PAN AFRICAN UNIVERSITY

Institute of Water and Energy Sciences (Including Climate Change)

THE IMPACT OF CLIMATE CHANGE ON EROSION AND FOOD SECURITY IN THE EXTREM WEST OF ALGERIA (TAFNA BASIN)

HAMEL

MOHAMMED

Date: //2018

Master in ***Energy/Water, Engineering/Policy track***

President: …………………………………….

Supervisor: HABI Mohammed

External Examiner: …………………………………….

Internal Examiner: ……………………………………

Academic Year: 2017-2018

DECLARATION

I, **HAMEL Mohammed** hereby declare that this thesis represents my personal work, realized to the best of my knowledge. I also declare that all information, material and results from other works presented here, have been fully cited and referenced in accordance with the academic rules and ethics.

Signed:– 27 -08-2018

Name HAMEL Mohammed **Date**

Signed: –27-08-2018

Name of supervisor: Prof HABI Mohammed **Date**

ABSTRACT

Water and soil are the most valuable capital for man. These fragile resources are undergoing unprecedented qualitative and quantitative degradation. The problem of soil degradation that no country seems to escape, dangerously affects agricultural production and therefore food security.

In Algeria, the problem of water and soil degradation remains a major concern. The main causes are erosion and desertification, which are mainly linked to human activities and climate change. About 6 million hectares are exposed to active erosion today and averages of 120 million tons of sediment are washed away each year by the waters threatening the dams (Heddadj, 1997). Population sustenance is increasingly threatened by accelerating of erosion (Sari, 1977) mainly in mountains with more than 8 million people. (Taabni, 1998)

In this research work, we will develop the subject of climate change and its impact on soil productivity.

RÉSUMÉ

L'eau et le sol constituent le capital le plus précieux pour l'homme. Ces ressources fragiles subissent aujourd'hui une dégradation qualitative et quantitative sans précédent. Le problème de la dégradation du sol qu'aucun pays ne semble y échapper, affecte dangereusement la production agricole et donc la sécurité alimentaire.

En Algérie, le problème de la dégradation de l'eau et du sol demeure une préoccupation majeure. Parmi les principales causes, il convient de citer l'érosion, la désertification qui est principalement liés aux activités humaines et au changement climatique. Environ 6 millions d'hectares sont exposés aujourd'hui à l'érosion active et en moyenne 120 millions de tonnes de sédiments sont emportés annuellement par les eaux menaçant ainsi les barrages (Heddadj, 1997). La subsistance des populations est de plus en plus menacée par l'accélération de l'érosion (Sari, 1977) principalement dans les montagnes où se concentrent plus de 8 millions d'habitants (Taabni, 1998).

Dans cette recherche on s'intéresse a développé le sujet de changement climatique et son impact sur la productivité du sol.

ACKNOWLEDGEMENT

I would first like to thank my thesis advisor Prof HABI Mohammed of the Faculty of Technology at the University of ABOUBAKER BELKAID. The door to Prof HABI office was always open whenever I ran into a trouble spot or had a question about my research or writing. He consistently allowed this research to be my own work, but steered me in the right the direction whenever he thought I needed it.

I would also like to thank the experts who were involved in the validation survey for this research project: MORSLI Boutkhil. Without his passionate participation and input, the validation survey could not have been successfully conducted.

TABLE OF CONTENTS

Chapter 3: Methodology

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANRH: AGENCE NATIONAL DES RESSOURCE HYDRIQUE

AGIR: National Agency for Integrate Water Resource Management

BC: Breakwater

CGIAR: The Consultative Group on International Agricultural Research

DSA: Agency of Agricultural services

DHW: Agency of water resource

FAO: Food and Agriculture Organization

FIVIMS: Food Insecurity and Vulnerability Information and Mapping System

GCOS: The Global Climate Observing System

GDP: Gross domestic product

GECAFS: Global Environmental Change and Food Systems

LDCs: Least Developed Countries

N: Nitrogen

ONS: National Office for Statistics

OPI: Irrigated Perimeters Office

SOC: The soil organic carbon

SRE: East Retake Station

SRO: West Retake Station

UNDESA: The United Nations Department of Economic and Social Affairs

UAA: Useful Agricultural Area

UNFCCC: United Nations Framework Convention on Climate Change

WFS: World Food Summit

WMO: The World Meteorological Organization

Introduction

The effects of climate change on our ecosystems are already severe and widespread, and ensuring food security in the face of climate change is among the most daunting challenges facing humankind. While some of the problems associated with climate change are emerging gradually, action is urgently needed now in order to allow enough time to build resilience into agricultural production systems. (FAO 2016)

Depletion of water resources and the rise in average global temperature have created conditions for a decline in agricultural production. This in turn leads to escalated food inflation globally as well as food shortages in the developing countries where the poor suffer greatly as they are unable to pay the up market prices for food. (Misra, A.K.2014)

Achieving food security and improve nutrition is at the heart of the sustainable development goals. At the same time, climate change is already impacting agriculture and food security and will make the challenge of ending hunger and malnutrition even more difficult. (Saidul, I. and Andrea, T. W. 2017)

According to the Food and Agricultural Organization of the United Nations (FAO), there are about 795 million people who are undernourished globally, with poor nutrition accounting for nearly 45% of deaths in children below the age of 5 annually. A further 13.5% of the populations in developing countries are undernourished due to the lack of food availability; stability of food; and/or economic and physical access to food (FAO. 2015). These findings are expected to be further exacerbated due to the rise in world population, projected by the United Nations to increase by 2.4 billion by 2050 (UNDESA. 2015).

The rise in population coupled with growing urbanization and increasing environmental problems such as pollution and deforestation would have detrimental effects on food production, distribution and consumption. In addition, the inability of food producers to meet the demands of the population would cause food prices to escalate. This, together with the increased occurrences of climate-related disasters and further climate changes worldwide, would worsen the problem of food security faced by the already-at-risk individuals/populations as well as the global community. (FAO. 2001)

Many of the resources needed for sustainable food security are already under heavy pressure; the challenges of food security are enormous. These challenges will be even more challenging as a result of climate change, which reduces the productivity of the majority of existing food systems and undermines the livelihoods of people who are already vulnerable to food insecurity (HLPE Rome, 2012).

The probability that the nations of the world will reach the goal of a maximum average temperature increase of 2 ° C set during the United Nations Framework Convention on Climate Change (UNFCCC) negotiations in Cancun is shrinking by time, if negotiations on global climate policies were to fail, temperature increases of around 4 ° C by the end of the century (which is the best estimate of the Intergovernmental Group Experts on Climate called Intergovernmental Panel on Climate Change (IPCC) for scenarios of increased emissions) cannot be discounted. While these increases may in some cases be beneficial, populations in some areas will suffer more than others from changes in average temperatures and precipitation. In addition, the prospect of greater variability and an increase in extreme weather events means that risk management, both locally and internationally, will be even more important than today (HLPE Rome, 2012).

Population growth will continue until 2050 and will be accompanied by unprecedented levels of urbanization. These changes will occur mainly in developing countries, many of which will most likely become middle-income countries. All of this will result in a rapid increase in the demand for food, both in terms of quantity and quality. At the same time, government policies to increase the proportion of bio fuel in energy consumption further undermine our collective ability to achieve sustainable food security (HLPE Rome, 2012).

The climate change we are experiencing today is a consequence of greenhouse gas (GHG) emissions from human activity. According to the IPCC, most of the increase in global average temperatures since the mid-twentieth century is most likely due to increases in anthropogenic GHG concentrations. Agricultural activities, including their indirect effects, deforestation and other forms of land-use change, account for about one-third of the global warming potential caused by GHG emissions today; it is therefore essential, as part of the overall effort to slow the pace of change (HLPE Rome, 2012).

The effects of climate change on plants, animals and natural systems are multiple. Changing temperatures and precipitation patterns can have a significant impact on agricultural productivity. The effects of changes in temperature averages are important, but other effects are also to be taken into account. In general, very little is known about the impact of climate change on pests and diseases of crops, livestock and fish, but it could be considerable. Over the next decades, climate change will subject animals and plants to multiple stresses in many agricultural and aquatic systems; we still know very little about the effects that these different stresses, added to each other, may have. Climate change should increase the irregularity of rainfall, which is already affecting livelihoods and production of a large number of rural families (HLPE Rome, 2012).

Since the primary purpose and commonality between agriculture, fisheries and forestry is food production to achieve food security, this essay will thus focus on understanding the dialectic relationship between climate change and food security: precisely how climate change impacts food security and how food production impacts climate change. Upon establishing the link between the three factors (soil, water, and crops), a clearer picture and understanding of what needs to be done so as to achieve food security amidst climate changes will emerge. Though there are many ways to examine climate change (Saidul, I. and Andrea 201, T. W. 2017).

Problem statement:

The climate change we are experiencing today is a consequence of greenhouse gas emissions resulting mainly from human activity. The effects of climate change are increasing and affecting the soil, the second largest reservoir of carbon, after the oceans, the availability of water through irregular rainfall and drought and soil productivity that will have a big impact on food security.

Objectives:

- Highlighting climate warming on the study area using scenarios
- Study of the impact of climate change on soil erosion
- Study of the impact of climate change on soil productivity

Research question and hypotheses:

The hypothesis is that climate is affected by change and this change affects soil (erosion and degradation) and soil productivity.

Relevance of the study:

This work is very relevant because it directly affects the livelihoods of the populations, thus food security. Topical subject that has significance on different levels: socio-economic and environmental.

Chapter 1: Purpose and Significance of the Study

1.1 Introduction

Global temperatures have been increasing since 1850. This raising is mainly owing to the accumulation of greenhouse gases in the atmosphere. The main causes are burning of fossil fuels (coal, oil and gas) to meet the increasing energy demands, and the spread of intensive agriculture, which is often accompanied by deforestation, to meet increasing food demands. The process of global warming shows no signs of abating and is expected to bring about long term changes in weather conditions (FAO ROME 2008)

1.2 Climate change in Tlemcen

Projected changes in climate in Tlemcen, as a result of increased greenhouse gas concentrations, are warmer temperatures, increased winter precipitation, a larger proportion of precipitation falling as rain rather than snow, and an increase in the intensity of extreme precipitation events. These changes will alter the land-atmosphere relationship that the agricultural industry relies on to remain stable, predictable, and profitable (Mahi, T. A. 2008).

In the Maghreb area, recent evolution of climate shows that warming is greater than the average. Indeed, if the global temperature rise in the 20th century to 0.74°C, the rise in the Maghreb area was between 1.5°C and 2°C depending on the region, more than the double of the average global rise (Mahi, T. A. 2008). As for the decrease in precipitation, it varies between 10% and 20%. On the other hand, numerous studies show that the climate projections, elaborated by the current general circulation models (GCMs), underestimate the rise of the temperatures and the fall of the precipitations in the Maghreb area. This shows that the Maghreb countries will suffer more than others from the effects of climate change, which is now a major concern for the region. Therefore, only a global vision is able to cope with this new scourge. Southern countries such as the Maghreb countries are affected and must implement an adaptation strategy. However, this approach cannot be carried out alone, and the countries of the North, in particular, must provide scientific, technical and financial support in the framework of international cooperation inspired by the principles of sustainable development. (Mahi, T. A. 2008).

1.3 Trend of climate change

The climate has changed dramatically since 1973, coinciding with the famous drought of the Sahel. Figure 1.1 shows the evolution of the temperature of Oran station between 1926 and 2006. This figure based on daily temperature data, shows that the temperature has increased more than 2°C (Mahi, T. A. 2008).

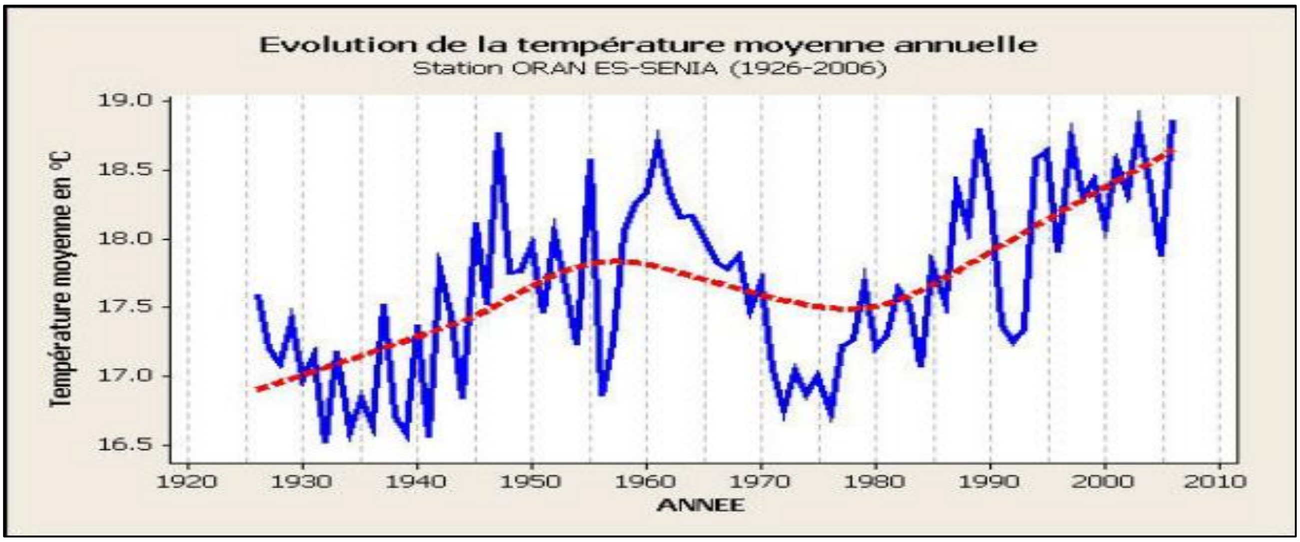


Figure 1.1 Evolution of the annual T° average in Oran in ° C (1926-2006) (MAHI)

Figure 1.2 shows the evolution of precipitation during the same period and highlights a decrease of the order of 15% of the same station.

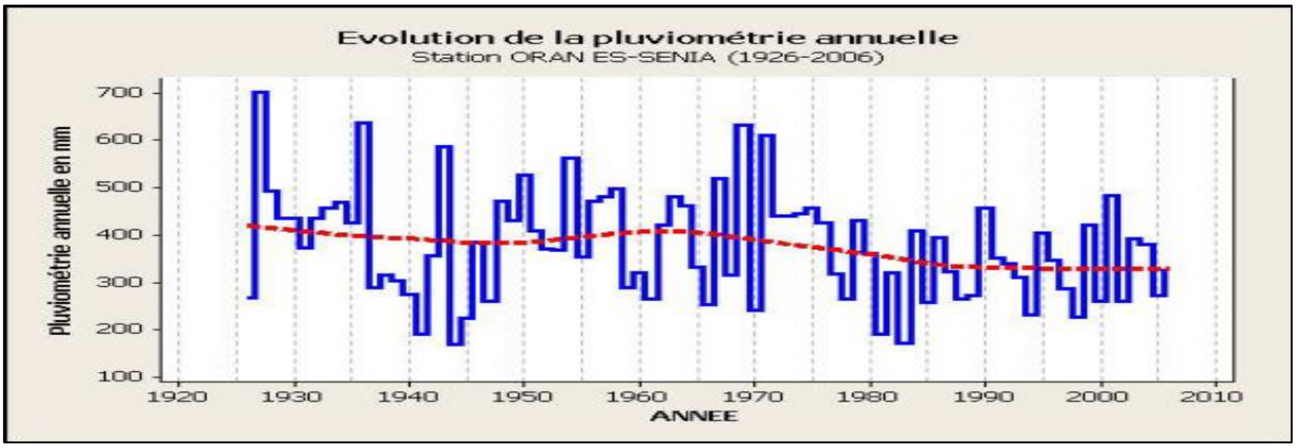


Figure 1.2 Evolution of the annual precipitation average in Oran in mm (1926-2006) (MAHI)

Since 1973, it is observed that:

- A greater occurrence of droughts: 1 in 3 years;
- An intensification of floods: 1990 (Tunisia), 2001 (Algeria: centennial record beaten) and 2002 (Morocco);
- An increasing number of heat waves in all seasons;
- Forest fires (annual loss of 25,000 hectares / year in Algeria and Morocco);
- A rise in sea level (3 to 4 times faster in Sfax than the world average, which is 1.5 -2mm / year).

For the climate projection, the general circulation models give an average temperature increase of 1° C and a decrease of 10 to 20% by 2020 and more than double these values by 2050 (Mahi, T. A. 2008).

Other forms of climate change in Tlemcen is the decrease in annual precipitation, this maps made on surfer show the impact of this climate change on rainfall in different area in Tafna Basin.

