Szkuta (as cited in Roger, Bonnet, Steinmetz, Salignon, & Peyre, 2015) discuss the effect of CC on human health, as it causes a specific type of diseases, which Seltzer P. et al. (1946) identify as endemic to certain regions where they are widely spread due to the climate there, i.e., vector-borne diseases, parasitoses, zoonoses… These infections occur more frequently as a result of CC, since it affects the natural habitat of wild animals (*"pathogen reservoirs"*) and push them through their search for

food and shelter to coexist with humans and their pets or farm animals. Hence, creating a suitable environment for viruses to be transmitted indirectly to humans before turning into epidemics. That was the case of the avian flu, spotted for the first time in Hong Kong in 1997, where it took the life of six (6) people (Van Der Werf, 2012). Before reemerging in 2003 all around the world, forcing governments to take drastic measures. In France, 200 million fowl were slaughtered, causing a financial loss of 80 Ms € (Bost & et al., 2006). In Nigeria, and according to the « Federal Livestock Department and Field Survey », in June 2006 the country destroyed 882,453 fowl costing it 4.82 million USD, a loss that grew to reach 11.7 Bs USD as a result of the poultry farming reimplementation operations in the country (ECOWAS, 2006).

Today, the situation has not improved, as during 2020-21, other outbreaks have been identified. In France for example, 492 infection hotspots in May 2021, triggered the destruction of about 3.5 Ms fowl (MAA, 2021). As for Algeria, in February 2021, the death of 50,000 infected laying hens required the slaughter of the remaining 2,000 fowl of the same farm (MARD, 2021).

On the other hand, Tambo F. et al. (as cited in Roger F. et al., 2015) state that in the case of food unavailability, it is common or rather frequent for individuals to seek the satisfaction of their needs in animal protein through hunting or the consumption of wild animals. A practice very favorable to the appearance of different zoonoses, including Ebola. Which according to Kortepeter MG et al. (as cited in Reynard, Volchkov, & Peyrefitte, 2014) emerged in Western Africa, first in 1976 in Northern DRC (former Zaire), where it led to the death of 280 persons, before taking the life of 2,500 others throughout neighboring countries. The WHO gives us an updated picture of the damages caused by the disease as it shows that thirty-eight (38) years after it first appeared, it reemerged in Senegal, causing the death of 226 (64% of total cases) people. Before reaching Guinea where the number of deaths rose to 2,543 (67% of total cases) persons during the period 2014-16. Then, Liberia and Sierra Leone with respectively 4,809 and 3,956 deaths (45% and 28% of total cases). Through their efforts to contain the epidemic, these countries resolved to implement different preventive policies that proved efficient against both the infection by and propagation of Ebola. As a result, only eight (8) cases including four (4) deaths where registered in 2017 in DRC (WHO, 2018). The situation remained under control until October 2021, as new cases were reported in DRC, where the government's response was fast, as it implemented a vaccination policy on 10/13/2021 in order to stop the propagation of the disease. (UN, 2021).

Nonetheless, Fish R. et al. (as cited in Roger F. et al., 2015) estimate that health systems face a challenge regarding health risk management, due to

the unpredictability of infectious diseases that tend to occur in different populations and at any time. Especially that during any CC induced infectious disease outbreak, health resources tend to be entirely dedicated to contain the spread of the disease, while access to health care facilities is restrained. Hence, putting the life of patients who suffer from non-transmissible illnesses like deficiency or plethora affections… at risk, due to their exclusion from health structures. That is the reason why research should be oriented towards identifying the transmissibility patterns of infectious diseases, not just to contain them, but also to adopt relevant health policies aiming to maintain human health and provide equal health care for all.

2- The Environnemental Situation in Algeria

According to Cowling RM et al. & Giorgi F et al., the Mediterranean region's climate is characterized by a "*high inter-annual variability with some episodes of extreme rain or drought*". However, it is identified as one of the world's most susceptible regions to CC, with predictions of an important decrease of precipitations, mainly during winter seasons (Lempereur, 2015).

Regarding the Maghreb, including Algeria, J. Despois (as cited in Mahi, 2011) describes the situation by focusing on the link between soil and climate, while highlighting the fact that in this part of the world, land is considered as the most valuable of assets. This puts the population in a critical position, as CC became a direct threat to their survival. Especially that the region has been suffering, for years now, from its consequences, that is the degradation and reduction of natural resources, due to different natural phenomena like floods, recurring droughts, and desertification, which had the most devastating effect.

2-1- Floods

Seltzer P. et al. (1946) describes the Algerian climate as variable, depending on the different seasons and areas of the country, which is affected by the Mediterranean Sea on one side and the Sahel on the other, causing a season alternation from rainy to dry. However, Mahi (2011) observes that for a period of almost thirty years (1975-2004), the country witnessed a precipitation instability similar to many parts of other Maghreb countries that went through a cycle of long periods of drought followed by some days of excessive rainfall, then a longer period of drought.