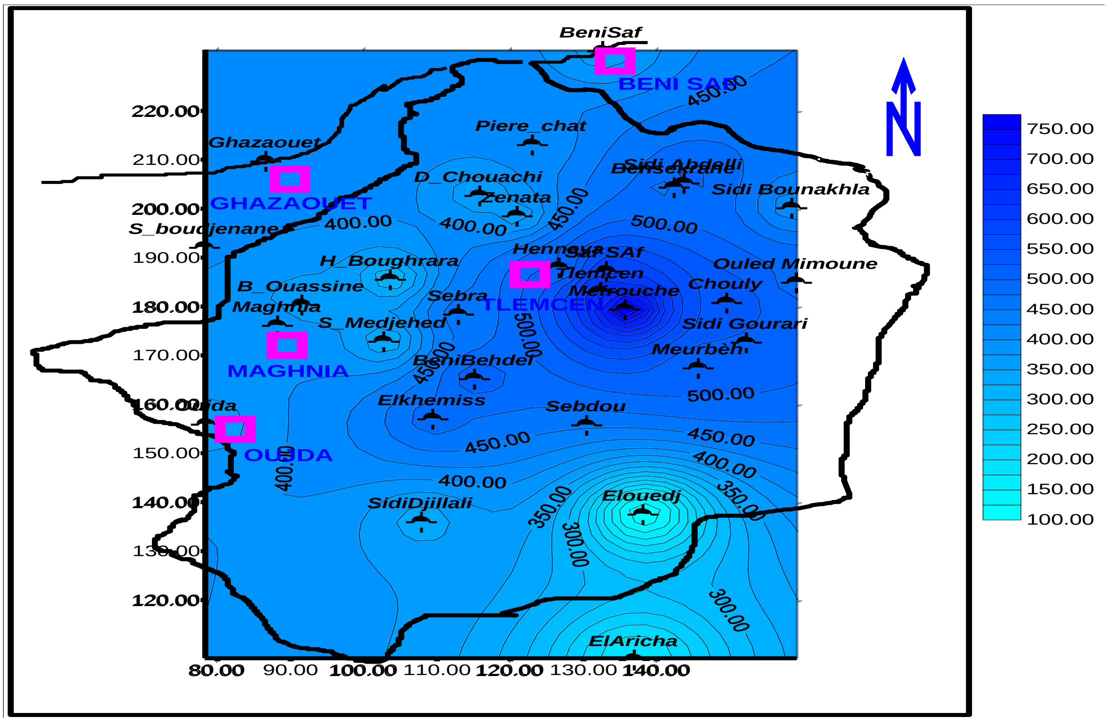


Figure 2.3 rainfalls in Tafna Basin in 1980

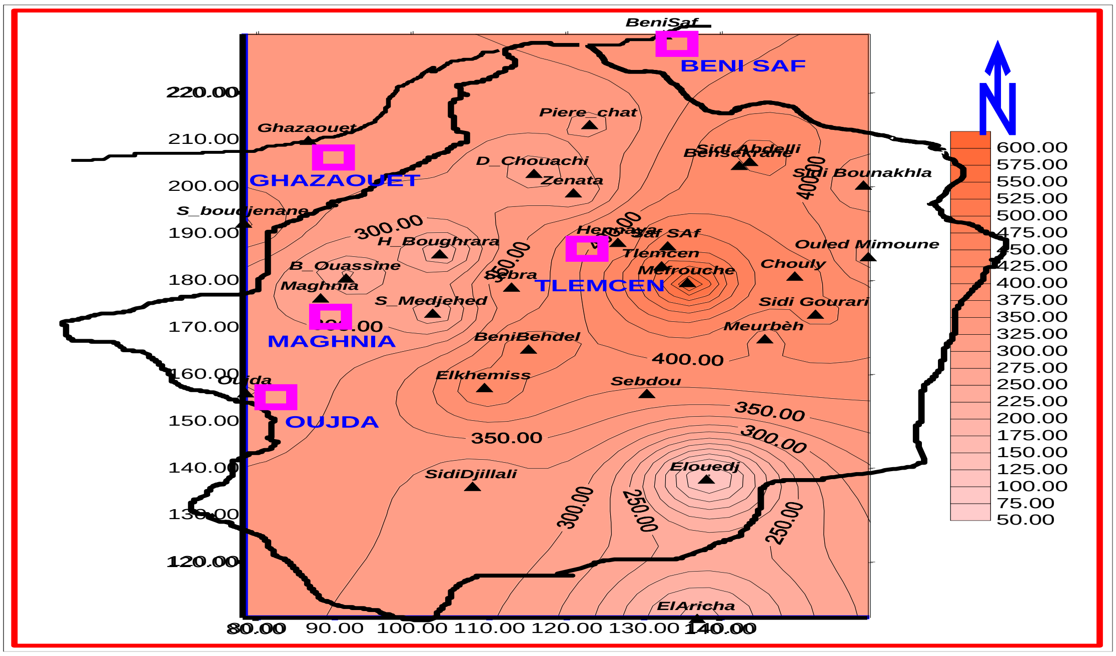


Figure 2.4 rainfalls in Tafna Basin in 2010

We notice from the two figures that the annual amount of rainfalls decreased, the maximum rainfalls decreased with 150 mm per year from 750 mm in some points to 600 mm, and the minimum rainfalls decreased from 100 mm to 50 mm.

1.4 Impacts of climate change

Natural resources in the Maghreb region (water, soil, forests and rangelands) have more or less rapid tendency to degradation that threatens the bases of survival in rural areas, and in particular the most marginalized regions. Natural resources will move towards greater vulnerability, but more generally, it is the viability and the future of the Maghreb countries that is likely to arise. Some of the most important impact includes:

- The decrease in surface water mobilization due to a decrease in surface runoff and an increasing frequency of drought periods;
- Accelerated soil degradation through increased water and wind erosion, and salinization due to higher evaporation coupled with lower rainfall;
- The occurrence and increasing intensity of floods;
- Overexploitation of groundwater;
- Sea level rise which threatens Tunisia particularly;

- Increased vulnerability of rained crops due to increased evapotranspiration and lower availability of precipitation water;
- The shortening of the plant cycle and the intra- and inter-seasonal variability, in addition to the occurrence of heat waves in any season disturbing and threatening the normal development of crops (arboriculture does not escape this threat);
- The increase of the occurrence of the risks of diseases and parasites threatening the plant, the animal as well as the man.

While the increase in the CO2 content of the atmosphere can increase the yields of certain crops, in the Maghreb region, this effect is thwarted by the lack of water availability and the accentuation of a dynamic of accumulation of deficits. Hydric conditions suffered by agriculture. The process of climate change will result in a Northward shift of the bioclimatic stages, leading the Maghreb region to a rise in arid and desert areas (Le Houérou, 1992). Finally, we can cite here two studies of the impact of climate change on cereals in Algeria and Morocco, by 2020. They show an average decrease of yield included in 10% and 20% (Mahi, T. A. 2008).

The effects of climate change are increasing and affecting the soil, the second largest reservoir of carbon, after the oceans, the availability of water through irregular rainfall and drought and soil productivity that will have a big impact on food security. The area where our research were conduct is in the West of Algeria, and exactly the Tafna basin, this basin is one of the most important basin in the country and it covers most of Tlemcen. The Tafna Basin is made up of large cities such as the State of Tlemcen which is largely integrated and partially the State of Ain Tmouchent. It has always been considered to be the main water tower of the Western areas due to the importance of its water resources. For underground resources, the quantification of its aquifers is not yet fully understood, in fact the extension of reservoirs and hydrodynamic characteristics remains to be specified or confirmed on the one hand and on the other hand the perimeters of protection are practically non-existent.

Chapter 2: Review of the Literature

2.1 Introduction

The Northwestern mountains of Algeria, which constitute an important socio-economic issue and represent a great potential for agricultural production, are affected by a dynamic of dangerous degradation and remain the most exposed to various forms of erosion (Morsli et al, 2004). Among the main causes are erosion, desertification which is mainly related to human activities and climate change (Heddadj, 1997). Some authors have already mentioned the existence of a climate change (Tabet el Aouel, 2012) and the land use by the irregularities of the rains (Morsli 2011). The Algerian West, where the erosion reaches 47% of the whole, is the most eroded region of the country. Erosion problems have worsened and spread to previously untouched areas. The equilibrium between vegetation, soil and water is disturbed in these mountain areas (Benchetrit, 1972). Erosion continues to pose serious problems for local communities and rural populations: land degradation, siltation of dams, destruction of infrastructure and flooding. Water erosion has become a widespread phenomenon and so serious that it can be mediated by disaster. Control of runoff and erosion has become a priority issue.

The importance of the issues raised needs a diagnosis of the dynamism of the various erosion processes and their causes. The study of erosion processes and the factors involved is of considerable interest for the optimal and sustainable use of soils. Effective erosion control requires good knowledge of the hydrodynamic behavior of soils subject to climatic fluctuations and various land uses (Morsli, 2011).

2.2 Defining terms and conceptualizing relationships

2.2.1 Food Security Update

In 1996, the World Food Summit adopted the following definition of food security: “Food security exists when all human beings have access at all times to physical and economic basis to sufficient, healthy and nutritious food allowing them to meet their energy needs and dietary preferences to lead a life healthy and active.”

"The four pillars of food security that implicitly emerge from this definition are the following: availability, access, utilization and stability. The nutritional dimension is part of integral to the concept of food security" (FAO, 2009a).

2.2.2 Food security

In May 2007, at the 33rdSession of the Committee of Food and Agriculture Organization (FAO) on World Food Security issued a statement to reaffirm its vision of a food-secure world:

> *"FAO's vision of a world without hunger is one in which most people are able, by themselves, to obtain the food they need for an active and healthy life, and where social safety nets ensure that those who lack resources still get enough to eat."* (FAO, 2007f)

This vision has its roots in the definition of food security adopted at the World Food Summit (WFS) in November 1996: "Food security exists when all people at all times have physical or economical access to sufficient safe nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996).

In the following year and half of WFS, the Inter-Agency Working Group established the Food Insecurity and Vulnerability Information and Mapping System (FIVIMS) elaborated a conceptual framework that gave operational meaning to this definition (Figure 2.1). FAO reaffirmed this view in its first published assessment of the implications of climate change for food security, contained in its 2015 to 2030 projections for world agriculture.FAO stressed that "food security depends more on socio-economic conditions than on agro climatic ones, and on access to food rather than the production or physical availability of food". It states that, on evaluation of potential impacts of climate change on food security, "it is not enough to assess the impacts on domestic production in food-insecure countries. One also needs to assess climate change impacts on foreign exchange earnings; determine the ability of food surplus countries to increase their commercial exports or food aid; and analyze how the incomes of the poor will be affected by climate change" (FAO, 2003b: 365_366).

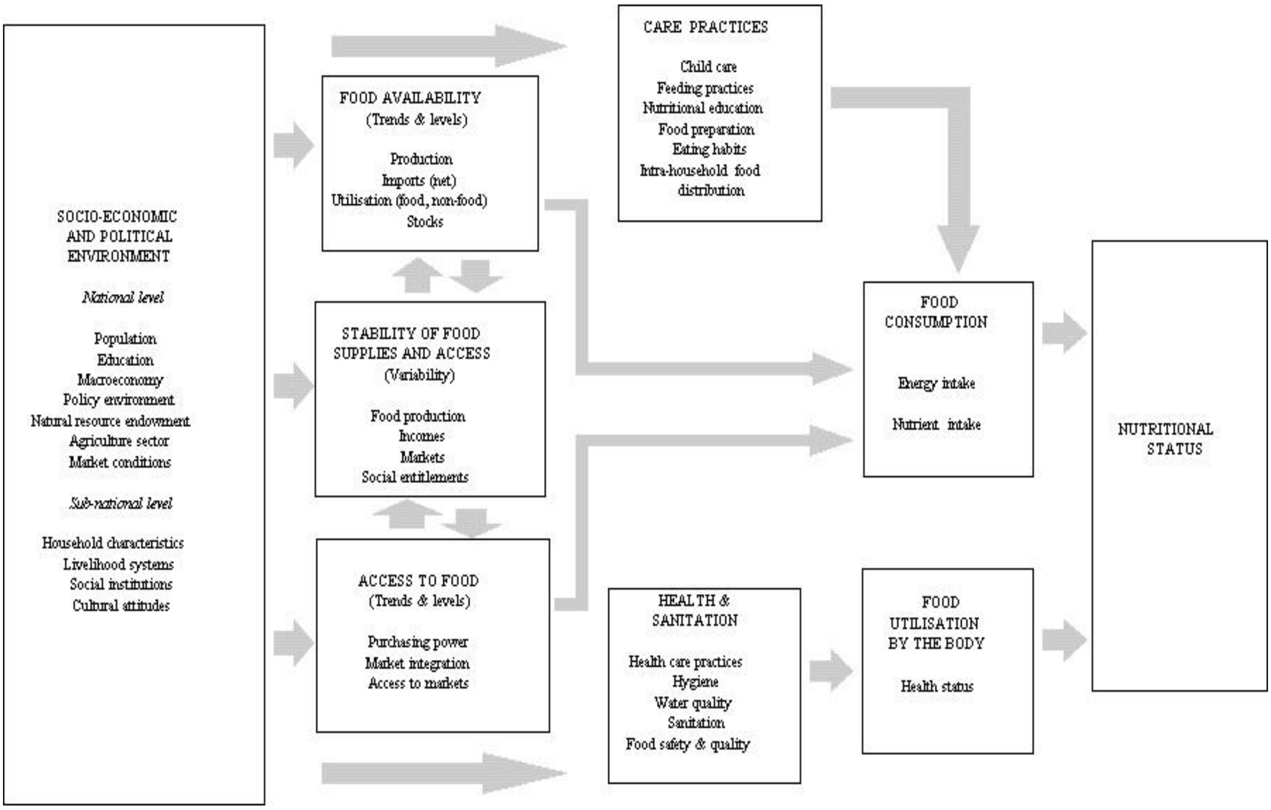


Figure 2.1 Conceptual frameworks of possible causes of low food consumption and poor nutritional status - source*:* FAO, 2000c.

2.2.3 Food system

Definitions of food security identify the outcomes of food security and are useful for formulating policies and deciding on actions, but the processes that lead to desired outcomes also matter. Most current definitions of food security therefore include references to processes as well as outcomes. Recent work describing the functioning of food systems has helped to show both desired food security goals and what needs to happen to bring these about. Between 1999 and 2003, a series of expert consultations, convened by the Global Environmental Change and Food Systems (GECAFS) project with FAO's participation, developed a version of the FIVIMS framework that further clarifies how a variety of processes along a food chain need to occur in order to bring about food security. Taken together, these processes constitute the food system, and the performance of the food system determines whether or not food security is achieved. GECAFS gives the following definition and graphical representation (Figure 2.2) (FAO, ROME, 2008):

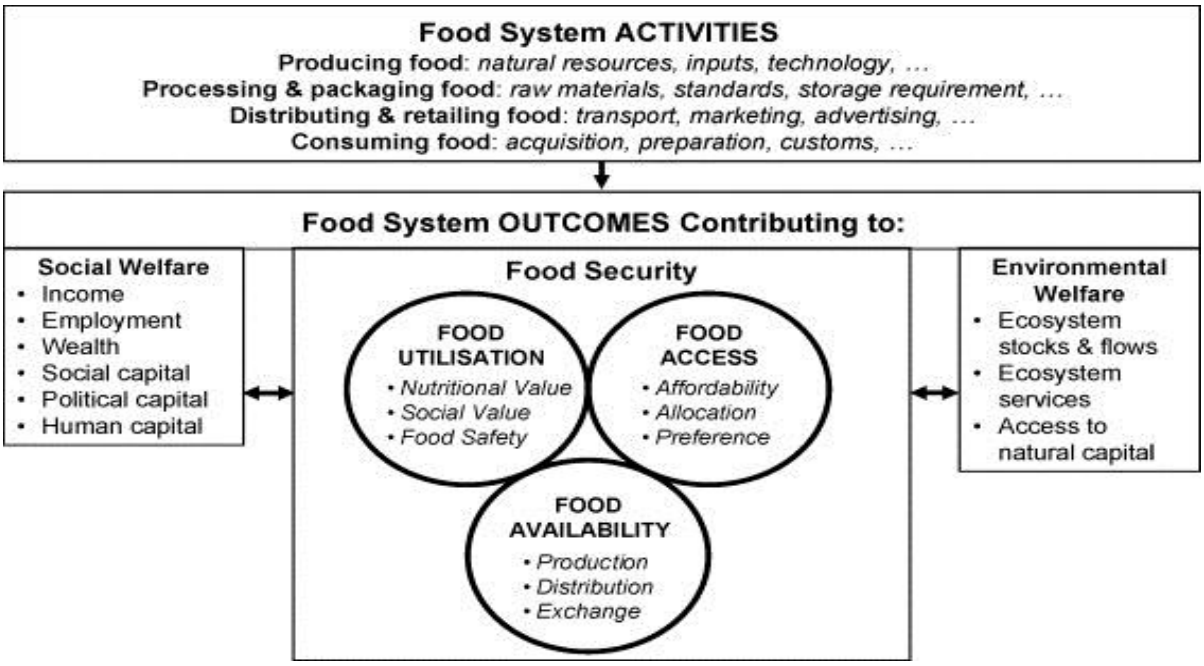


Figure 2.2 Food system outcomes contribution Source GECAFS Online

2.2.4 Food chain

The sum of all the processes in a food system is sometimes referred to as a food chain, and often given catchy slogans such as "from plough to plate" or "from farm to fork". The main conceptual difference between a food system and a food chain is that the system is holistic, comprising a set of simultaneously interacting processes, whereas the chain is linear, containing a sequence of activities that need to occur for people to obtain food (FAO, ROME, 2008).

2.3How all Three Factors Affect Food Security?

The impact of soil, water and crops on food security will be measured using four components: food availability, economic and physical access to food, food utilization and the stability of food supply. Food availability refers to the physical presence of food available for consumption; economic and physical access to food refers to having the ability/resources to acquire food; food utilization refers to having the "appropriate nutritional content of food and the ability of the body to use it effectively"; and stability of food supply refers to the ability to ensure that there is sufficient food for individuals all the time (Burke and Lobell, p. 14).

2.3.1 Food Availability

If the soil lacks nutrients or is unable to support the growth of crops, there would be a lack of supply of crops and hence the availability of them. Likewise, if the water is contaminated due to its high acidic concentration, crops would die as the acidity of the water would kill the crops. In addition, the rise of natural disasters such as floods and droughts affect food security, as drought prevents the growing of crops and leads to crop failure or the delay of crop production, while floods cause crops to die or the land to be unsuitable for agricultural purposes due to the lack of fertile soil. Crops are sensitive to changes in temperature and precipitation, and a rise in global mean temperatures by 2°C can destabilize agricultural practices and crop production periods (Kang, Y.; Khan, S.; Ma, X.2009). In addition, food availability is further threatened as climate change leading to climate fluctuations has the potential to lead to the loss of local diversity and translate to lower variety of resources for both current and future generations (Úbeda, B.; Di Giacomo, A.S.; Neiff, J.J.; Loiselle, S.A.; Poi, A.S.G.; Gálvez, J.A.; Casco, S.; Cózar, A.2013).