Consequently, the dry soils of this region suffered from a series of heavy erosion events (Jan. 1990 in Tunisia, Nov. 2001 in Algeria, Nov. 2002 in Morocco). This led to dramatic human and financial (infrastructures,

buildings…) losses in these countries. For example, in 1980 Tunisia estimated that 1.3 Ms ha (23.68%) out of its 5.5 Ms ha of mapped land was impacted by erosion, with 740,000 ha (56.92%) mildly to severely affected. In addition, 3 Ms ha (20% of the territory) suffered from water erosion with 50% identified as severely threatened; mainly, the arable lands of the country's Center and North regions, reaching 1.2 Ms ha that represent fourth (¼) the country's farm land. In Algeria, the 2001 floods caused 1.000 deaths and 1 Bs USD of financial loss.

2-2- Drought

Drought is one of the most serious obstacles faced by agriculture in the developing world. Lacape J-M. et al. (2015) identify the variability of rains as a probable cause for the farming production decrease, mainly cereals.

Based on the botanical analysis of the Maghreb trees, Mahi (2011) states that the region has undergone several episodes of drought for centuries. In fact, the analysis of the periods of drought the region underwent during the last century, showed that the frequency during 1950-60, shifted from one drought event in a decade to two or even three during the same period. Before reaching its highest level between 1985 and 2005, accompanied by a very important expansion. In Tunisia, the study revealed, during 1907-97, the country went through twenty-three (23) years of drought; while Morocco witnessed twenty-one (21) years of generalized and non-generalized drought between 1804 and 1996. In Algeria, a different study conducted by Seltzer P. et al. (1946) regarding the precipitation variability during 1913-38, showed that although the 25-year average pluviometry was of 120 Bs M^3 (300 mm) spread over an irrigated surface of about 400,000 Km^2, neither regularity nor equal space distribution were observed. First, during 1919-20 (the driest season) waterfall volumes didn't exceed 85 Bs M^3 (212 mm), secondly, it was only 150 mm in the high plains but 250 mm in the Tell. The same for 1927-28 (season with the heaviest rains), for an average precipitation volume of 155 M^3 (388 mm), it was regions like Texanna and Mascara that recorded respectively 958 mm and 732 mm.

Furthermore, the National Statistical Office reveals that the average volume of water in Algeria during 2009-11 was split by ten (10) compared to the last century, as it didn't exceed 12.707 Bs M^3. Leading us to conclude that recurrent droughts constitute one of the factors leading to the reduction of water availability in the country (NSO, 2018). However, Hirche A. et al. (as cited in Nedjraoui & Bédrani, 2008), estimate that the drought in Algeria is centered in the steppe, mainly in Western areas. As precipitations diminished by 18 to 27% during the last decades, making the dry seasons last about two (2) months longer. Knowing that the region relies on rainfed agriculture, mainly cereal farming, distributed over a surface of 20 Ms ha,

as well as animal husbandry that represents the main activity of its population. Which finds itself in a precarious situation due to water scarcity, as this resource reserves are way below the expressed needs and is currently affected by CC.

Nevertheless, another factor of the region's soil deterioration is the decrease of the vegetation cover due to overgrazing, land clearing and drought. A situation that imposed, according to Abaab A. et al. & Bourbouze A., Guillaume H. (as cited in Daoudi, Terranti, Hammouda, & Bedrani, 2013), to undertake changes at the level of agricultural and pastoral proceeds to adapt to this climatic variability. In addition to the introduction of a new herd management (mobility and food supply), and the acquisition and replacement of irrigation practices, mainly for cereal farming and market gardening.

In order to comprehend the extent at which the production systems and adaptation practices followed by agropastoral farmers to fight drought were vulnerable, Daoudi A. et al. (2013) carried out a study from 2008 to 2010. During this study, Forty-nine (49) households were selected from two municipalities located in Laghouat: Dayet Debdeb and Thnaya, both situated in the Central Steppe of the Algerian Southwest (470 km from Algiers). The population's main activity is extensive sheep grazing (no transhumance) and subsistence rainfed cereal farming, relying on an average annual precipitation of 215 mm for the last twenty (20) years. Regarding land ownership, Bedrani (as cited in Daoudi et al., 2013) states that the plots are part of the State Private Domain, with surfaces $\leq$ 15 ha each of rangelands for 73% of the population. The study results showed that yields depended strongly on rainfall and that drought had disastrous repercussions on the population's livelihood. Regarding cereal cultivation, during the agricultural year 2007-08, 50% of agropastoral farmers who sowed durum wheat and barley made no harvest because of the rainfall decrease, while during the next rainy years 2008-10, the yield size tripled. Concerning animal farming, during the dry year, only 26.5% of agropastoral farmers were able to preserve most of their flocks (farmers with more than 50 ewes), while 33% were able to preserve less than 20 sheep, and 14.3% lost their entire flocks. The following rainy years, all agropastoral farmers renewed their flocks with an increase of 10 to 28.5%.

Furthermore, the study observed the methods of preservation of the agropastoral farming and local adaptation, i.e., partnership and shepherding.

- ✓ *Farming Partnerships*: a first agropastoral farmer provides the land and half the quantity of the seeds to a second one who contributes with the other half of the seeds and the plowing expenses. At harvest time, both

support the harvesting expenditures evenly, and at the end share the benefits equally.