As mentioned earlier, climate change has the potential to alter the geographical distribution of some marine animals such as oil sardines, due to increased temperatures in water bodies that make the water conditions unsuitable for their continual survival. This migration can increase the number of fisheries in those areas and thus increase employment opportunities as well as food. Some might view the migration of fishes to other regions in a positive light as it would increase food availability and physical access to food in those regions. However, the original habitats from which these fishes originate would be greatly affected. Fisheries and local fishermen would notice a substantial drop in catch as fishes that are unable to adapt to changing water conditions shift to other water bodies. The drop in catch would thus result in a decrease in food availability, employment and a rise in prices due to the drop in supply. This would in turn affect food security as now these places would have reduced access and availability of food (Saidul, I. and Andrea, T. W.2017).

2.3.2 Economic and Physical Access to Food

When crops fail due to climate-related disasters, farmers are unable to sell their crops to earn money to support their families. Between 2003 and 2013, these disasters affected more than 1.9 billion people in developing countries and resulted in about half a trillion US dollars in estimated damages (FAO.2015) .FAO estimates that the "agricultural sector absorbs approximately 22 percent of the total economic impact of these disasters" which in turn affects its capability to support food security (FAO.2015). Evidently the effects of climate change are unequal. The poor (developing countries) are more affected by climate change and crop failure, being mainly agricultural economies, as compared to the rich (developed countries), as poor countries lack the knowledge and skills to deal with such changes, i.e., the ability to stockpile sufficient food for their people when crises strike. In addition, farmers in developing countries often live from one harvest to another, and thus the failure of one harvest might cause them to lose all their savings. As such, they no longer have the financial means to buy food or obtain food from their harvest. This is especially so in developing countries where the governmental supports for farmers are not as strong as those in developed countries. Thus, when crops fail, these farmers are often left without a safety net to recoup from their losses or the ability to provide food for their family. It is postulated that with increased climate change, rice production in the Philippines might decrease as much as 75% by 2100 (Singh, D.P.2014).This decline might result in many Filipinos having to settle for meals with little or no rice due to the rice shortage as well as the lack of economic access to food. This problem can however be lessened if the government intervenes and implements climate adaptation programs, i.e., increased use of technology for agricultural purposes, to help prevent such significant losses in rice production (Singh, D.P.2014).Climate change might increase the frequency and intensity of climate-related disasters that can further exacerbate the existing problems that climate change has brought upon food security as it further disrupts crop production, livestock rearing and trade. This might in turn result in premium prices for food, thus worsening the problem of food insecurity. Climate-related disasters might also cause infrastructural damages, thus trapping individuals in areas where they have limited or no physical access to food. In addition to this scenario, natural disasters might create conditions that prevent the transportation of food from producers to customers. The inability of food exports to reach their final destinations might lead to food shortages in such communities, thereby leading to food insecurity (Saidul, I. and Andrea, T. W.2017).

2.3.3 Food Utilization

Climate change affects the variety of foods with higher nutritional value that are available for people, due to disruptions in trade and crop production. As indicated earlier, climate change can alter the nutritional value in the crops produced as it changes the nutrient levels in soil.

Individuals whose main diet consists of crops produced under impoverished soil conditions are susceptible to malnutrition and nutrient deficiencies due to decreased nutrient content in the foods they are consuming. Therefore, the full nutritional value of food cannot be fully absorbed if climate change causes changes in food production factors, i.e., soil and water, that decrease the nutritional value found in food yields. Food utilization is thus negatively affected, as nutritional content of food is insufficient for the body to use it effectively to meet the dietary needs for a healthy lifestyle (St. Clair, S.B.; Lynch, J.P.2010, Gschwendtner, S.; Tejedor, J.; Mueller, C.; Dannenmann, M.; Knabner, I.K.; Schloter, M 2014). In addition, climate change might affect the safety of the food, as the use of contaminated water to grow crops might indirectly cause consumers to consume toxic products. Climate-related disasters such as flooding might also cause harmful substances to enter water sources such as wells, thus polluting water sources that are used for hydration and agricultural purposes. Flooding might also lead to large pools of stagnant water in communities that can increase the chances of vector-borne (e.g., malaria and dengue) and water-borne (e.g., cholera) diseases that affect the health of individuals and their ability to utilize food properly (IPCC 2016).

In times of climate-related disasters, people might not have the luxury to pick foods that are rich in nutrients due to the shortage in food availability. Instead, they might turn to rationing consumption to prioritize calorie-rich but nutrient-poor foods, which will lead to a decrease in dietary quality, resulting in the loss of health, productivity capacity and low incomes (Porter, J.R.; Xie, L.; Challinor, A.J.; Cochrane, K.; Howden, S.M.; Iqbal, M.M.; Travasso, M.I. 2014). Thus, food security is threatened, as food cannot be utilized as effectively due to the decline in nutritional value of food and food safety.

Stability of Food Supply, Climate change affects the stability of food due to changing anthropogenic conditions, drying–rewetting cycles and global mean temperatures that would affect livestock rearing and crop productions. Some governments and farmers have turned to technological advances and developments in hopes of reducing the effects of climate change on food stability. However, there is a possibility that technological advances used to mitigate the effects of climate change might further exacerbate the issue of food security and climate change. Climate change is a complex matter and the full extent of its effects is still being unraveled today. It remains to be seen if the technological advancements incorporated into food production systems will indeed lead to reduced climate change effects and increased food stability, as many of these advances are still in their infancy period. More research and time is thus needed to gain a better understanding of these advances.

Stability of food supply is not only affected by climate change but also by other factors such as food distribution and transportation. It has often been reported that climate change increases the frequency and intensity of climate-related disasters, and this in turn affects the stability of food supply as food trade is hindered when planes and ships are grounded/docked due to poor visibility as a result of harsh weather conditions or access roads that are destroyed by earthquakes or flooding. Instability of food supply is felt mostly in developing countries that do not practice stock-piling. Often, these countries lack the technical expertise and financial resources to bring in experts and engineers to help build infrastructures that can with stand the impact of natural disasters, and storage conditions that allow for food to be stored for an extended period of time. Stability of food supply is thus affected when major infrastructure and transportation hubs such as airports/ports are closed or food storage buildings collapse during such disasters. In addition, developing countries lack the monetary funds and technological advancements necessary to help mitigate crises such as the acidification of oceans and salinization of the soil, to ensure constant production and supply of food for their people. Therefore, based on the components of food security—food availability, economic and physical access, utilization and the stability of food, it is obvious that climate change has both a direct and indirect impact on food security. The inability of people to get their hands on nutritious food to meet their dietary needs and food preferences for an active and healthy life goes against the very definition of food security. The examples given have shown the current and future challenges that climate change will bring to agricultural and livestock-rearing methods that are used to meet the food demands of the population (FAO, ROME, 2008).

Numerous research studies on the effects of climate change on food production have led to many governments or farmers incorporating various adaptation methods to their agricultural practices so as to reduce the effects of climate change on yields. However, many researchers fail to see that there is a connection between food production systems and climate change, e.g., “rice farming is responsible for approximately 10% of the methane released” into the atmosphere (Burke and Lobell, p. 189). In order to gain a better understanding of the issue of food in/security, it is essential that both systems be examined without prejudice. As such, this paper would now examine the impact of food production systems on climate change in hopes of providing a more balanced view of the issues of food in/security and greater understanding of the issue of climate change and food in/security. Food production systems would be examined instead of the components of food security as the latter is the by-product of the former. Without food production systems, there would not be a concept of food security as there would be no production of food to allow all people, at all times, to have physical, social and economic access to sufficient, safe and nutritious food (FAO. 2015).

2.4 Food security in Algeria

In Algeria, agriculture ranks third in terms of contribution to gross domestic product (GDP). It employs nearly 25% of the total labor force and covers nearly 42 million hectares, or just over 17% of the total area of 238 million hectares. These areas are distributed as follow: 31.9 million hectares of rangelands, 8.2 million hectares of utilized agricultural area (UAA) and the remainder (83% of the total area) being unproductive land. Only 2 million hectares of these areas have a rainfall level greater than 450 mm / year. Despite a relative improvement in global indices (figure 2.3) and even if its contribution to GDP is growing ($ 11.086 billion in 2008 against $ 10.152 billion in 2007), the conditions for the evolution of agricultural activity remain worrying and production remains in deficit is far from satisfying local demand.

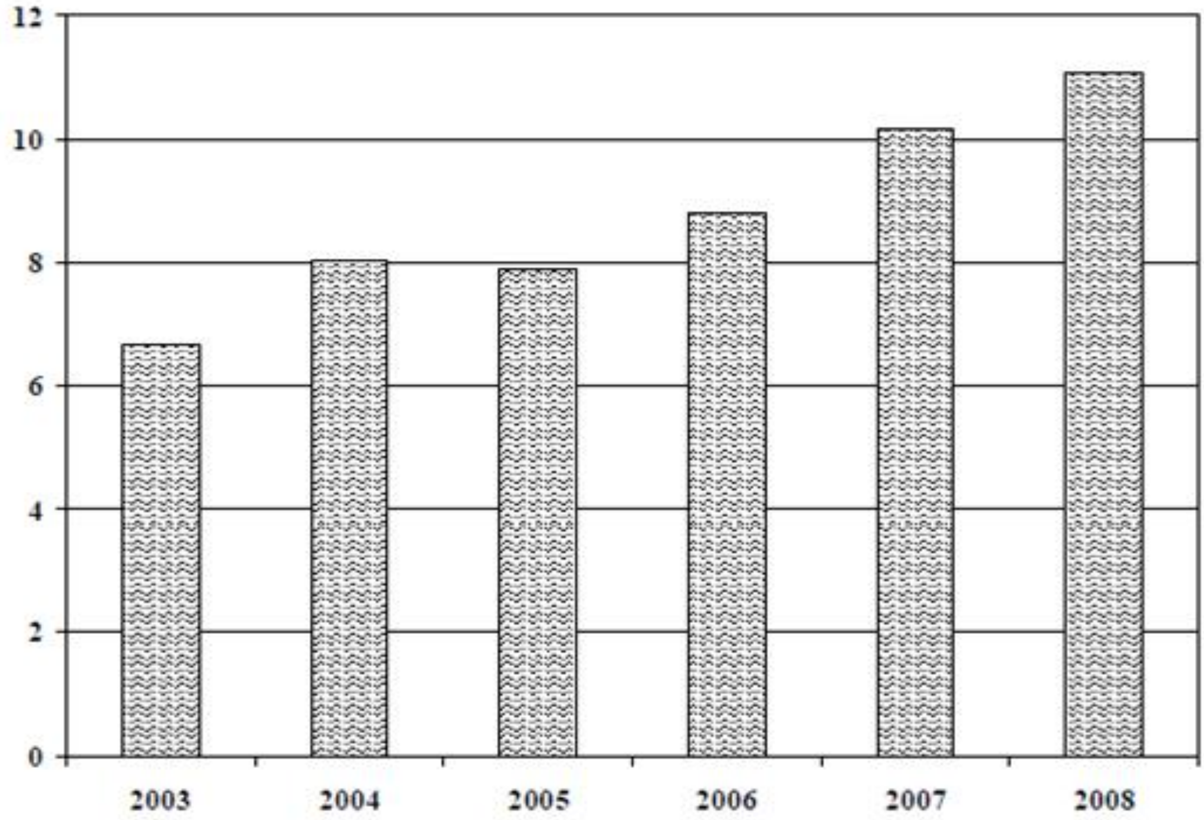


Figure 2.3Sector contribution of agriculture in GDP in $

Source: MF country Report Vo.09/111, April 2009

2.4.1 Food consumption in Algeria

The Algerian population is characterized by a food mode based essentially on the consumption of cereals in all its forms (pasta, couscous, bread cakes, etc.). Thus, the average per capita cereal consumption is one of the largest in the world. In 2005, it was estimated at 223 kg per year per person (FAOSTAT, 2005). Figure 2.4 illustrates the evolution of grain consumption in Algeria since the 1960s.

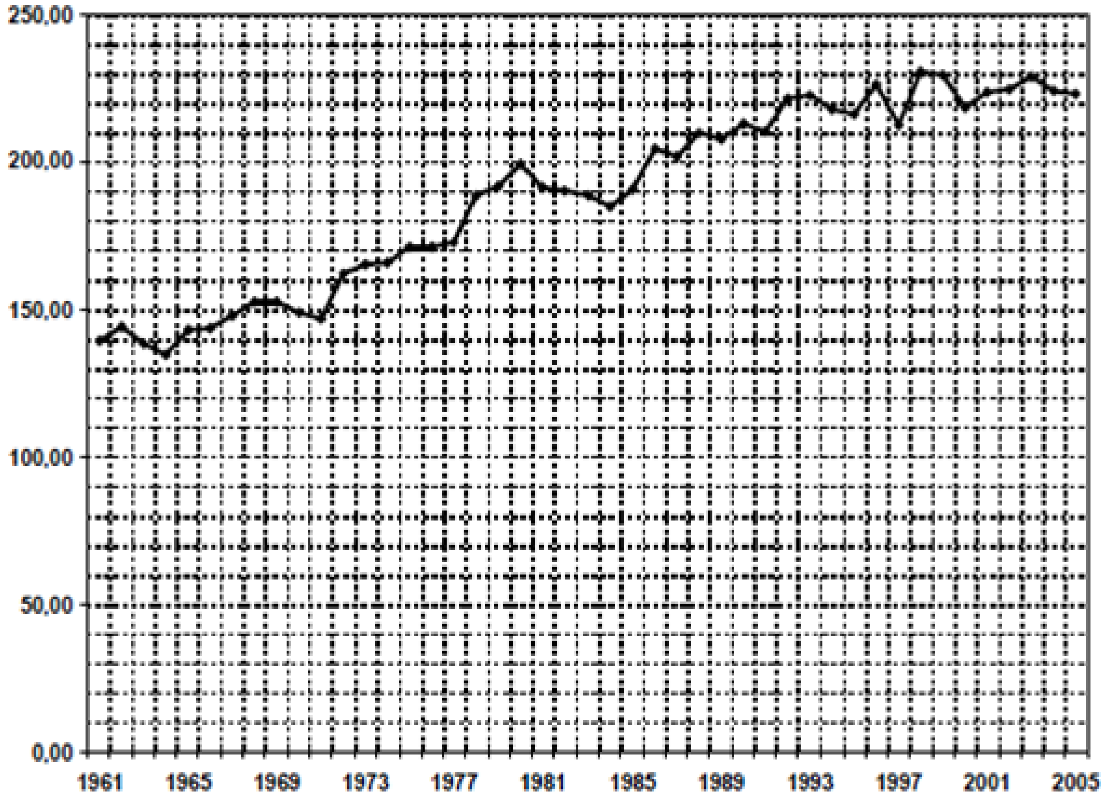


Figure 2.4 evolution of cereal consumption in Algeria (in kg/year/person)

Source: FAOSTAT | OAA Division of Statistics

This cereal consumption is dominated by that of wheat whose evolution is traced in figure 2.4.1 the consumption has doubled in half a century.

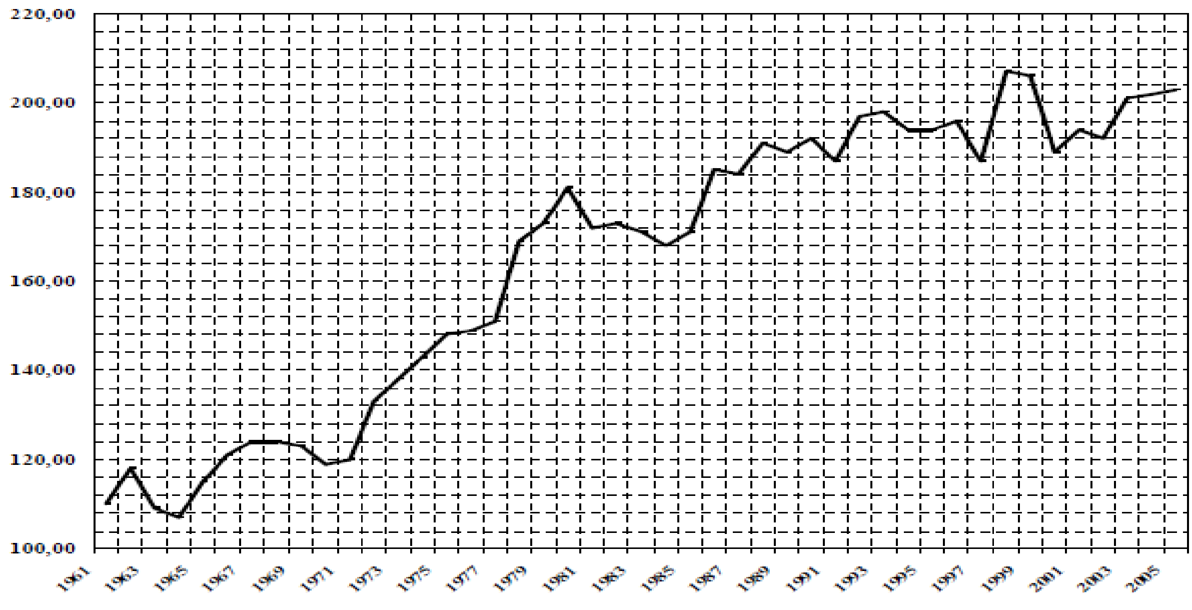


Figure 2.4.1 Evolution of wheat food consumption (in kg /p/ y) Source: FAO

Despite the improvement in wheat production, the agricultural sector is often unable to cope with the growth in demand for wheat, mainly due to changes in dietary habits (partly due to colonization) and higher levels of quality of life.
With more than 203 kg per person per year (FAOSTAT, 2005), Algerian agriculture is structurally unfit to satisfy a growing demand for wheat which has ranked Algeria in 2008 as the fourth largest importer in the world wheat, after the Europe of 27, Brazil and Egypt. The demand for wheat in Algeria has increased five-fold since independence and the chronic deficit between supply and demand is growing steadily Figure 2.4.2

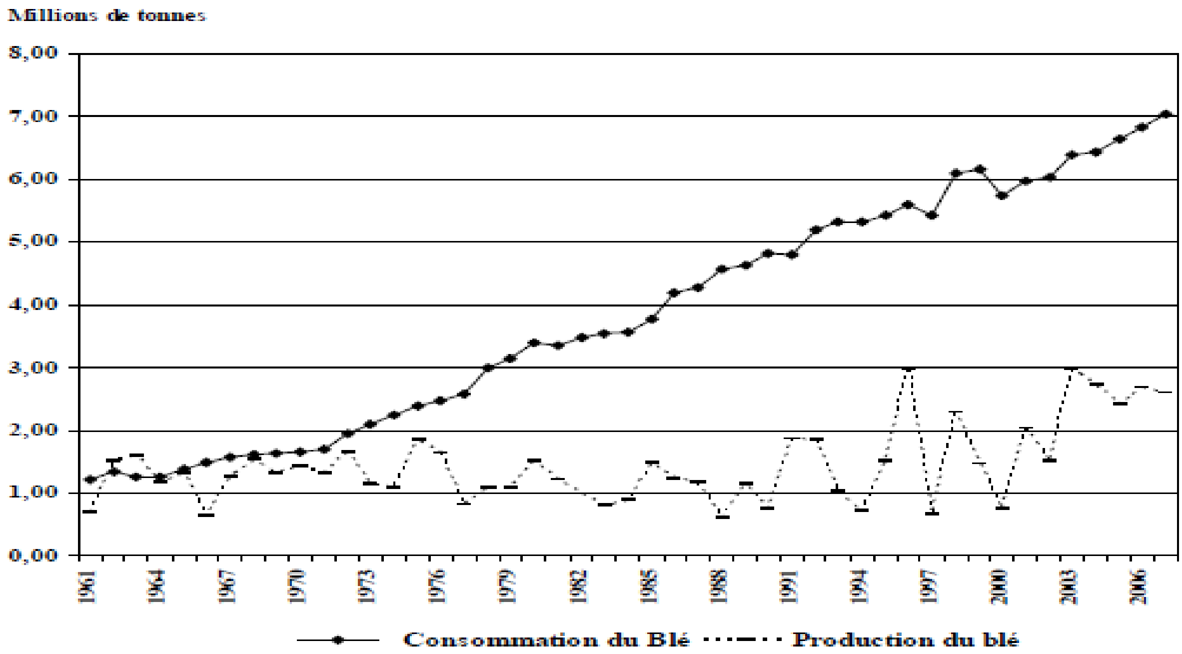


Figure 2.4.2 Evolution of total wheat production and consumption in Algeria

Source: FAO

Another study expresses the complexity of food systems and their link to food security as follows: "Dynamic interactions between and within the biogeophysical and human environments lead to the production, processing, preparation and consumption of food, resulting in food systems that underpin food security" (Gregory, Ingram and Brklacich, 2005).

2.5 CLIMATE AND CLIMATE CHANGE

2.5.1 Climate and its measurement

Climate refers to the characteristic conditions of the earth's lower surface atmosphere at a specific location; weather refers to the day-to-day fluctuations in these conditions at the same location. The variables that are commonly used by meteorologists to measure daily weather phenomena are air temperature, precipitation (e.g., rain, sleet, snow and hail), atmospheric pressure and humidity, wind, and sunshine and cloud cover. When these weather phenomena are measured systematically at a specific location over several years, a record of observations is accumulated from which averages, ranges, maximums and minimums for each variable can be computed, along with the frequency and duration of more extreme events (FAO ROME. 2008). The World Meteorological Organization (WMO) requires the calculation of averages for consecutive periods of 30 years, with the latest being from 1961 to 1990. Such a period is long enough to eliminate year-to-year variations. The averages are used in the study of climate change, and as a base with which current conditions can be compared (UK Met Office Online).

Climate can be described at different scales. Global climate is the average temperature of the earth's surface and the atmosphere in contact with it, and is measured by analyzing thousands of temperature records collected from stations all over the world, both on land and at sea. Most current projections of climate change refer to global climate, but climate can also be described at other scales, based on records for weather variables collected from stations in the zones concerned. Zonal climates include the following:

Latitudinal climates are temperature regimes determined by the location north or south of the equator. They include polar climate, temperate climate, sub-tropical climate and tropical climate.

Regional climates are patterns of weather that affect a significant geographical area and that can be identified by special features that distinguish them from other climate patterns. The main factors determining regional climate are: (i) differences in temperature caused by distance from the equator and seasonal changes in the angle of the sun's rays as the earth rotates; (ii) planetary distribution of land and sea masses;

and (iii) the worldwide system of winds, called the general circulation, which arises as a result of temperature difference between the equator and the poles. Examples of regional climates are maritime climate, continental climate, monsoon climate, Mediterranean climate, Sahelian climate and desert climate.

Local climates have influence over very small geographical areas, of only a few kilometers or tens of kilometers across. They include land and sea breezes, the orographic lifting of air masses and formation of clouds on the windward side of mountains, and the heat island effects of cities. Under certain conditions, local climatic effects may predominate over the more general pattern of regional or latitudinal climate. If the area involved is very small, such as in a flower bed or a shady grove, it may be referred to as a microclimate. Microclimates can also be created artificially, as in hothouses, museum displays or storage environments where temperature and humidity are controlled (FAO ROME. 2008).

2.5.2 Climate system

The climate system is highly complex. Under the influence of the sun's radiation, it determines the earth's climate (WMO, 1992) and consists of:

- The atmosphere: gaseous matter above the earth's surface;
- The hydrosphere: liquid water on or below the earth's surface;
- The cry sphere: snow and ice on or below the earth's surface;
- The lithosphere: earth's land surface (e.g., rock, soil and sediment);
- The biosphere: earth's plants and animal life, including humans.

Although climate per serelates only to the varying states of the earth's atmosphere, the other parts of the climate system also have significant roles in forming climate, through their interactions with the atmosphere (Figure 2.5).The Global Climate Observing System (GCOS) has developed a list of variables essential for monitoring changes in the climate system (FAO ROME. 2008).

Sun's radiation

Interacting with

The climate system				
Biosphere (all living organisms, including humans	Lithosphere (soil, rock, sediment)	Atmosphere (air, water vapor, other gaseous matter)	Hydrosphere (liquid water)	Cry sphere (snow, ice perm)

Produces

Atmospheric condition (Surface air temperature, precipitation, humidity atmospheric pressure, cloud cover / hours of sunshine, wind velocity and direction)	
Weather (daily atmospheric conditions in specific location)	Climate (average atmospheric conditions, means and variability, over 3 decades in a specific location)

At different scales

Global climate	Latitudinal climates	Regional climates	Local and micro-climates

Figure 2.5 the formation of climate -Source: FAO/NRCB.

2.5.3 Climate variability and climate change

There is no internationally agreed definition of the term "climate change" Climate change can refer to:

- Long-term changes in average weather conditions (WMO usage);
- All changes in the climate system, including the drivers of change, the changes themselves and their effects (GCOS usage);
- Only human-induced changes in the climate system (United Nations Framework Convention on Climate Change - UNFCCC usage).

There is also no agreement on how to define the term "climate variability". Climate has been in a constant state of change throughout the earth's 4.5 billion-year history, but most of these changes occur on astronomical or geological time scales, and are too slow to be observed on a human scale. Natural climate variation on these scales is sometimes referred to as “climate variability”, as distinct from human-induced climate change. UNFCCC has adopted this usage (e.g., UNFCCC, 1992). For meteorologists and climatologists, however, climate variability refers only to the year-to-year variations of atmospheric conditions around a mean state (WMO, 1992).

To assess climate change and food security, FAO prefers to use a comprehensive definition of climate change that encompasses changes in long-term averages for all the essential climate variables. For many of these variables, however, the observational record is too short to clarify whether recent changes represent true shifts in long-term means (climate change), or are simply anomalies around a stable mean (climate variability) (FAO ROME. 2008).

2.5.4 Effects of global warming on the climate system

Global warming is the immediate consequence of increased greenhouse gas emissions with no offsetting increases in carbon storage on earth. This paper is concerned mainly with the projected effects of the current episode of human-induced global warming on the climate system, now and for the next several decades, as these are the effects that will both cause additional stresses and create new opportunities for food systems, with consequent implications for food security. The linear depiction shown in Figure 2.6 is a rough approximation of how the interactive dynamics of global warming, climate system response and changes in weather patterns may work in different parts of the globe (FAO ROME. 2008).

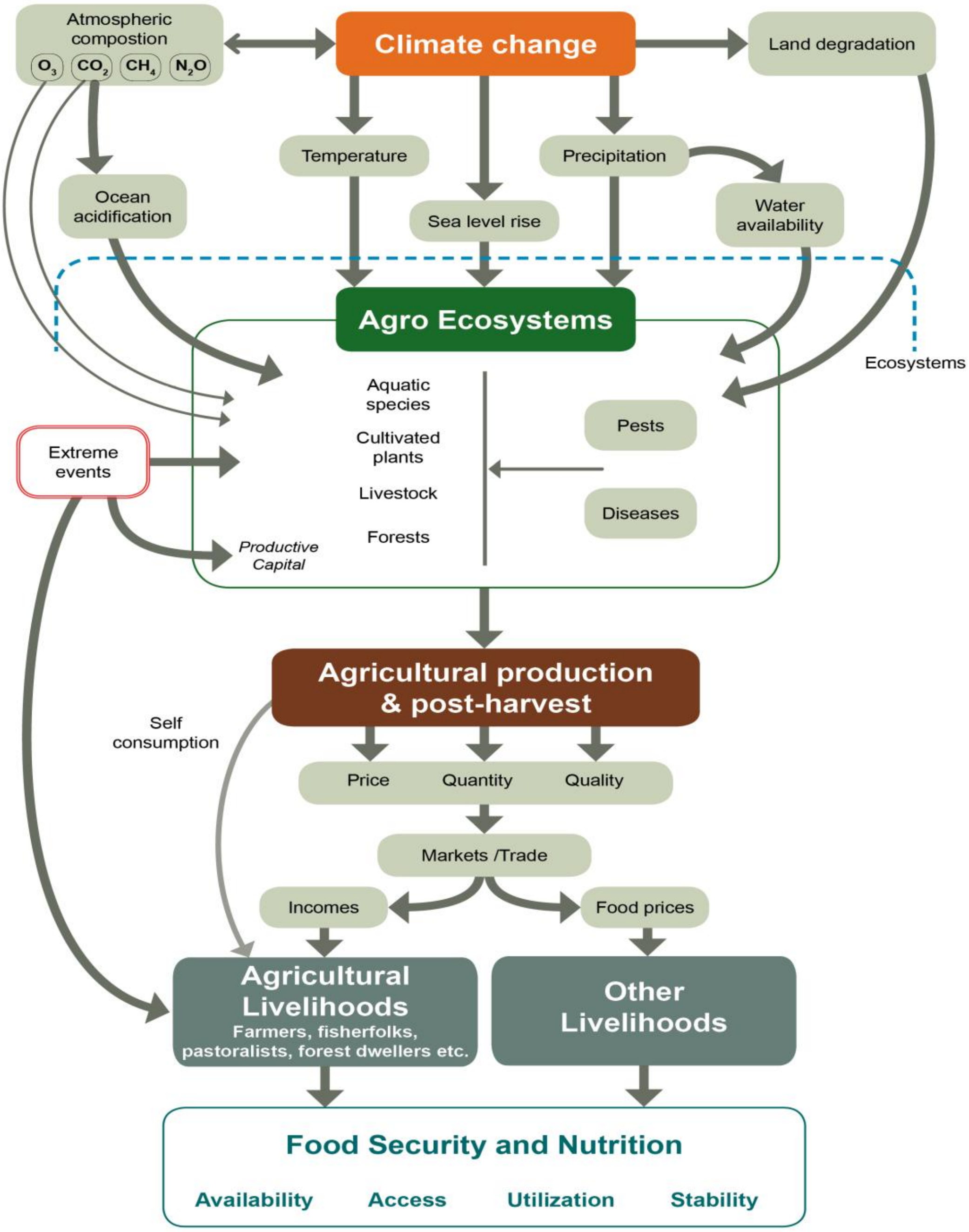


Figure 2.6 Schematic representations of the cascading effects of climate change impacts on food security and nutrition. A range of physical, biological and biophysical impacts bear on ecosystems and agro-ecosystems, translating into impacts on agricultural production. This has quantity, quality and price effects, with impacts on the income of farm households and on purchasing power of non-farm households. All four dimensions of Food security and nutrition are impacted by these effects.

2.6 Main Climate Changes of Importance for the Agriculture Sectors

The latest IPCC report confirms the main findings of previous IPCC reports on the evolution of the climate as well as its main physical effects, such as consequences for land and ocean temperature change, sea-level rise and ocean acidification. It also brings better understanding of potential spatial changes in precipitation, in intensity and seasonal distribution. Moreover, improvements in modeling as well as in data collection and use enable making better projections on a medium-term perspective and at a much more localized scope. These improvements are of crucial importance to better understand and project potential impacts on agricultural systems. As stated in the Synthesis of the last IPCC report “cascading impacts of climate change can now be attributed along chains of evidence from physical climate through to intermediate systems and then to people” (IPCC, 2014a).

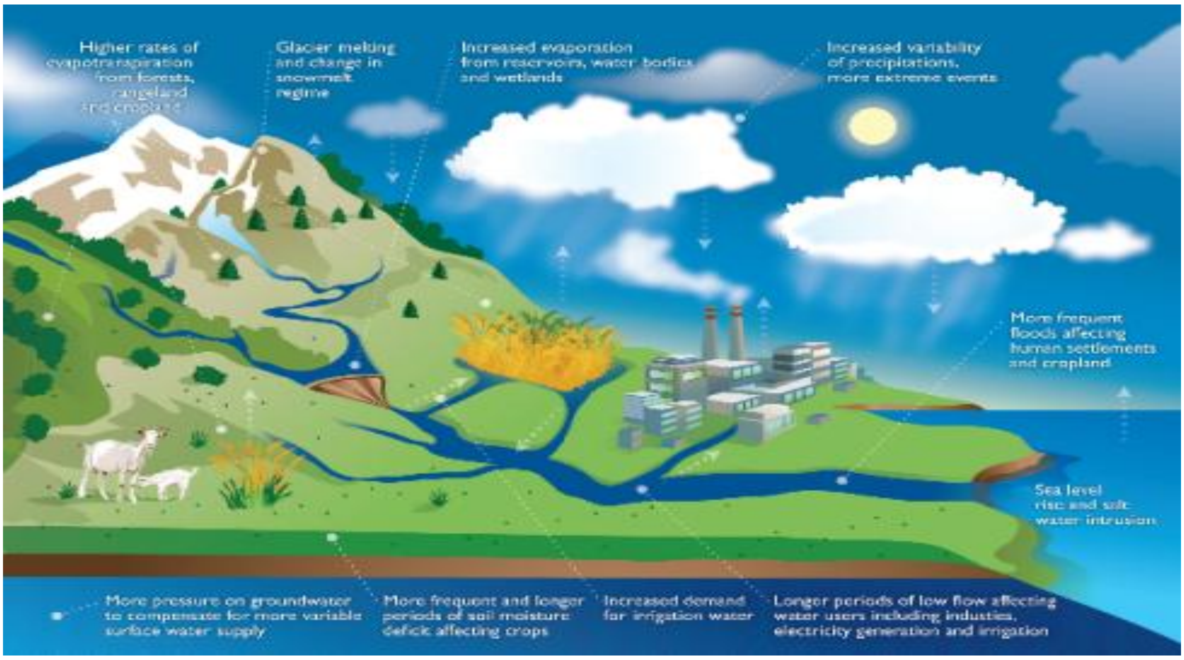


Figure 2.7 How climate change affects all the elements of the water cycle and its impact on agriculture. Source*:* FAO (2013b)

2.7 Climate change puts the soil under pressure

In some parts of Europe, higher temperatures could lead to proliferation of vegetation and an increase in the volume of carbon stored in the soil. However, higher temperatures may also increase decomposition and mineralization of organic matter in the soil, thus reducing the organic carbon content. In other areas, low levels of oxygen in the water impede the decomposition of the organic carboniferous matter of stable peat lands. If these areas dry up, the material organic matter is rapidly at risk of decomposition, releasing carbon dioxide (CO2) the atmosphere. There are already signs that soil moisture content is affected by rising temperatures and changes in precipitation patterns. According to projections, this trend may continue and result in a general change in soil moisture in summer in most part of Europe during the period from 2021 to 2050, with large decreases in the Mediterranean region and some increases in the northeastern Europe. The increasing concentration of carbon dioxide in our atmosphere is likely to have as effect that microbes contained in the soil act more quickly to break down the organic matter, which could release even more carbon dioxide. The emission of gas greenhouse effect should be particularly important in the extreme north of Europe and in Russia, where melting permafrost could release large amounts of methane, which is a much stronger greenhouse gas than carbon dioxide (EEA). 2015.

2.8 Soil Erosion

Soil erosion is the most widespread form of soil degradation. Land area globally affected by erosion, 1094 million Ha (Mha) by water erosion, of which 751 Mha is severely affected and 549 Mha by wind erosion, of which 296 Mha is severely affected. Whereas the effects of erosion on productivity and non-point source pollution are widely recognized, those on the C dynamics and attendant emission of greenhouse gases (GHGs) are not. Despite its global significance, erosion-induced carbon (C) emission into the atmosphere remains misunderstood and unquantified component of the global carbon budget. Soil erosion is a four-stage process involving detachment, breakdown, transport/ redistribution and deposition of sediments. The soil organic carbon (SOC) pool is influenced during all four stages. Being a selective process, erosion preferentially removes the light organic fraction of a low density of < 1.8 Mg/m3. A combination of mineralization and C export by erosion causes a severe depletion of the SOC pool on eroded compared with uneroded or slightly eroded soils. In addition, the SOC redistributed over the landscape or deposited in depression sites may be prone to mineralization because of breakdown of aggregates leading to exposure of hitherto encapsulated C to microbial processes among other reasons (EEA). 2015.