- ✓ *Shepherding:* it is carried out by an agropastoral farmer with a small number of sheep, who, for one season, herds a flock belonging to either a neighbor living in the city, hence unable to take care of it himself, or a stranger to the region whose own area suffers from drought (south the wilaya for example). In this process, the agropastoral farmer in question receives a payment covering the costs of shepherding and grazing.

In 2008-09 and 2009-10, respectively 44.2% and 37.5% agropastoral farmers solicited the help of a cereal farming association for 25% of the surface of their plots. Meanwhile, for shepherding and grazing, the rates exceeded respectively 38% and 68% for 35% and 49.8% of the total number of sheep.

Finally, undertaking such adaptation strategies is considered as the only way to renew the already fragile agropastoral farmers' flocks and cultivations. In fact, about 80% of the 2009-10 seeds ensued from a partnership between 50% of the agropastoral farmers in 2008-09. Nevertheless, these methods remain useful only if droughts were to occur on a less frequent basis, while in the case of persistent droughts these agropastoral farmers could lose their livelihood; therefore, alternative strategies should be implemented.

2-3- Desertification

Desertification is estimated to be the most sensitive and worrying subject when it comes to tackle environment issues. Since it weighs heavily on any country's economy, as it destroys the population's livelihood and reduces it to poverty, especially in regions already living in precarious conditions (Benslimane, Hamimed, El Zerey, Khaldi, & Mederbal, 2008). As correct as this description could be, Nedjraoui D. and Bedrani S. (2008) outline the fact that it doesn't consider the desert progression (UN, 2021), which represents a decrease of both the vegetation cover and ecological potential, a degradation of soils located in arid, semi-arid and dry sub-humid regions, as well as a reduction of water resources (Bied-Charreton, 2007).

Thomas, Arrar and Le Houerou (as cited in Benslimane et al., 2008) estimate that desertification affects 39.2% of the planet, i.e., 51.6×10^6 km² of deteriorated land, with Northern Africa alone holding around 9.42% of this surface, i.e., 4.86×10^6 km². A situation mainly caused by acute and recurring droughts, as well as intensive agricultural activities like overgrazing…

According to Bied-Charreton (2007), the countries most affected by desertification are located in Africa, Asia and Latin America, where it affects 39.2% of the available land of the world. Regarding Africa,

desertification is mainly centered in the North African Sahara, the Sahel, the Horn of Africa, certain regions of Eastern and Southern Africa. For Asia, it can be observed in India, Pakistan, a part of China, as well as the countries of Central Asia and the Middle East. When it comes to Southern America, desertification affects mainly Mexico, parts of Brazil, Argentina, and Chile.

Agoumi A. (as cited in Daoudi et al., 2013) estimates that the Maghreb region is one of the most vulnerable areas to CC, mainly as a result of drought. The damages caused by this phenomenon are becoming more serious due to its recurrence, as it went from occurring once every decade during the last 20th century, to five or six times during the same decade in the 21st century. Leading the region, according to Mahi (2011), to suffer from an irreversible desertification, due to the lack of global strategies and means dedicated to address the problem. As for Bonte et al. & Paillard et al. (as cited in Daoudi A. et al., 2013) they estimate that the effects of desertification in Algeria are clearly visible and observe that as one of the Maghreb countries, its development is hindered by it. Additionally, Nedjraoui and Bédrani (2008) observe that it became common to see sand deposits transported by the winds and sometimes turn into dunes, a situation more manifest in towns like Mecheria or Naama that are often subjected to sandstorms. They estimate that the two practices of overgrazing and land clearing play a major role in the accentuation of desertification. This can be observed through two distinct maps on land use -One, established in 1978 by the USTHB of Algiers' Research Center on Terrestrial Biology, regarding the Southern West of Oran. The other, in 2003, in the framework of the program of the Long Term Ecological Surveillance Observatories Network (ROSELT)-, which make it clear that the country has undergone a very important transformation of its vegetation cover. Besides, Le Houerou, Aidoud and Bedrani (as cited in Nedjraoui and Bédrani, 2008) locate desertification damages in the steppes of arid and semi-arid regions, known for extensive sheep breeding, and threatened by recurring droughts, overgrazing, and an overexploitation of soils that are not adapted to agriculture…

In fact, as from 1978, several prevalent plants disappeared, as psammophile species that didn't even exist in 1978, started to proliferate between 1981-87 due to sand build-up.

The following Table 1 highlights the alarming decrease of three (3) varieties of plants, namely; Stipa tenacissima (esparto), Artemisia herba-alba (White wormwood) and Lygeum spartum (esparto grass), over the period 1978-93.

Table 1. Evolution of the pastoral production (PP) of the main steppes (ROSELT/Algeria, 2005)

Facies	PP (FU/ha) 1978	PP (FU/ha) 1993	Δ
Stipa tenacissima (esparto)	70-140	18-074	-52; -56
White wormwood	70-190	22-120	-48; -70
Lygeum spartum (esparto grass)	80-200	25-082	-55; -118

FU: Feed Unit, Δ **:** variation 'added by us'.

Source: Nedjraoui , Bédrani (2008).