Displacement of soil from the place of its formation by causative agents (e.g., raindrop, runoff, wind, gravity, etc.) and its deposition at a depression and/or protected site is a natural geologic phenomenon. The slow geologic erosion is a constructive process, which has created vast tracts of fertile soils of alluvial flood plains and loess plateaus around the world. These soils, with built-in soil fertility renewal mechanisms, have supported ancient civilizations (e.g., in the valleys of the Nile, Euphrates, Indus, Yangtze) and thriving cultures for millennia. In contrast, the accelerated soil erosion, exacerbated by anthropogenic perturbations, is a destructive process. It depletes soil fertility, degrades soil structure, reduces the effective rooting depth and destroys the most basic of all natural resources. Numerous, once-thriving civilizations have vanished because of the degradation of the resource base on which they arose (Lowdermilk, 1953; Eckholm, 1976; Olson, 1981; Brown, 1981, 1984; Dragnet, 1982).

The importance of protecting and restoring the soil resource is increasingly been recognized by the world community (Lal, 1998; Barford et al., 2001; Lal, 2001). Sustainable management of soil received strong support at the Rio summit in 1992 and it's Agenda 21 (UNCED, 1992), UN Framework Convention on Climate Change (UNFCCC, 1992) and Articles 3.3 and 3.4 of the Kyoto Protocol (UNFCC, 1997), the 1994 UN Framework Convention to Combat Desertification (UNFCD, 1996). These conventions are indicative of the recognition by the world community of strong linkages between soil degradation and desertification on the one hand and loss of biodiversity, threat to food security, increase in poverty and risks of accelerated greenhouse effect and climate change on the other (EEA). 2015.

Soil is an important - and often neglected - element of the climate system. It's about the second largest carbon reservoir, or "sink", after the oceans. Following the considered region, climate change could result in the storage of an increased carbon quantity in plants and soil as a result of growth plant, or cause the emission of larger amounts of carbon in the atmosphere. Restoration of key terrestrial ecosystems and a sustainable use of lands in urban and rural areas can help us mitigate and adapt to climate change.

Climate change is often perceived as a phenomenon that occurs in the atmosphere. And in fact, during photosynthesis, plants take carbon from the atmosphere. But atmospheric carbon also affects the soil since the carbon not used for growth of the aerial part of the plants is distributed by the root system in the soil. If undisturbed, this carbon can become stable and remain confined for thousands of years. Healthy soils can mitigate climate change. Not all soils are equal to carbon storage. The most carbon-rich soils are peat lands, which are generally found in northern Europe, the United Kingdom and Ireland. Grazing lands also store a lot of carbon per hectare. In contrast, the soil in the warm, dry areas of southern Europe contains less carbon (EEA). 2015.

The onset and expansion of agriculture has accelerated soil erosion by rainfall and runoff substantially, mobilizing vast quantities of soil organic carbon (SOC) globally. Studies show that at timescales of decennia to millennia this mobilized SOC can significantly alter previously estimated carbon emissions from land use change (LUC).

Carbon emissions from land use change (LUC), recently estimated as 1.0±0.5 Pg C yr-1, form the second largest anthropogenic source of atmospheric CO_2 (Victoria Naipal, 20 July 2018). However, their uncertainty 40 range is large, making it difficult to constrain the net land-atmosphere carbon fluxes and reduce the biases in the global carbon budget

(Victoria Naipal, 20 July 2018). The absence of soil erosion in assessments of LUC is an important part of this uncertainty, as soil erosion is strongly connected to LUC (Victoria Naipal, 20 July 2018).

The expansion of agriculture has accelerated soil erosion by rainfall and runoff significantly, mobilizing around 783 ± 243 Pg of soil organic carbon (SOC) globally over the past 8000 years (Wang *et al*., 2017). Most of the mobilized SOC is redeposit in alluvial and colluvial soils, where it is stabilized and buried for decades to millennia (Hoffmann *et al.*, 2013a; Hoffmann *et al.*, 2013b; Wang *et al.*, 2017). Together with dynamic replacement of removed SOC by new litter input at the eroding sites, and the progressive exposure of carbon-poor deep soils, this translocated and buried SOC can lead to a net carbon sink at the catchment scale, potentially offsetting a large part of the carbon emissions from LUC (Berhe *et al.*, 2007; Bouchoms *et al.*, 2017; Harden *et al.*, 1999; Hoffmann *et al*., 2013a; Lal, 2003; Stallard, 1998; Wang *et al.*, 2017).

On eroding sites, soil erosion keeps the SOC stocks below a steady-state (Van Oost *et al.*, 2012) and can lead to substantial CO2 emissions in certain regions (Billings *et al.*, 2010; Worrall *et al*., 2016; Lal, 2003). CO2 emission from soil erosion can take place during the breakdown of soil aggregates by erosion and during the transport of the eroded SOC by runoff and later also by streams and rivers.

2.9 Forms of erosion

Erosion can take different forms that combine in time and space.

2.9.1 Water erosion

The most troublesome erosive phenomena appear rather caused by the forces developed by the water. The main factor in this erosion is runoff, the spatial distribution of which is controlled by that of precipitation and soil surface characteristics. The dynamics of erosion depend on the influence of the factors involved.

Soil erosion develops when rainwater, no longer able to seep into the soil, dribbles over the parcel carrying away the soil particles. This refusal of the soil to absorb excess water appears either when the intensity of the rains is greater than the infiltrability of the soil surface ("Hortonian" runoff), or when the rain arrives on a surface partially or totally saturated by a water table (saturation runoff). These two types of runoff usually occur in very different environments, although sometimes a combination of both (Cros-Cayot, 1996) is observed. Once the runoff is triggered on the parcel, erosion can take different forms that combine in time and space: diffuse erosion, parallel gullies and linear erosion.

2.9.1.1 Splash erosion (splash effect)

It is the elementary erosion caused by the shock of the drop of water endowed with a certain kinetic energy. Raindrops break clods and clumps and throw away the particles (Figure 2.8).

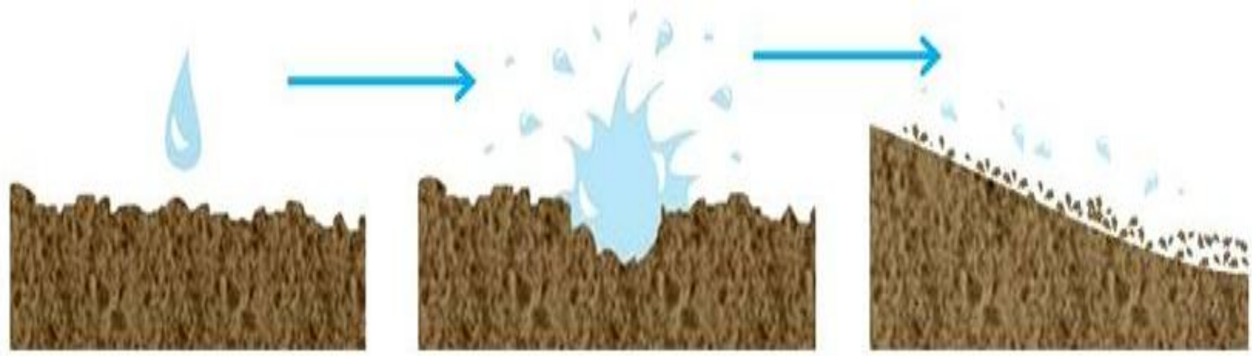


Figure 2.8 splash phenomenon and particle displacement

This phenomenon of splash, displaces the particles over a few tens of cm, the distance depends on the mass of the particles and the angle of incidence of the drops of rain with respect to the surface. The displaced fine particles are trapped between the coarser elements and close the pores: the surface of the soil loses its infiltration capacity and on certain soils, a crust of flapping appears which facilitates the triggering of the runoff process and the soil erosion (M. BOUTKHIL. 2015).

2.9.1.2 Aquifer erosion

We speak of aquifer erosion when the energy of the raindrops attacks the entire surface of the ground and the transport of the torn material is carried out by the sheet runoff. This is the initial stage of soil degradation through water erosion (Roose, 1994). This type of erosion results in more or less uniform stripping of the surface layer of the soil by runoff water. Non-seeping water trickles down the ground in the form of a sheet of water or diffuse nets. This diffuse or flat runoff is manifested by a shear force and pulls off the particles. It is the most common form of erosion although its symptomatic effects seem less perceptible since it concerns the fine particles of the soil (clays, silts and organic matter). The consequences of this erosion are stripping of the superficial horizons. If measures are not taken to correct this incipient erosion, it will then evolve towards linear erosion: claws, channels and gullies (Roose et al., 1996, Morsli et al., 2004).

The traces left on the ground by the various types of erosion reflect the local efficiency of processes that use a variety of energy sources and various factors that modify their expression. Indicators of sheet erosion that are easy to spot on the soil surface are light-colored beaches, clear sand sheets, pickling (damsels combed), and climbing of pebbles on the soil surface.

2.9.1.3 Linear Erosion

When the intensity of the rains is greater than the infiltration of the surface of the ground or when the rain arrives on a surface partially or totally saturated by a ground, it is formed at first time puddles of water, which overflowing go communicate with each other by nets that gain speed and develop clean energy capable of digging the ground. It is the shearing forces of the water laden with sand and gravel that pull up aggregates at the bottom and on the flanks of the channels (Figure 2.9). The resistance of a soil profile to runoff will therefore be different from the sensitivity of a soil to the beat of raindrops. It first forms simple claws and then dissymmetric channels that can evolve into metric gullies. (Hjulström 1935) showed that when the nets exceed the speed of 25cm / s, they acquire sufficient energy to pull and mobilize the particles (clays, silts, gravel, pebbles and blocks).

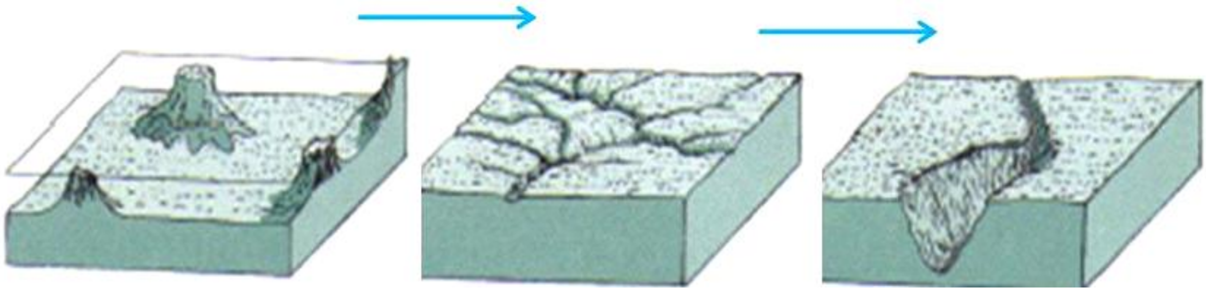


Figure 2.9: evolution of water erosion

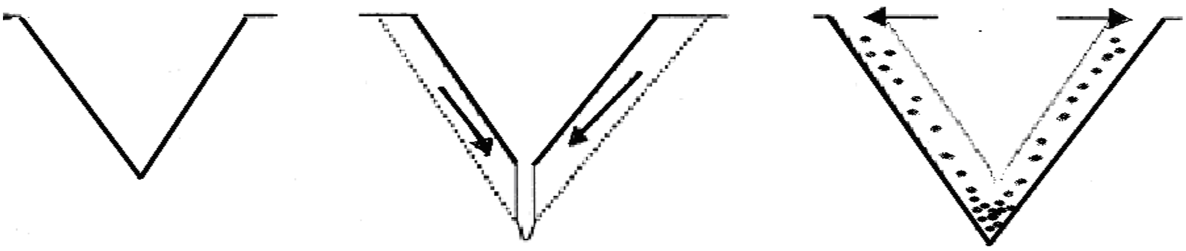
The cause of linear erosion is to be found in the runoff energy, which depends on both the runoff mass (M) and the square of its velocity (V) at the plots. At the watershed level, the runoff energy depends on the mass of the runoff (M), the attractive force (G) and the difference in altitude (H) between the top and bottom of the watershed.

Runoff energy = ½ M x V^2 at the plot or = ½ .M.G.H. on watershed.

When the runoff is organized, it digs obvious forms deeper and deeper along the lines of least resistance. Stream erosion claws occur when small canals or microfilts are less than 10 cm deep and channel erosion occurs when they exceed 10 cm (Roose, 1994). Both of these forms of erosion can be erased by agricultural implements. When the hollows reach the 50 cm depth and more than they can no longer be erased by cultural techniques, it is called "gully erosion".

When gullies join each other by ridges and cause a touch of the rock, we arrive at the final stage of the badland gully. At this stage of generalized gully, any development is no longer possible. Badland often develops on soft substrates.

In nature, we observe different types of gullies, most often V-shaped gullies that print in a homogeneous material; more or less loose (sandy-clay, clay, marly or shaly). Gullies evolve through erosion and alteration of the rock (Figure 2.10). In the Mediterranean environment the alteration of marls and shale can reach 4 to 10 mm per year. U-shaped gullies are frequently observed in nature on heterogeneous and / or resistant materials. During floods, the water exerts a lateral thrust on the lower side of the slope until it collapses and the channel of the gully widens laterally through the scouring and collapse of the banks.



1

over deepening gullies **2**digging and sliding lips **3** widening and overcrowding

Figure 2.10 evolution of V-shaped gullies on homogeneous material (marl) by overcrowding (Morsli, 1996)

Tunneling tunnel gullies, still referred to as suffocation, can develop in a surface-cracked material, either on soils rich in swelling clays or on marls rich in gypsum or other soluble minerals. Soil cracks into which hypodermic runoff (water circulation in soil cracks and pockets of gypsum dissolution) will gradually turn into tunnels, which collapse and form regressive gullies that progress rapidly during big showers. This form of gulling is difficult to treat.

2.9.1.4 Mass Erosion

While groundwater erosion is affecting the soil surface, gully draining the slope, mass movements involve a volume within the soil cover and geological formations. The water acts this time not by stripping, but by deterioration of the physical qualities in depth and can then cause either landslides or recesses. Mass erosion (landslide) or flow (mudflows) is a process commonly observed on steep slopes, poorly coherent rocks (clays, marls, shale) when the substrate is saturated (Avenard, 1990). Many landslides have been observed in Algeria. There are several types of landslides:

- Slow "creeping" landslides: these are more or less slow landslides of the soil cover, usually without detachment, which is generally observed on steep slopes due to the recumbent form of young forest seedlings. In pastoral areas, the movement of animals along the slopes can also cause slippage in the form of stairs (Moeyersons, 1989).

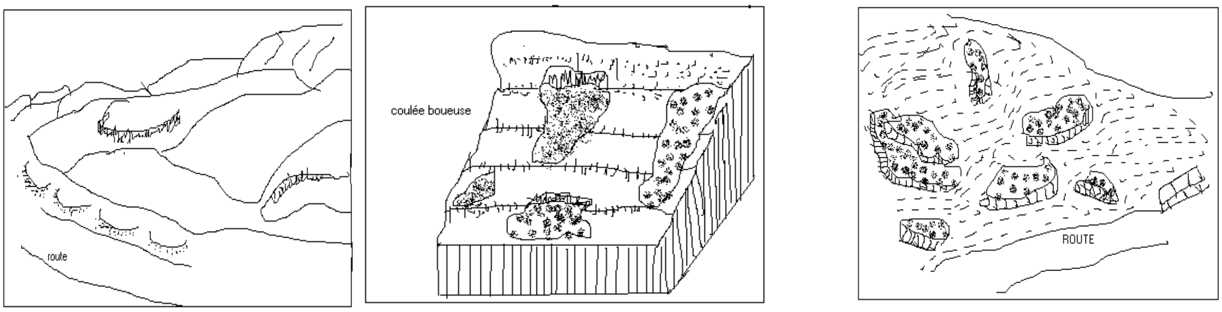
- Rapid landslides: these are detachments of a more or less thick layer of soil, sliding on a more compact horizon, serving as a sliding plane.

- Mottled hillsides: these are soft forms that appear in wet conditions when the superficial horizons exceed the point of plasticity and progress slowly, between the root grid that holds the surface horizon and the impermeable compact horizon that represents the otherness of marl or argillites for example.

- Mudslides (Fig. 2.11.6): These are high-density mixtures of water and earth that have exceeded the liquidity point and carry considerable masses of mud and large blocks of rock at high speed.

- Rotational sliding in "spoon shots": these are slips where the surface of the ground and a part of the mass slide while making a rotation, so that it appears a counterpoise on the slope. This is often a whole series of spoon strokes, leaving the landscape a mottled appearance.

- Local forms: rock fall, bank failures or slope collapses that cause localized landslides. These are very common at the head of the ravine. They drag the upper part of the lips of a ravine and advance the ravine to the top of the hill by regressive erosion.



1. Mass Movement: Mottled Landscape 2. Muddy Sequence 3. Roadside Decay

Figure 2.11: diagram of some examples of mass movements

2.9.2 Dry or agricultural mechanical erosion

This phenomenon, very little known, very little quantified is not due to the intervention of water or wind. This is the result of the repetitive pressures exerted by the simple push of the agricultural implements which results in the stripping of the superficial horizons of the tops of the slopes (Fig.2.12.7). This has the effect of transporting the masses of land downstream of the top sequences where they will accumulate either in banks bordering the plots or in concave colluvions of texture little different from the original horizons.

The factors influencing the amount of earth moved are: the type of tool, the frequency of the passages, the orientation of the work, the slope. This type of additional erosion, often underestimated, may be in step with water erosion. This is why there is often a tendency to confuse sheet erosion with dry mechanical erosion by explaining the white spots at the top of the slope and at the end of the slope as evidence of erosion in the aquifer while mechanical erosion may be more important than sheet erosion (Wassmer 1981, Nyamulinda 1989). The moved materials are not sorted (non-selective).

Erosive processes depend on a multiplicity of interacting factors and are therefore complex to understand. Since these factors are mainly natural data in their broadest sense, the hydrological response of a watershed relates to characteristics related to the climate of the environment, the soil, the topography, and the different properties of the watershed and human actions.

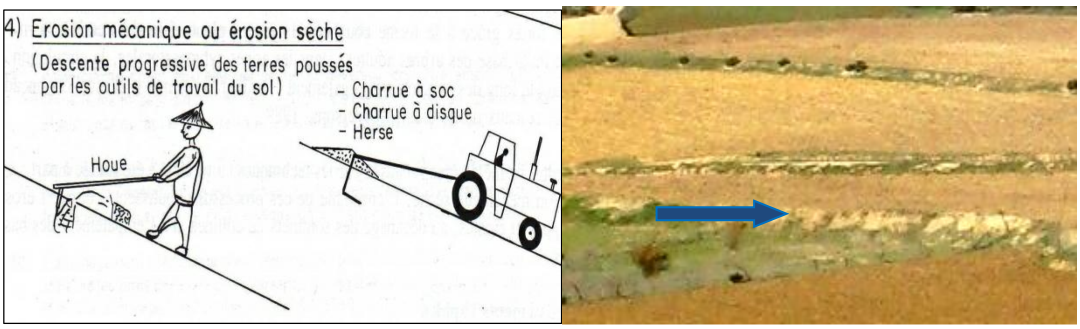


Figure 2.12: dry mechanical erosion

By gravity and by simple pushing of the agricultural implements, this type of erosion decodes the superficial horizons of the soil from the top of the downward slope of the top sequence where they accumulate by forming bulges.

2.9.3 Natural factors affecting erosion and runoff

Erosive processes depend on a multiplicity of interacting factors, and are therefore complex to model. The factors of erosion are natural data in the broad sense to take into account to study the erosive phenomena. Climate, lithology, soil, slope, vegetation cover, and cultivation techniques are the factors that govern soil erosion (Roose 1994).

2.9.3.1. Climate

Climate is an important factor that directly conditions the mechanism of erosion. In addition to the influence of wind temperature, rainfall is the most important climatic factor of water erosion. The more abundant and intense the rains, the more they release a kinetic energy and develop a destructive aggression of the aggregates: these will be all the more fragile if the soil is very dry (explosion of the aggregates) or very wet (weak cohesion): the impact of raindrops can break up and scatter aggregates, the finest soil particles (fine sands, silts, clays and organic matter) can easily be washed away by runoff.

Climatic parameters should be considered when assessing the problem of water erosion. These are mainly precipitation characteristics: spatial and temporal distribution of rainfall, intensity, duration and frequency of precipitation, time between two events, form. The erosivity of the rain, also known as climatic aggressivety index (Rusa), takes into account the interactions between these characteristics.

R (Erosivity) = **E** (kinetic energy) **x I** ^{30} (maximum rainfall intensity in 30 minutes)

The aggressiveness index of Wischmeier (Rusa) ranges from 20 to 650 in the United States, from 20 to 150 in Europe, from 100 to 500 in the tropics and from 50 to 350 in the Mediterranean region (Roose, 1994).).

The pluviogram of each rainfall is a painstaking and time-consuming exercise, and since not all information on rainfall intensity is available, many authors (Fournier, 1960, Arnolds', 1980, Roose, 1981, Rango and Arnoldus, 1987) attempted to simplify the estimation of the rainfall erosivity index. By stripping stations in West Africa for more than 20 years, Roose (1981) found that Wischmeier erosivity index is directly related to mean annual rainfall (Ham). And he proposed a simple empirical formula that will estimate the annual variability of erosivity.

The formula is: Ram = Ham. a +/- 0.05

With "a" is estimated at 0.5 in the plain, 0.6 at the edge of the ocean, 0.2 to 0.3 in the tropical mountains, 0.1 in the Mediterranean zone and at least 0.1 in the temperate oceanic zone.

There is an intensity threshold below which runoff is not formed. The classic Wischmeier index for quantifying soil erosion in the U.S.A., places this limit at an average intensity of 25 mm / h for at least 30 minutes (Wischmeier, 1959). The authors do not all agree on the limit intensity of runoff. This value has been questioned by European authors who have shown that the runoff may appear for threshold values much lower (2 to 10 mm / h). This intensity is found to vary in the degree of soil wetting and degradation of the soil surface before the onset of rainfall, as well as the characteristics of local situations (Lafforgue and Naah 1976, Boiffin 1984, Raheliarisoa 1986).(Casenave and Valentine, 1989). Lal (1976) believes that the maximum current intensity in 7 minutes or 15 minutes is even better correlated with erosion than intensity in 30 minutes. This may be true locally but not necessarily everywhere (De Noni and Viennot, 1991).

Even though the rains are not all dripping, they still leave traces by degrading the surface of the soil, favoring the birth of low permeability crusts and accelerating the runoff during the next showers. Rainfall can be in the form of heavy showers that cause heavy runoff. In Mediterranean climate, daily rainfall can reach or exceed 100 mm and instantaneous intensities of 5 mm / minute (Roose, 1994). Storm rain can be accompanied by high intensities.

2.9.3.2 Ground

Soils affect runoff and erosion processes primarily by their hydrodynamic and structural properties. The infiltrability of a given soil depends on the succession and physical characteristics of the horizons that constitute it. In general, the more the soil has a succession of horizons with contrasting physical characteristics, with low hydraulic conductivities and low water retention capacity, the more the infiltration will be limited (Stengel, 1988).

The erodibility of a soil is its resistance as more or less coherent materials to two sources of energy: the dropping of raindrops on the soil surface and the shearing of the runoff between the clods and in the claws or claws. Channels many trials were conducted in the field under simulated rain. For example, Dumas (1965) in Tunisia has shown that on plots of 50 m2, the erodibility of soils is a function of the rate of pebbles, the rate of organic matter and the equivalent soil moisture, which is a function of the texture. The level of pebbles on the soil surface is related to infiltration and runoff (Blavet et al., 2004). The erodibility index varies from K = 0.01 for the most resistant soils to K = 0.4 for moderately fragile soils and 0.70 for the most fragile soils. The more soils are rich in organic matter, clay, limestone and stable macro aggregates> 200 μ, the more the soil cover is resistant to the aggressiveness of the rains. And the more soils are rich in fine sands and silts, exchangeable sodium or salt, the more the aggregates are unstable. Soil resistance depends on the intrinsic characteristics of the soil and its surface condition.

2.9.3.3 Topography

The slope strongly influences the importance of erosion, but the existence of erosion and intense runoff on gentle slopes indicates that it does not need a steep slope to trigger this phenomenon: the rained action is enough (Fournier, 1967). The slope is involved in erosion phenomena because of its shape, inclination and length. In the area of weak slopes, inclination of slopes increases runoff, but on steep slope, better internal drainage and slower formation of flapping films are observed, which are destroyed as they are formed by runoff energy (Heusch, 1970, Roose, 1973 and 1977, Valentine, 1981).In the USLE model, the topographic factor (SL) essentially takes into account the length (L) and especially the inclination of the slope (S):

$$SL = (0.76 + 0.53\ S + 0.076\ S^2) \times L^{0.5} / 100$$

In this model, SL varies from 0.1 to 20 on slopes of 1 to 25%, slopes most often cultivated. For crops on steeper slopes, the model has been extended, but it turns out that in many cases erosion no longer increases exponentially. The effect of slope length is complex. Out of 580 plots coupled with slope length, Wischmeier (1966) observed an increase in erosion in 40% of cases. This calls into question the systematic use of the slope factor to determine the risks of soil degradation. The shape of the slope is also important. Wischmeier (1966) showed that earth losses on a concave slope are less than that of a convex slope.

The topographic position of the parcel in the landscape, especially in the Mediterranean, may also play a major role (Heusch 1970, Roose 1994).

2.9.3.4 Vegetation cover

To stop erosion, a plant cover is all the more effective in absorbing the kinetic energy of raindrops, covering a large proportion of the soil during periods when the rains are the most aggressive year; it slows runoff and maintains good porosity on the soil surface. However, it is difficult to evoke the protective action of a plant cover without specifying the cultivation techniques in the broadest sense.

Among the conditional factors of erosion, vegetation cover is certainly the most important factor. We must also add the role played by the stems of plants, by the roots and especially by the litter on the slicks. By reducing the rate of runoff, the infiltration time and also its volume are increased. This braking by the plants is however more effective on the trapping of the solid charge than on the reduction of the streamed volume. When the soil is covered with matoral or grass, erosion does not exceed (0.2-2 t/ha/year) (Laouina, 1992). Whatever the slope, the cultivation techniques, the fragility of the soil and the climatic aggressivity, a complete plant cover ensures an excellent conservation of water and soil. His influence takes precedence over all other factors. Vegetation cover is the most important parameter at our disposal to reduce the risk of erosion (Roose 1977, Hudson 1992). It is therefore with the biological methods favoring this cover, that it is necessary to address in priority to ensure the economy of the water, to improve the infiltration and the production and obviously, the conservation of the soil.

2.9.3.5 Human factor

The anthropological explanation is often invoked to interpret the degraded state of the environment and the current exaggeration of erosive phenomena. Postulates are advanced stating a rapid or catastrophic rate of change. In the Mediterranean, space is under heavy pressure from man, especially in mountainous areas (Dufaure, 1984). The phenomenon of water erosion is a natural process, the extent of which has worsened with the use of soil by man (Remy and Bissonnais 1998, Maillo 1998).

The socio-economic aspects and the effect of cultural practices have a great impact on erosion and soil conservation. As much as man can by wise cultural techniques and facilities, stop almost completely the erosion of soils, as much it can precipitate it in a frightening way to the point of totally ruining entire regions. With uncontrolled land uses, humans are at the forefront of soil degradation factors. Effects affect both vegetation and soil by destroying vegetation cover and surface soil structure.

Chapter 3: Methodology

The Tafna Basin is characterized by a semi - arid climate with two predominant seasons. Wet and cold season runs from October to May with fairly erratic rains, the other, warmer season extends from June to September with low rainfall. The Tafna Basin is transboundary basin where the third of its area is localized in Morocco, and therefore the underground resources are also exploited by the region of Oujda (Morocco).The Tafna Basin, 7245 km² of area in outlet (Mediterranean Sea), is bounded in the South by Tlemcen mounts, in the North by the Mediterranean Sea and Oran High Plains, continued to the West by the Median Moroccan Atlas and in the East by the Daïa mounts. Tlemcen mounts constitute a mountain barrier, with 800-1400m of elevation, in the North, Maghnia, Hennaya and Sidi Abdelli plains. The basin is localized in sub humid to semi-arid region and many of the rivers' tributaries are intermittent streams (FAO ROME. 2008).

3.1 Introduction

Climate change will affect all four dimensions of food security: food availability, food accessibility, food utilization and food systems stability. It will have an impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. Its impacts will be both short term, resulting from more frequent and more intense extreme weather events, and long term, caused by changing temperatures and precipitation patterns,

People who are already vulnerable and food insecure are likely to be the first affected.

Agriculture-based livelihood systems that are already vulnerable to food insecurity face immediate risk of increased crop failure, new patterns of pests and diseases, lack of appropriate seeds and planting material, and loss of livestock. People living on the coasts and floodplains and in mountains, dry lands and the Arctic are most at risk (FAO ROME. 2008).

3.2 How Climate Change is Affecting Food Security

Although there are many factors affecting climate change, the main factor often flagged as the cause for worsening climate conditions is the increase of greenhouse gas emissions in the atmosphere. The increased concentration of GHGs in the atmosphere is expected to trap more heat on earth which in turn results in an increase in global mean temperatures. Climate change causes adverse impacts on both ecosystems and human societies as it increases the incidence of floods, droughts and other climate-related disasters that have the potential to affect farmlands, livestock and animal husbandry, which are essential for agricultural purposes. In order to better understand the effects of climate change on food security, we will focus on three factors identified to have the most direct effects on food production: soil, water and crops. These three factors are crucial in understanding the effects that climate change has on food security as they are the most basic and essential components of food production Saidul, I. and Andrea 201, T. W. (2017).

3.3Water Resources

3.3.1 Water

Similar to soil resources, water resources are also scarce and susceptible to pollution, contamination, eutrophication and changes in climate. It has been reported by the United Nations Department of Economic and Social Affairs (UNDESA) in 2014 that existing climate change scenarios would result in almost half the world's population living in areas of high water stress by 2030. The changing precipitation is altering the hydrological systems, affecting water quality and quantity. Water availability is being threatened by climate change as it has the potential to decrease or cause fluctuations in temperature and precipitation in some regions of the world. Fluctuations in rainfall and temperature can potentially cause crop failure especially for crops that require high temperature and rainfall conditions, e.g., rice. As mentioned earlier, climate change affects the drying-rewetting cycles of the land, thereby changing the Nitrogen (N) content in soils. This in turn affects water resources when nitrates from the soil seep into groundwater systems and alter the nutrient concentration of water bodies. The increased N concentration in water bodies may lead to the process of eutrophication. Eutrophication is a process whereby nutrient overloads in the water body lead to an increase in floating plant communities and plankton. In addition, increased production of floating plant communities is also facilitated by warmer water bodies, due to climate change, that encourages and prolongs the growing period.

The increased growth in floating plant communities will have an adverse effect on submerged plant communities, as sunlight needed for these plants to photosynthesize is being blocked and absorbed by the plants floating on the surface. In order to grow, these floating plant communities compete with submerged plants and other marine animals for nutrients present in the water bodies.

The inability of submerged plant communities to photosynthesize, respire and absorb the necessary nutrients might eventually lead to the death of these plants. The deaths of submerged plant communities will alter the chemical balance in water bodies due to the increase in oxygen content in water bodies, as plants are no longer able to take in oxygen and convert it to carbon dioxide via the process of respiration. This in turn upsets the aquatic biodiversity as marine animals reliant on these plants for food are also affected by changes in the food chain. Animals which are not able to switch to alternative forms of food might either die or have nutritional deficiencies due to changes in nutrition uptake. Thus, increased nitrogen content in water bodies and warmer water conditions have led to the increase in floating plant communities at the expense of submerged aquatic plant diversity. In addition, the high concentration of GHGs in the atmosphere together with the irresponsible disposal of chemicals into water bodies has altered water concentration, leading to ocean acidification and hypoxia that will influence the distribution and productivity of fisheries and aquaculture in many places. The rising global temperature has also led to the rise in the temperature of water bodies, and marine animals that are unable to acclimatize or migrate to cooler water bodies will thus be affected. Studies have indicated that even a small rise of 1°C in water temperature could greatly impact the mortality of fishes, breeding, geographical distributions, and harvests.

It has also been postulated that rising temperatures in water bodies have led to smaller body sizes of fishes such as herring and haddock. This is because warmer water conditions have increased the anabolic oxygen demand underwater while simultaneously reducing oxygen solubility necessary for survival. Thus, in order to adapt to the change in oxygen content underwater, fish species have evolved to have smaller bodies so that they have a larger surface area to volume ratio to balance their oxygen demand and uptake. This biological change in fishes is worrying as it not only represents a decrease in per-capita reproductive rates and decreased resilience against predators and altered ecosystems, it also threatens food security. With reduced per-capita reproductive rates, the fish species population will be significantly reduced. Warmer water conditions thus threaten food security, as these warmer conditions result in the reduction of food availability and stability-decreased fish species populations and smaller body-sized fishes. In addition, rising global temperatures have also resulted in water bodies drying up, leading to the phenomenon of desertification. Desertification causes the loss of arable land as the lack of water causes the land to harden and make it unsuitable for crop production or livestock rearing. Clearly, climate change has a significant influence over water as it not only alters the physical conditions (e.g., temperature and land conditions) and chemical environment (e.g., acidity and oxygen content) in water bodies but also changes the biological environment, i.e., the decline in aquatic life and the shift in marine species distribution and abundance. These changes will in turn reduce agricultural output and this, coupled with growing world population, food supply demands and consistent or worsening climatic conditions, will in turn result in detrimental impacts on food security.

3.3.2 Physical characteristics of the basin

Table 3.1 Basin and Sub-Basins

Code S/Basin	Name of Basin	Name of Sub-basins	wadis	Area Km ^{2}	Mean rainfalls mm/year	Mean annual wadis flow m^3/s
1601	TAFNA	Mouilah Upstream	Mouilah	745	299	0,382
1602		Mouilah Downstream	Mouilah	1228	341	
1603		Boughrara	Mehaguène	665	339	
1604		Tafna Upstream	Tafna	1294	389	0,025
1605		Tafna Boukiou	Tafna Boukiou	978	398	0,0167
1606		Isser Cedra	Isser Cedra	1118	421	0;150
1607		Isser Sikkak	Isser Sikkak	825	432	
1608		Tafna Maritime	Tafna	392	362	0,484
TOTAL		**08**	**-**	**7 245**	**372,625**	

SOURCE: ANRH

3.3.2.1 Form and characteristics

The basin of the Tafna has a rather elongated form for the most part.

3.3.2.2Reliefs

3.3.2.2.1The Mountainous Areas

a) Traras Mountains

These mountains located north of the basin are represented by a chain of coastal mountains on 1250 km2. This area extends from the mouth of the Tafna to the border between Algeria and Morocco, the morphological nature of this region is marked by strong erosion.

b) Sebaâ Chioukh Mountains:

This area located in the north - east of the basin, forms the southern extension of the Traras Mountains. This mountain range extends over 250 square kilometers from the mouth of the Tafna in the west to the Tessala Mountains (Wilaya of Ain Tmouchent).

c) Tlemcen Mountains

Located at the southern end of the basin and spreading along the whole length of the Tlemcen Mountains, they occupy an area of about 3,000 square kilometers. The average altitude varies between 1,200 and 1,500 m, with Djebel Tenouchfi reaching a peak of 1,843 m.