Nedjraoui and Charrier (as cited in Nedjraoui and Bédrani 2008) focus on the case of the esparto, which is *"an endemic species to the Western Mediterranean"*, and despite being the most adapted plant to drought, it underwent a continuous reduction since its inventory during the last century. From a surface Charrier estimates at 5Ms ha in 1873, to be evaluated by Boudy at 4Ms ha in 1950. Before reaching 2.025 Ms ha in 1989, according to the National Center for Space Technology survey that revealed the disappearance of half (½) the esparto mats.

The surface decrease of these plants can be considered as a clear indicator of desertification, especially that more than 60% of the rangeland that had a vegetation cover superior to 25% are currently left with no more than 10%.

Later, as part of the preparation of a tracking card of the desertification progression in the North of the country, another study was launched by Benslimane (2008), who used satellite remote sensing technology to assess both the ecosystems and soils. This study concluded that one of the main causes of soil degradation in the North was the decrease of precipitations.

According to Hadjiat (as cited in Benslimane, 2008), the most sensitive areas to desertification are situated in the Tell, where the main cause is water erosion, affecting 28% of the land in the North, and causing: a decrease in vegetation cover, soil erosion, yield reduction, dam silting, and population impoverishment. Regarding the Western region of the country, mostly affected, the degradation of the land reached 47%, due to several factors, like farming methods, climatic causes (rainfall, temperatures…) soil types… Concerning the high plateau of the steppes, soil degradation is linked to wind erosion, which mainly affects rangelands suffering from the consequences of droughts and overgrazing. In fact, rangelands face two challenges: on one side, a decrease of the vegetative cover, and the drying of water points; and on the other, the increase of sheep populations. Not to mention the disorder witnessed at the level of the plots belonging to the *"Arch"*, flooded by flocks due to their legal status, as well as the breeders' sedentary lifestyle and the overexploitation of the land. Finally, and according to this same study, desertification reached an expanse of 945.000 ha (9.5% of the total surface) of land described as "very deteriorated",

which didn't exceed 600.000 ha in 1980, following the National Office of Studies for the Rural Development (BNEDER). This explains the fast pace at which the phenomenon is evolving, estimated to 13.800 ha per year, particularly in the Western High Plains, dubbed the *"South Oran Steppe"*.

3- The Cost of Disasters and the Fight against CC

The term disasters includes all types of natural catastrophes, namely ; floods, windstorms, earthquakes, volcanic eruptions, forest and bush fires, blazes… (Munich Re, 2003).

3-1- The cost of disasters

According to the estimations of the insurance company *« Munich Re »* (2003), in 1998 the developing world experienced economic losses caused by disasters linked to CC in the range of 42 Bs USD, including costs subsequent to the Yangtze river floods in China and Hurricane Mitch in Central America. For countries like Nicaragua and Honduras, the losses reached at least 66% of their GDP (Heller, 2002). The OECD (2011) estimates the Australian agriculture's losses, related to natural disasters, in 2010-11, to be between 459 and 550.8 Ms USD. With some products more affected than others, like cotton at about 138 Ms USD, as well as fruits and vegetables at about 206 Ms USD. Besides, in February 2011, Northern Queensland underwent heavy losses related to banana and sugar production valued at 275 Ms USD.

In 2019-20, *"Munich Re*" estimated the cost of bush fires in Australia at 1.4 Bs USD "adjusted to inflation". Fires that caused the destruction of about 10 Ms Km^2 of bushes and forests as well as 3,000 buildings. They also affected the air quality from Queensland to South Australia (Faust & Markus, 2020).

However, it remains important to remember that the region of Southeastern Australia has been suffering for decades from bushfires due to the increase of temperatures and decrease of rainfall, turning the bushes into a favorable environment for fire ignition. Nevertheless, it was not until December 2019 that the temperatures exceeded, for the first time since 1910, 40°C lasting 11 days. In fact, this temperature rise was due to the Indian Ocean Dipole and the Southern Annular Mode, which affected temperatures, rainfalls and wind acceleration, leading to both drought in Southeastern Australia and extremely hot and dry winds blowing on the desert, hence increasing the probability of fire ignition by about 30%, causing bushfires in December 2019.

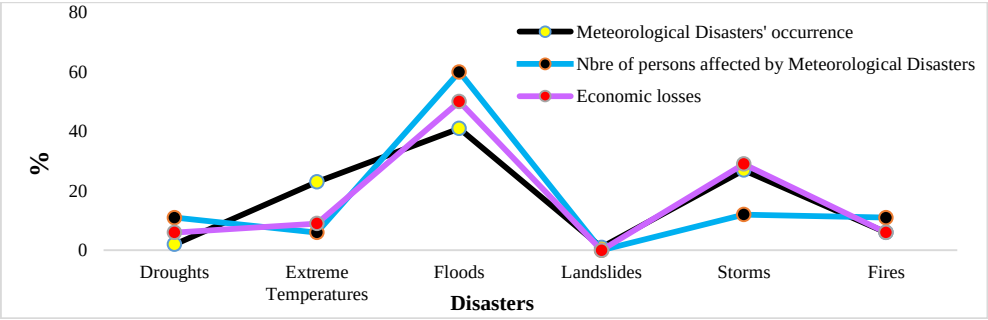
According to the Centre for Research on the Epidemiology of Disasters (CRED), Europe witnessed during 2001-20, 999 different natural disasters,

95% of them related to meteorological variations. As a result, 11 Ms people were affected and 150,000 lost their lives (CRED, 2021).