3.3.2.2.2The Plains and Plateau Zone

a) Maghnia Plain

It is limited to the North and North - East by the Southern foothills of the Traras, to the South by the Northern foothills of the Tlemcen Mountains and to the West by a natural extension formed by the plain of Angad. This plain has great agricultural potentialities.

b)Hennaya Plain

It is limited to the South by the Northern foothills of the Tlemcen Mountains and to the north by the Zenata Plateau. By its geographical position and its granular structure, the plain benefits from its location and its proximity to water points (watercourse, groundwater) for the development of a traditional agriculture.

c) Zenata Plateau

It is located in the North-West of the plain of Hennaya, and consists of Mediterranean red soil. The tabular aspect of this plateau has led to the construction of a large airport.

d)Plateau Sidi Abdelli

The plateau is formed of calcareous brown soils. The water capacity is very important on the plateau.

e) The high steppe plains

They limit to the south the basin with the highest point Djebel Makaidou at 1320 m altitude. The municipalities of El Bouihi, Sidi Djillali and El Gor occupy this space. In this area, water resources are very low and underground resources are deep. Despite the facts that these massifs are covered by forests and scrub (kind of vegetation cover in this area), these plains suffer from soil degradation caused by intense soil erosion.

3.3.2.2.3Forests

The forest plays a preponderant role in protecting against erosion and desertification phenomena.

The Tafna Basin has some 1,995 square kilometers of forests concentrated to the south (Tlemcen Mountains) and to the north (Traras Mountains) of the basin.

The forest area represents 22.12% of the total area of the basin.

3.3.3Climatology

The Tafna basin is characterized by a semi-arid climate with two predominant periods. A wet, cool season extending from October to May with rather irregular rains; the other season, dry and warmer extends from June to September with a low rainfall.

a) Rainfall

The average rainfall of the Tafna watershed is 450 mm / year

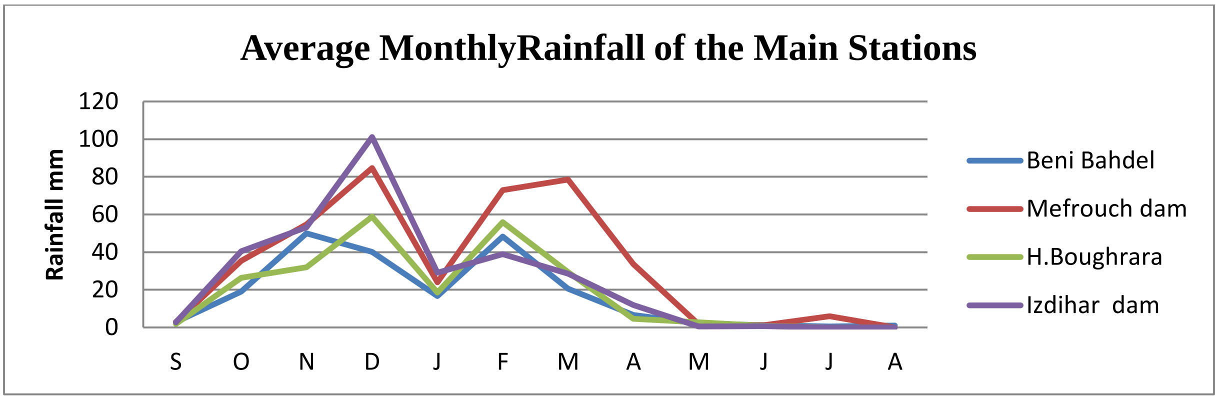


Figure 3.1Average Monthly Rainfall of the Main Stations (2004-2005)

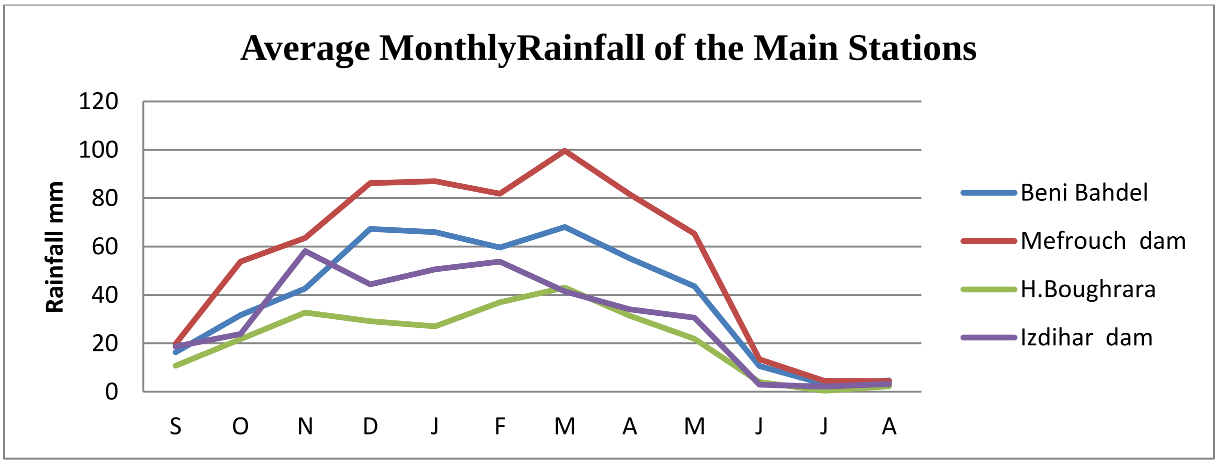


Figure 3.2 Mean Annual Rainfalls of the Main Stations (2004-2005)

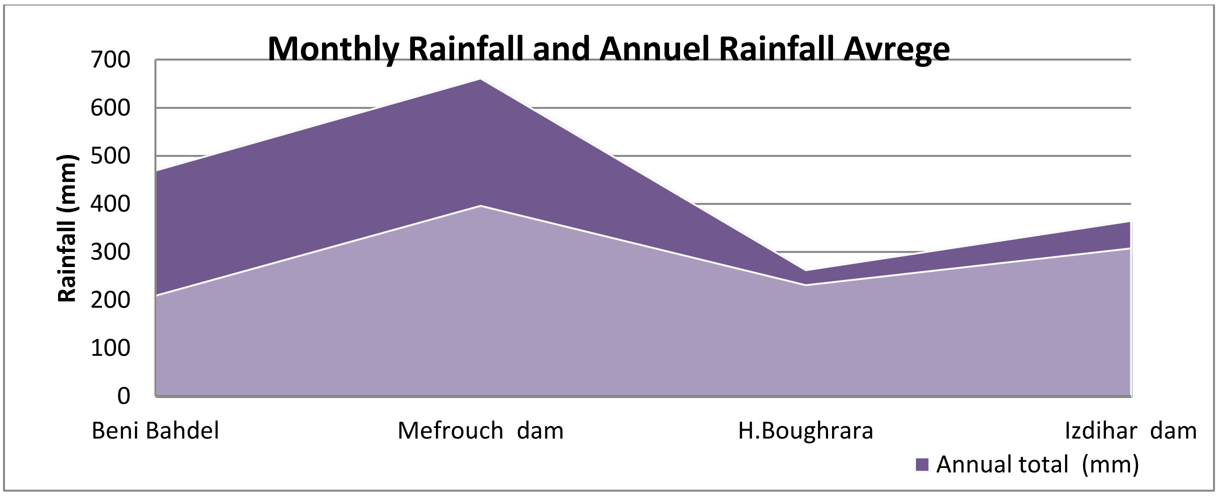


Figure 3.3 Comparison of monthly rainfall and annual rainfall average (2005-2004)

The year 2005 was characterized by low rainfall which has had a significant impact on the water balance. This situation only confirms the drought situation recorded for several years.

b) Hydrometric Stations

All stations belong to the (Agence National Des Ressource Hydrique) - National Water Resource Agency - (ANRH) network

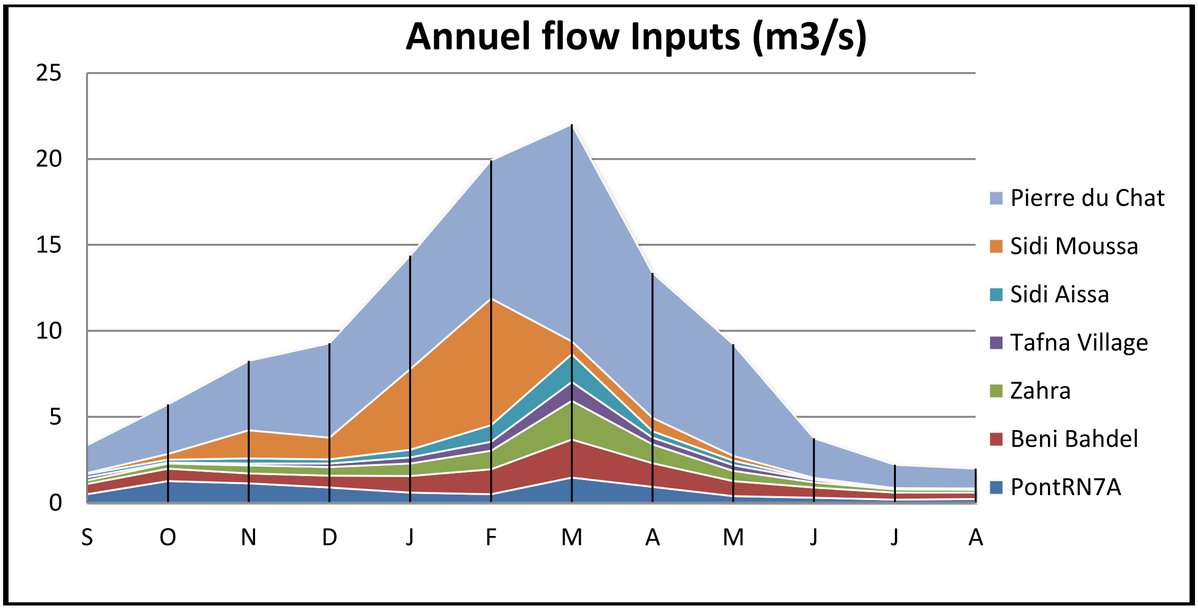


Figure 3.4 Annual Average Flow Inputs of the different stations (m3/s) 2005

The station pièrre de chat is the output of the Tafna Basin; this is why the flow is more in this station, the map represents the hydrological network and the hydrological stations (see AppendixE)

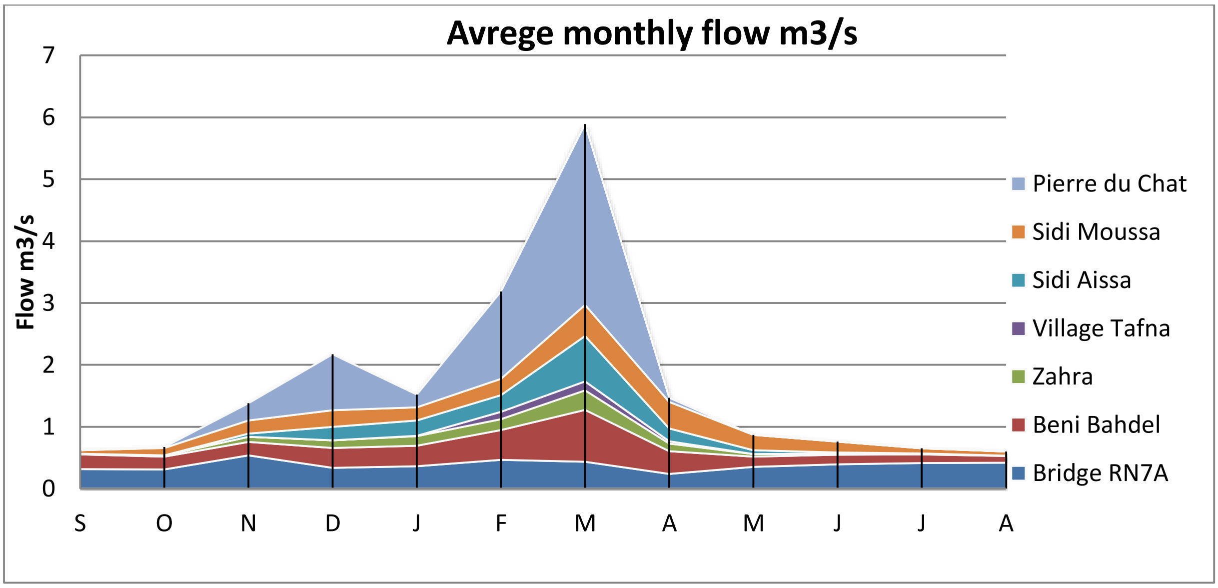


Figure 3.5 Monthly Average Liquid Inputs for 2004-2005 (m3/s)

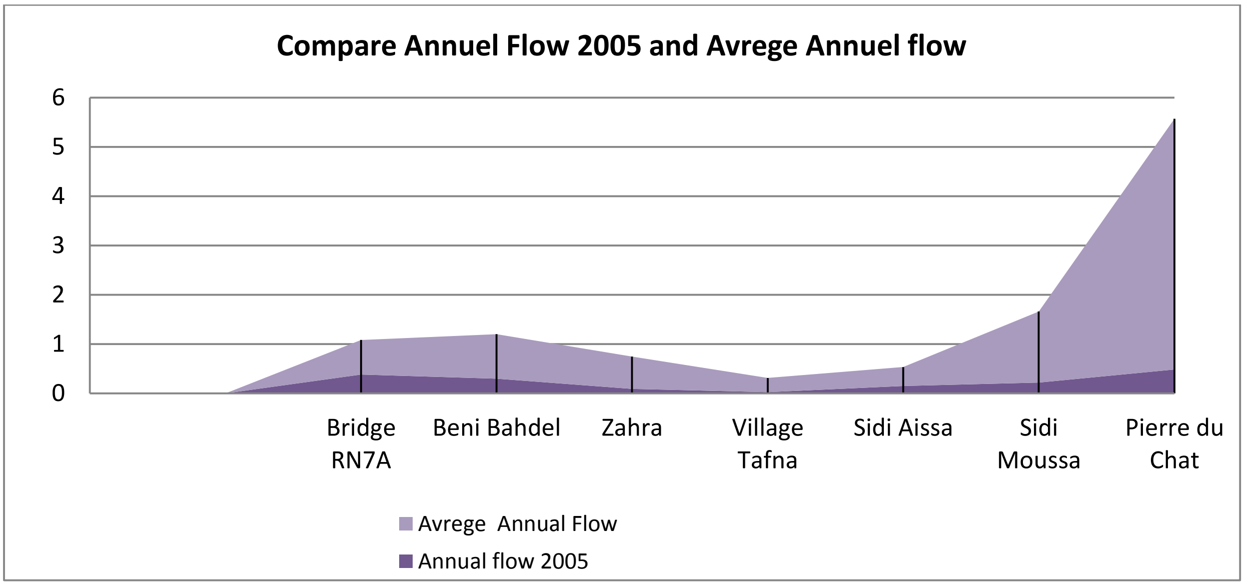


Figure 3.6 Comparison of annual Flow and average annual flow 2005

NB: The Figure 3.4, 3.5 and 3.6 correspond to the main stations used for dam management. The data of the average monthly and inter annual contributions of the other stations does not exist at the level of the ANRH