Figure 1 displays the different types of natural disasters the region experienced for nineteen (19) years. It shows that floods (41% chance of occurrence) are the most prevalent meteorological disaster, affecting 60% of the population. Followed by Storms and droughts (27%), which affect respectively 12% and 11% of the population. Finally, extreme temperatures (23%) that affect 6% of the population. Nevertheless, temperature variation was the only natural disaster to take the lives of 149,000 persons. In fact, temperature oscillation caused 146,000 deaths due to their rise and 3,800 others as a result of their decrease. Numbers that are much higher than floods, which in spite of their frequency, caused only 4,142 deaths.

These numbers show that the waves of heat and cold in Europe represent the meteorological disasters with the highest risk of death to populations. For this reason, the priority should be given to the protection against temperature variations when implementing new policies.

Figure 1: Meteorological Disasters Consequences in Europe %, 2001-20



Source: Figure made by us from (CRED, 2021).

3-2- Climate Change Prevention Policies

Before implementing a policy to fight CC, governments usually consider the effects CC have on human activity, as well as the budgets it would require. Therefore, Torquebiau (2015) estimates that consumers' behavior can influence production processes in a positive or negative way. Thus, the choice of diet can become a tool orienting the implemented production and management policies. Besides, the FAO (2018) estimates that production, transformation and transport methods, as well as consumption models can become a factor of energy consumption increase, hence of Greenhouse Gases. In addition, a new strategy focusing on a resilient *"nutrition sensitive"* agriculture must be established, in order to achieve a sustainable

food supply, which could be introduced into a sustainable food supply system, contributing to the survival of humans but also the planet.

It is in this spirit, Thomas et al. (as cited in Andrieu, 2015) observe, that several solutions have been adopted by farmers, industrialists and consumers alike, in order to face the economic and environmental challenges caused by CC. Such as the policy of reduction of food loss and waste, which is estimated, as reported in 2019 by the FAO (as cited in Kaabache R. , 2019), to be about 1.3 Bs tons of damaged food every year. Causing 3.3 Bs tons of global greenhouse gases, and the loss of 250 km^3 of water that is equal to the annual flow of the Volga river in Russia. Thence, the FAO (2018) estimates that reducing these losses may become a way to decrease Carbon emissions and improve FS. Nonetheless, due to the unclear dimension of CC, this solution seems to be insufficient, requiring as reported by Andrieu N. (2015), the introduction of a new type of agriculture aimed at supporting the research about the transition from the conventional cultivation to a sustainable farming more adapted to CC. Such a sustainable approach was proposed by the FAO in 2010, under the name *Climate Smart Agriculture*. It includes both concepts of adaptation and attenuation. In fact, it targets three main goals, namely; FS through production, Adaptation to CC via agriculture resilience, and CC attenuation by either reducing greenhouse gas emissions or capturing carbon.

This proposition holds a solution to the severe damages CC has caused to agriculture. It suggests a new farming method aiming to preserve FS in the most affected countries. Yet, it can't be achieved without the support of a public policy that would especially enable small scale farmers to achieve this transition. Since it implies a coordination between both sectors of agriculture and environment, in addition to a financing package meant to combine public and private sector resources to fight against CC and guarantee FS.

As a matter of fact, this new approach tries to take up the three challenges of Adaptation, Attenuation and FS in the same time, while taking in consideration agricultural practices, public policies and financial means. However, a new agricultural procedure can't bear fruits with an agrarian structure that doesn't allow farmers to choose their strategies. Therefore, agrarian structure change is a priority in the fight against CC. For example, the *"Re-greening of the Sahel"* in Niger weren't to be successful if not for the research/development programs and the implementation of a new agrarian policy. In fact, after allowing small-scale farmers to own trees and apply new reforestation methods, propitious results were observed in just few years, i.e., an increase of tree density that contributed to a change in the microclimate, as well as an increase of land's productivity (adaptation). In

addition to biodiversity development and vegetative stability (attenuation), all leading to an improvement of the farmers' financial and nutritional situation (FS).

Regarding Algeria, during sixty (60) years of independence, the country adopted several agrarian policies. From self-rule in 1963 to law No 10-03 of August 15th, 2010 on the existing structure overhaul, these policies aimed to improve the small-scale farmers' social and economic condition, enabling them to become the country's economic development locomotive (Hersi, 1981; Bessaoud, 2016). However, despite the fact that a well-established policy could achieve this mutation, no real transformation was operated.

In fact, from 1962 to the late 1960s, no clear agrarian policy was followed, as the priority, back then, was to retrieve public domains in order to insure an agricultural production and keep an already existing part of the market. Especially that during the 1960s, the farming sector provided the country with 25% of its GDP, in addition to more than 50% of its foreign exchange earnings resulting from the export of wine, citrus fruits, and market gardening products. Hence, it was decided to maintain the colonial agrarian structure, even if the production of both wine and orange was suffering from the French market's pressures and couldn't be marketed abroad (Chaulet C. , 1991).

Nine years after its independence the country started the agrarian revolution, following the edict No 71-73 of 1971 (Ait Amara H. , 1992), exactly on the same year it declared the hydrocarbons nationalization (Chaulet C. , 1987). This measure aimed at abolishing ground rent and all forms of rural capitalistic exploitation like tenant farming and sharecropping, as well as erasing big properties and creating intensive small-scaled exploitations instead, in order to maintain the agricultural production while decreasing rural exodus and creating employment (Ait Amara H. , 1999; Adair, 1983; Bourenana, 1981). Nonetheless, Ait Amara (1992, 1999) estimates that the agrarian revolution produced no tangible results. Since it led to no change or disruption of agricultural practices. In fact, plots of land were recovered, and put under the responsibility of the National Fund of the Agrarian Revolution (FNRA) that was unable to distribute them in their integrity. This was due to the lack of applicants, who preferred other sectors such as public works, where they didn't have to comply with State requirements, like the obligation to integrate both a collective exploitation and a farmer's co-op in order to benefit from the equipment and loans, limiting their benefits.

By restoring colonial land and implementing the agrarian revolution in 1971, the State was able to retrieve 40% of the country's Utilized Agricultural Area, and create Socialist Public Domains. However, in the

1980s following the recommendations of the IMF and the World Bank, public authorities decided to free the real estate market and allow land exploitation. Nevertheless, it was not before 1990, thanks to the implementation of the law on agrarian reform that former landowners gained the right to recover their plots. A measure, established in order to stimulate the country's agriculture and economy by allowing the private sector to emerge. A goal that couldn't be achieved, as the majority of the landowners were dead or lacked the financial means to invest in their assets, hence their inability to give any new boost to a sector that remained stagnant for three decades.

Twenty years later, a new reform came to complete the process of the 1990s regarding the State private domain exploitation through law No 10-03 of August 15th, 2010; on the transformation of the permanent possession status into a renewable 40-year-concession. A law that can refrain the investment in such plots, due to the limited time of exploitation. Knowing that a 2001 survey revealed that only 25% of the country's agricultural private landowners hold title deeds for their plots, making it impossible for them to apply for state financing or support. Besides, according to Bouhou and Nemouchi (as cited in Ait Amara 1992, 1999), it can discourage from investing in a field that has no incentives to offer.

Nowadays, solutions can be implemented in order to reduce the damaging effects of drought and desertification, such as a better management of the grazing process through limiting the number of flocks on an acquired land. In fact, Daoudi et al. (2013) & Benslimane (2008) have demonstrated through their respective studies that though agropastoral farmers live in a precarious situation due to CC, desertification itself constitutes an important factor, because of the overgrazing of the land maintained in its collective (Arch) state, which leads to soil degradation and wind erosion increase. This situation has caused the impoverishment of the populations and the increase of drift from rural areas to big cities. For those who stay, they either overexploit the domains abandoned by their owners or those belonging to the Arch in order to survive the dry seasons. However, and due to the recurring droughts, this solution cannot be sustainable, particularly as the overexploitation of the land requires an alternation between rainy and dry seasons. Therefore, it can lead to an aggravation of the current condition of the populations, with a looming threat of food insecurity, internal migration, hence a social and economic crisis at a national level. As a result, a new agrarian structure may become a way to encourage the farmers, through facilitating the process of loan granting, which can be an incentive to restore the deteriorated land, leading to the reduction of desertification, which is identified as the biggest threat to the country's agriculture.

Conclusion

The current century is marked by the effects of climate change that constitutes a serious threat to the advance of agriculture in the developing world. Nevertheless, it shouldn't be considered as the only reason for the failure of these countries to improve their agricultural situation. In fact, Benachenhou (as cited in Bedrani, 1981) estimates that the improvement of the productivity of the farming sector depends on the management of the existing resources, i.e., the ability to implement a strategy and to lead it to fruition using its productive potential. Thence, the implementation of a sustainable management of the resources. Regarding Algeria, it is crucial for the country to restore its agricultural land. Particularly that its Utilized Agricultural Area doesn't exceed 85 Ms ha, for a population of more than 40 Ms inhabitants, which equals to a surface of 0.2 ha of cultivable land per person in 2017-18 according to the NSO (2018). In addition to what Chaulet (1991) describes as non-renewable water resources in the desert, as well as the damages the land experienced for years (erosion, desertification, exhaustion of the soil…) particularly during the last colonization. Therefore, the land should be given enough time to regenerate as the overexploitation may lead to its permanent degradation, turning it barren.

Agriculture is considered as the basis for the development of any country; however, in Algeria this sector can't be expected to take up such a role yet, due to the colonial agrarian policy the country inherited and has continued to follow to date, without adding any improvements to it (Omari, Moisseron, & Alpha, 2012). Consequently, a solution may lie on the adoption of a new agrarian policy to implement after a thorough study of the current agrarian situation. This transformation could lead to take decisions related to the restoration of the soil and the establishment of a sustainable farming, according to the nutritional needs of the population and the quality of the climate.

Bibliography

actu-environnement.com. (2019, 06 05). *actu-environnement.com*. Consulté le 09 02, 2021, sur actu-environnement.com: https://www.actu-environnement.com /ae/ dictionnaire- nvironnement/definition/changement-climatique

Adair, P. (1983). Rétrospective de la réforme agraire en Algérie (1972-1982). *Revue Tiers Monde*(93), 153-168.

Ait Amara, H. (1992). La terre et ses enjeux en Algérie. *Revue des mondes musulmans et de la méditerranée*, 186-196.

Ait Amara, H. (1999). La transition de l'agriculture algérienne vers un régime de propriété individuelle et d'exploitation familiale. *Cahiers Options Méditerranéennes*(36), 127-137.

Andrieu, N. e. (2015). Exploitations agricoles climato-intelligentes ? Études de cas au Burkina Faso et en Colombi. Dans E. Torquebiau, *Changement climatique et agricultures du monde* (pp. 136-146.). Versailles: Quae.

Bedrani, S. (1981). L'agriculture algérienne face au marché mondial. Dans S. Bedrani, M. Bourenane, & M. J., *Les politiques agraire* (pp. 11-). Alger: Crea.

Belaaz, M. (2003). Le barrage vert en tant que patrimoine naturel national et moyen de lutte contre la désertification. *XIIE congrès forestier mondial : Forêt, source de vie*, (pp. 1-8). Quebec.

Benslimane, M., Hamimed, A., El Zerey, W., Khaldi, A., & Mederbal, K. (2008, décembre). Analyse et suivi du phénomène de la désertification en Algérie du nord. *VertigO, la revue électronique en sciences de l'environnement, 8*(3). doi:10.4000/vertigo.6782.

Bessaoud, O. (2016). Les réformes agraires postcoloniales au Maghreb : un processus inachevé. *Revue d'histoire moderne et contemporaine*(63-4/4 bis), 115-137.

Bied-Charreton, M. (2007). Éditorial : État du monde. *Cirad, désertification, 3*(293), 3-5.

Bost, F., & al. (2006). *Images économiques du monde : géo politique économie 2007.* Paris: Armand Collin.

Bourenana, N. (1981). Les causes structurelles de la crise de l'agriculture algerienne. Dans S. Bedrani, M. Bourenane, & J. Molina, *Les politiques agraires en Algérie, vers l'autonomie ou la dépendance ?* Alger: Crea.

Bricas, N., & Conaré, D. (2019). Perspectives historiques sur les liens entre ville et alimentation. *la revue de l'institut veolia - facts reports*, 6-11.

CEDEAO. (2006). *Impacts socio-économiques de la grippe aviaire en Afrique de l'ouest : « étude de cas au Nigeria».* Ouagadougou ; Washington: CILSS ; FEWS NET/USAID.

Chaulet, C. (1987). *La terre, les frères et l'argent, stratégie familiale et production agricole en Algérie depuis 1962.* Alger: OPU.

Chaulet, C. (1991). Agriculture et nourriture dans les réformes algériennes : un espace pour les paysans ? *Revue Tiers Monde*(128), 741-770.

Cred. (2021). *Extreme weather events in Europe.* Munich: Cred.

Daoudi, A., Terranti, S., Hammouda, R. F., & Bedrani, S. (2013, juil. août). Adaptation à la sécheresse en steppe algérienne : le cas des stratégies produdives des agropasteurs de Hadj Mechri. *Cah Agric, 22*(4), 303-310.

Faust, E., & Markus, S. (2020, juillet 09). *Record losses from the Black Summer bushfires in Australia.* Consulté le octobre 06, 2021, sur Munich Re: https://www.munichre.com/topics-online/

Ghounini, A. (2015). *Nutrition appliquée à la santé publique.* Algiers: OPU.

Gitz, V. (2016). Climate change and food security: risks and responses. *Watch Letter de Ciheam*(37).

Heller, P. S. (2002, mars). S'adapter au changement climatique. *Finances & Développement*, 29-31.

Hersi, A. (1981). Les mutations des structures agraires en Algérie depuis 1962. *OPU*(203), Alger.

Hulse, J. H. (1995). *Science, agriculture et sécurité alimentaire.* Otawa: CNRC.

Hulse, J. H. (2008). *Développement durable : un avenir incertain, Avons-nous oublié les leçons du passé ?* Ontario ; Paris: PUL ; L'Harmattan.

Kaabache, R. (2018). Sécurité alimentaire et politiques préventives : Impact sur la santé et le bien-être des individus en Algérie. *Abaad Iktissadia, 8*(1), 341-365.

Kaabache, R. (2019). Impact du comportement alimentaire sur la santé et l'alimentation durable, Cas de l'Algérie. *Economy and environment review, 2*(2), 131-148.

Latham, M. C. (2001). *La nutrition dans les pays en développement.* Rome: FAO.

Lempereur, M. (2015, Juillet). Variabilité saisonnière et interannuelle de la croissance du chêne vert méditerranéen et vulnérabilité au changement climatique, thèse de doctorat en Écologie fonctionnelle. 222. Montpelier, france: Université de Montpelier II.

MAA. (2021, 10 01). *Influenza aviaire : la situation en France*. Consulté le 11 05, 2021, sur agriculture.gouv.fr: https://agriculture.gouv.fr/influenza-aviaire-la-situation-en-france

MADR. (2021, février 14). *انفلونزا الطيور بيان.* Consulté le novembre 05, 2021, sur MADR.gov.dz: https://madr.gov.dz/2021/02/14/%d8%a7%d9%86%d9%81%d9%84%d9%88%d9%86%d8%b2%d8%a7-%d8%a7%d9%84%d8%b7%d9%8a%d9%88%d8%b1-%d8%a8%d9%8a%d8%a7%d9%86/

Mahi, T.-A. (2011). *Développement et environnement au Maghreb : contraintes et enjeux.* Alger: Benmerabet.

Melgar-Quinonez, H. (2018). Les effets des changements climatiques sur la sécurité alimentaire et la nutrition. *Actes du Colloque International organisé par le gouvernement du Québec en collaboration avec la FAO, Québec, 24-27 septembre 2017* (p. 10). Rome: FAO.

Munich Re, G. (2003). *Annual review: natural catastrophes 2002.* Munich: Munich: Munich Re.

Nedjraoui, D., & Bédrani, S. (2008). La désertification dans les steppes algériennes : causes, impacts et actions de lutte. *VertigO, 08*(01). doi:10.4000/vertigo.5375

NU. (2021, octobre 26). *La désertification*. Récupéré sur UN.org.: servances/desertification-day/background

NU. (2021, 10 18). *Santé : Ebola : trois nouveaux cas confirmés dont un décès dans le nord-est de la RDC*. Consulté le 11 05, 2021, sur news.un.org: Nation unis, Santé : Ebola : trois nouveaux cas confirmés dont un décès dhttps://news.un.org/fr/story /2021/10 /1106492

OCDE. (2011). *Politiques agricoles : suivi et évaluation 2011 : Pays de l'OCDE et économies émergentes.* Paris: OCDE. Récupéré sur https://www.oecd.org/fr/publications/politiques-agricoles-suivi-et-evaluation-22217398.htm

Omari, C., Moisseron, J.-Y., & Alpha, A. (2012). L'agriculture algérienne face aux défis alimentaires, trajectoire historique et perspectives. *Revue Tiers Monde*(210), 123-141.

OMS. (2018, 01). *OMS*. Consulté le 11 05, 2021, sur who.int: https://apps.who.int/mediacentre/factsheets/fs103/fr/index.html.

ONS. (2018). *Algérie en quelques chiffres, résultat : 2015-2017.* Alger: ONS.

Padilla, M. (2009). Comportements et sécurité alimentaires en méditerranée : état des lieux et prospective . *futuribles*, 47-65.

Rastoin, J.-L. (2010). le modèle alimentaire méditerranéen : un levier stratégique durable pour les entreprises. *Les Cahiers du CREAD*, 9-17.

Reynard, O., Volchkov, V., & Peyrefitte, C. (2014). Une première épidémie de fièvre à virus Ebola en Afrique de l'Ouest. *Med Sci, 30*(6-7), 671–673.

Roger, F., Bonnet, P., Steinmetz, P., Salignon, P., & Peyre, M. (2015). Steinmetz Philippe, Salignon Pierre, « Une seule santé » pour mieux articuler politiques sanitaires et

changement climatique . Dans E. Torquebiau, *Changement climatique et agricultures du monde* (pp. 225-235). Versailles: Quae.

Seltzer, P., Lasserre, A., Granojean , A., Auber, R., & Fourey, A. (1946). *Le Climat de l'Algérie, Travaux de l'institut de météorologie et de physique du globe de l'Algérie.* Alger: Imprimerie La Typo-litho & J. Carbonel.

Sherbrooke, U. d. (2021, janvier 30). *Perspective Monde*. Consulté le 01 30, 2021, sur Perspective.usherbrooke: https:// perspective. usherbrooke.ca /bilan/servlet / BMImportExportPays?codePays=SGP

Sokona, Y. (2018). Changements climatiques, sécurité alimentaire et nutrition : les enjeux. Dans FAO (Éd.), *Actes du Colloque International organisé par le gouvernement du Québec en collaboration avec la FAO, Québec, 24-27 septembre 2017* (pp. 9-10). Rome: FAO.

Torquebiau, E., Tissier, J., & Grosclaude, J.-Y. (2015). Comment le changement climatique modifie la donne agricole. Dans E. Torquebiau, *Changement climatique et agricultures du monde* (pp. 9- 24.). Versailles: Quae.

UNICEF. (2021, juillet 30). *A madagascar les enfants sont au bord de la famine.* Consulté le septembre 08, 2021, sur UNICEF: https://www.unicef.fr/article/madagascar-les-enfants-sont-au-bord-de-la-famine.

Van Der Werf, S. (2012, 11). *Grippe aviaire.* Consulté le 11 04, 2021, sur Institut Pasteur: https://www.pasteur.fr/fr/centre-medical/fiches-maladies/grippe-aviaire.

Van Diemen, R. (2019). Annex I: Glossary. Dans GIEC, *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems* (pp. 803-829.). Genève: GIEC.