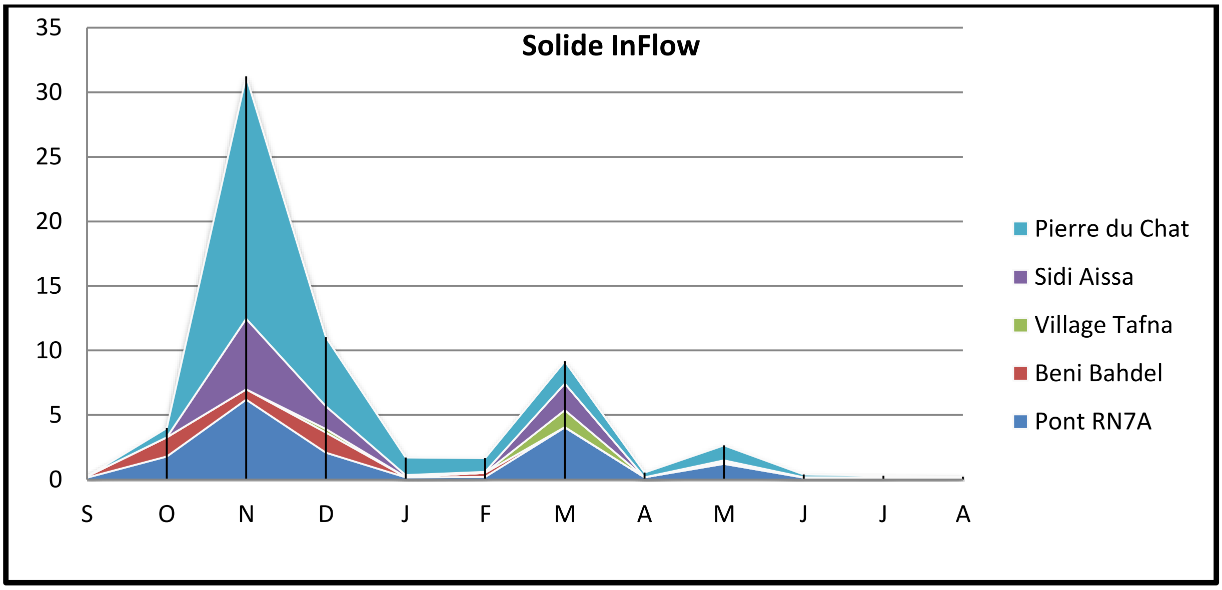
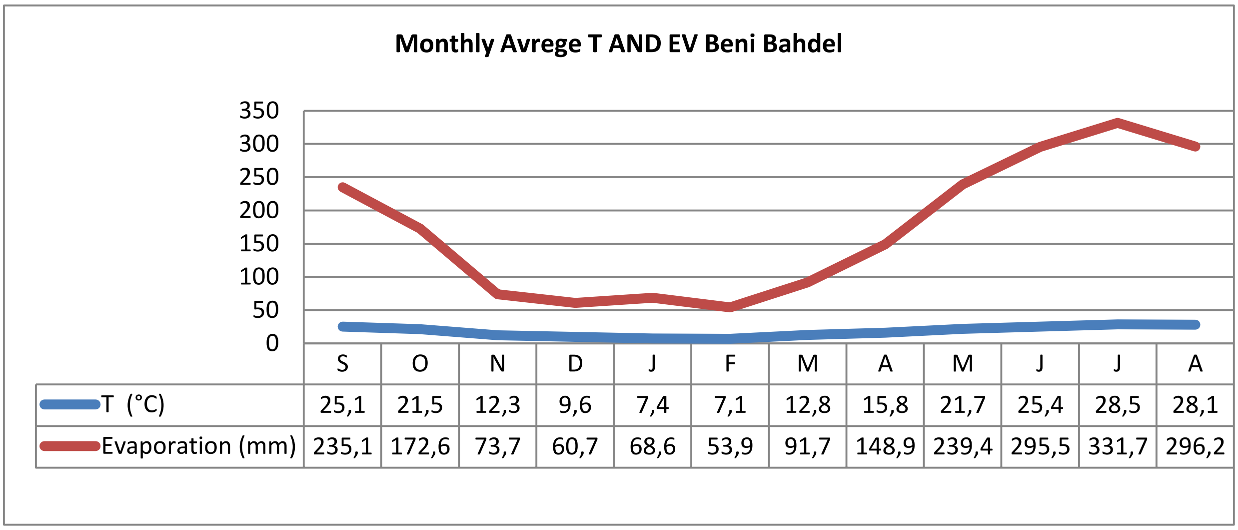
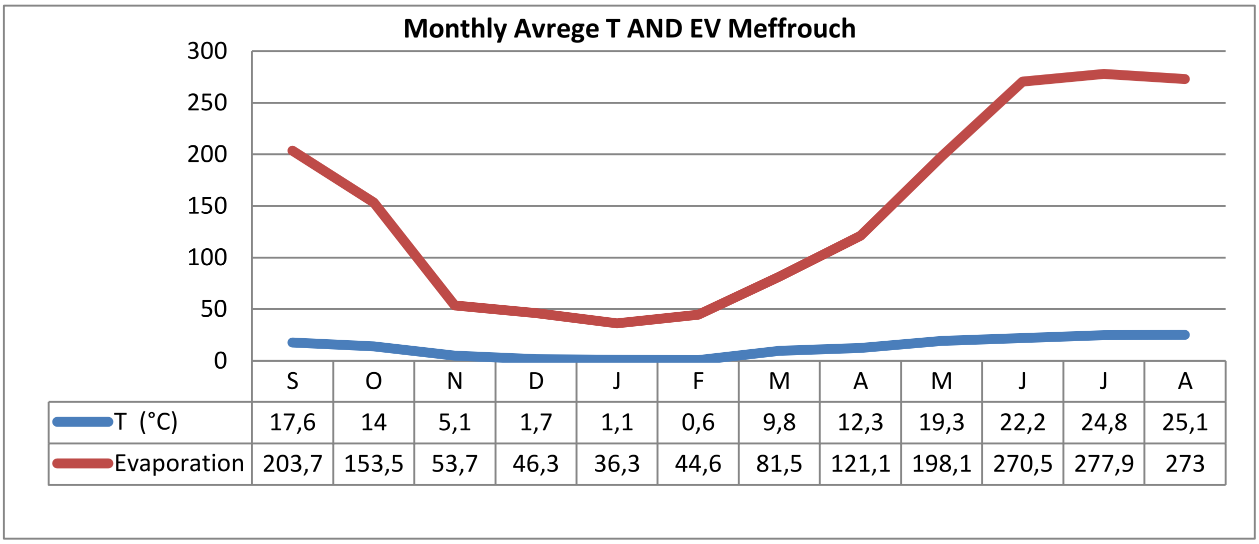


Figure 3.7 Monthly Average Solid Inflows for 2003-2004 (m3/s)



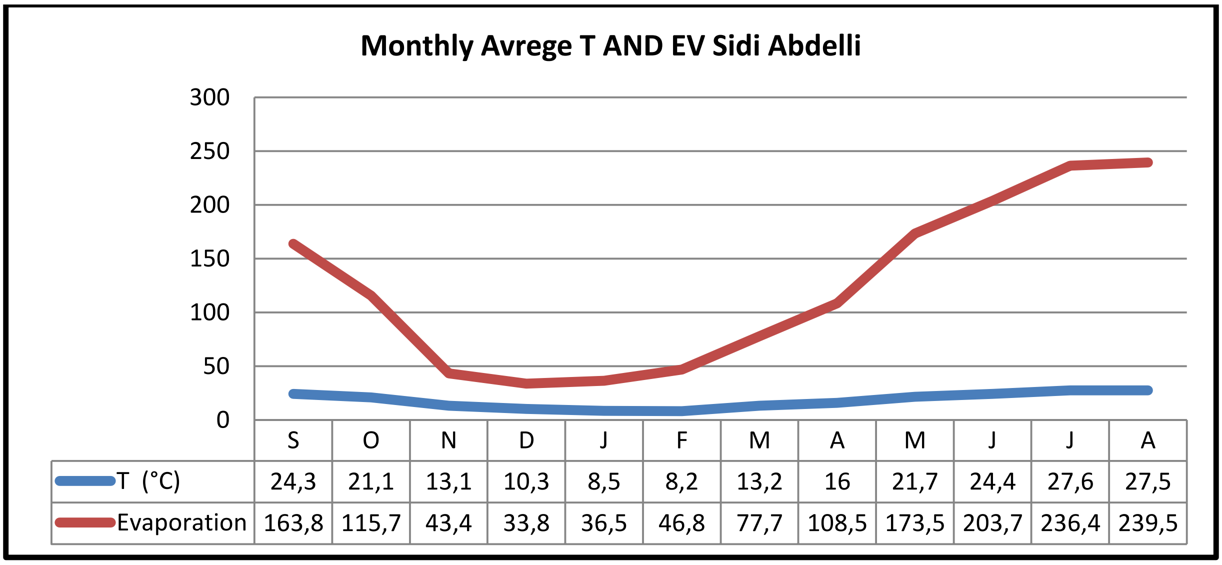
	S	O	N	D	J	F	M	A	M	J	J	A
T (°C)	25,1	21,5	12,3	9,6	7,4	7,1	12,8	15,8	21,7	25,4	28,5	28,1
Evaporation (mm)	235,1	172,6	73,7	60,7	68,6	53,9	91,7	148,9	239,4	295,5	331,7	296,2

Figure 3.8 Monthly Average T (°C) and Evap mm Beni Bahdel Dam (2004-2005)



	S	O	N	D	J	F	M	A	M	J	J	A
T (°C)	17,6	14	5,1	1,7	1,1	0,6	9,8	12,3	19,3	22,2	24,8	25,1
Evaporation	203,7	153,5	53,7	46,3	36,3	44,6	81,5	121,1	198,1	270,5	277,9	273

Figure 3.9 Monthly Average T (°C) and Evap mm at Meffrouch Dam (2004-2005)



	S	O	N	D	J	F	M	A	M	J	J	A
T (°C)	24,3	21,1	13,1	10,3	8,5	8,2	13,2	16	21,7	24,4	27,6	27,5
Evaporation	163,8	115,7	43,4	33,8	36,5	46,8	77,7	108,5	173,5	203,7	236,4	239,5

Figure 3.10 Monthly Average T (°C) and Evap mm Sidi Abdelli Dam (2004-2005)

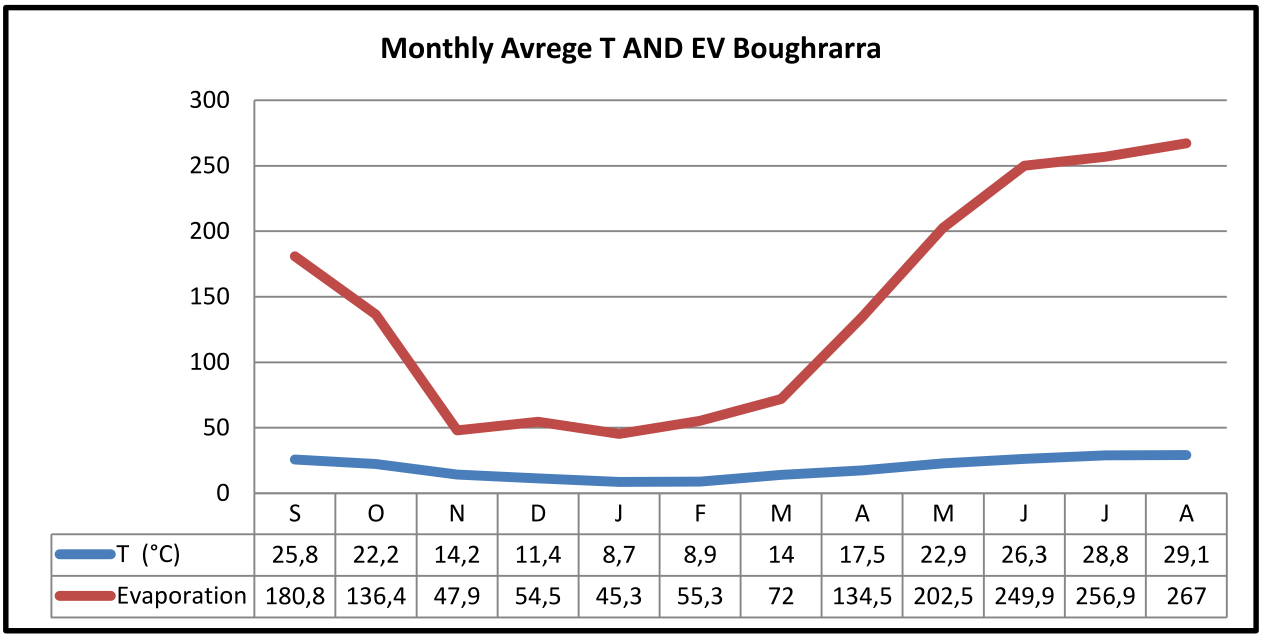


Figure 3.11 Monthly Average T (°C) and Evap mm at Boughrarra (2004-2005)

The thermal regime is characterized by average annual temperatures varying between:

- 7.1 and 28.5 for the Beni Bahdel station;
- 0.6 and 25.1 for the Meffrouch station;
- 8.2 and 27.6 for the Sidi Abdelli station;
- 8.7 and 29.1 for the Boughrarra station.

The values of evaporation are important from June to August and they are low from November to March.

NB: The average monthly temperatures and evaporations are evaluated only for the main stations (The data of the other stations does not exist at the level of the ANRH

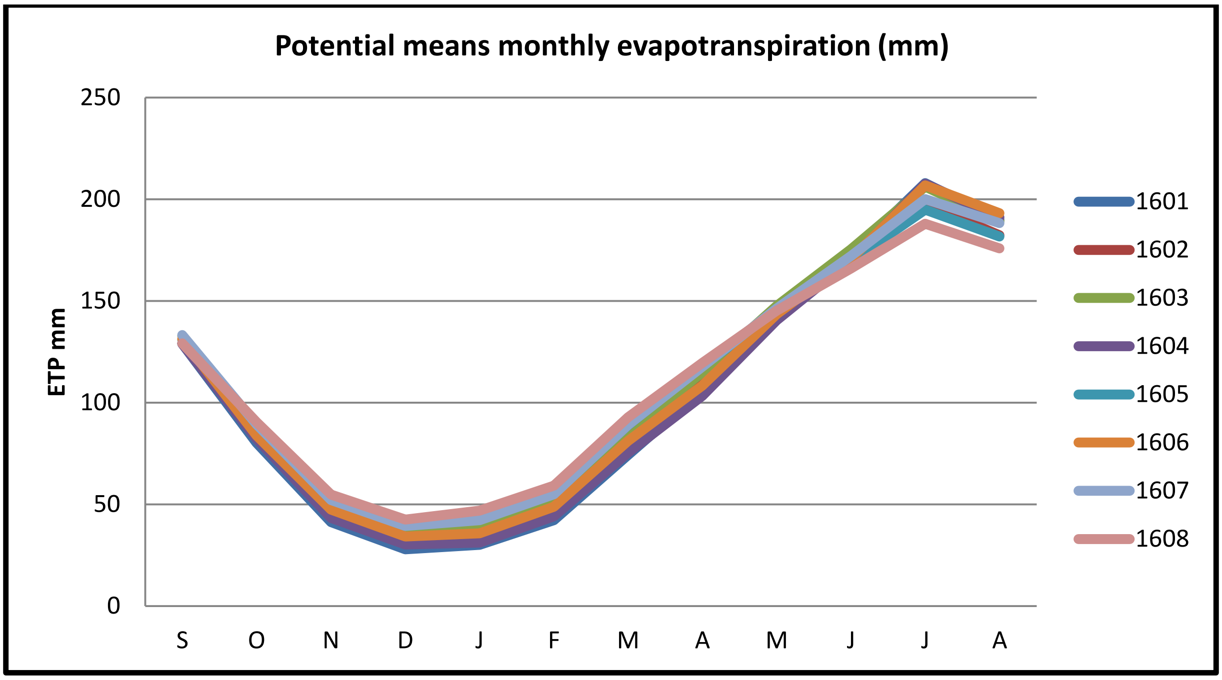


Figure 3.12 Potential means monthly evapotranspiration (mm) (2004-2005)

The data collected in this table has been taken at the various ANRH stations. We are seeing high values in the sub-basins 1603, 1607 and 1608 (sub-basin of Sikkak, Tafna).

c) Other parameters

- Humidity is minimal from July to August, and maximum from December to January;
- The sunstroke is about 3000 hours /y with an average of 8.2 hours / day;
- Wind has a steady speed all year round.

d) Hydrography:

The flow of the wadis is dependent on the rainfall intensity.

d.1 Hydrographic Network (Appendix A and B)

The formation of the hydrographic network is strongly conditioned by the characteristic factors of the lands traversed by the various wadis. Thus lithology intervenes on the degree of ramification of wadis. This is the case of the wadi Tafna which crosses the limestone of the Tlemcen Mountains and follows the direction

South-West, North-East of the dominant relief represented by the mountain range of the Traras and the Tlemcen Mountains. The Tafna Basin has an atrophied hydrographic scalp characteristic of semi-arid zones. It is made up of a multitude of wadis whose flow during the low water period is zero. Wadi Tafna is a 170-kilometer-long stream, which originates south of Sebdou, at an altitude of 1500 m, in the Tlemcen Mountains. The course is subdivided into three parts (High Tafna, Middle Tafna and Lower Tafna)

Table 3.2 Density of drainage (Table 13)

Watershed	**Area Km^2**	**Total linear Km**	**Density of drainage Km/Km^2**
Tafna	7 245	3 621	0,50

Source: ANRH

Table 3.3 General Characteristics of Rivers

Code S/ Basin	Rivers	Length (Km)	Rivers type
1602	Mouilah river	81,23	Main river
1602	El Awadij river	12,66	Affluent
1603	Mehaguene river	40,85	Affluent
1603	El Abbes river	53,31	Affluent
1603	Aounia river	29,85	Affluent
1604	Tafna river	28,40	Main river
1604	Sebdou river	9,099	Affluent
1605	Souf en Nirouf river	7,17	Affluent
1605	Bou Annag river	16,34	Affluent
1605	Boukiou river	20,06	Affluent
1606	Beniane river	8,37	Affluent
1606	El Fernan river	17,21	Affluent
1606	Chouly river	11,56	Affluent
1606	Bezaz river	14,26	Affluent
1606	Isser river	23,36	main river
1606	Bou Hadi river	22,01	Affluent
1607	El Amiguier river	11,369	Affluent
1607	Sikkak river	30,64	main river
1608	Lemmba river	1,51	Affluent
1608	Feid El Atteuch	3,13	Affluent
1608	Ed Diab river	5,62	Affluent

Source: ANRH

The graph below represents the main wadis with their respective lengths per sub-basin.

d.2 Wetlands

The only wetland that exists is Dayet El Ferd, but it is located outside the basin Dayet El Ferd is located in the daïra Sidi Djillali about sixty kilometers southwest of the capital of the Wilaya of Tlemcen. It has an average area of 700 ha, and an altitude of 1075 m. It is the main wetland of the wilaya of Tlemcen representing an important ecological environment with a classification program "RAMSAR" 1971.This site is the receptacle of the central watershed of the wadi (Belhadji Boucif daira of Sebdou, municipality of El Aricha).It is an expanse of permanent and stagnant saltwater marshes. It is fed during floods by a series of wadis (Bentaicha and Bral) carrying all the runoff from the entire watershed. Further north and near the mouth of the Tafna wadi, the flat topography gives birth to a seasonal flood zone.

NB: There is no wetland in the Tafna Basin according to the information collected.

3.3.4Geology - Hydrogeology

3.3.4.1 Regional Geological Framework

We can distinguish from North to South the following spaces:

a) The Tellien Domain

It is a segment of the Alpine chain oriented East-West.

b) The Tlemcenien Domain

It occupies an intermediate zone between the Tellien domain and the high Oranian plains. It includes, from West to East, the horst of Ghar Roubane, the mountains of Tlemcen, the Daia Mountains and the Saida Mountains.

c) The High Plains of Oran

They differ from the Tlemcenien domain from the morphological, structural, tectonic, stratigraphic and pale geographic points of view. Their southern limit corresponds to a continuous series of fractures that form the North Atlas flexure.

d) Saharan Atlas

The chain of the Saharan Atlas corresponds to WSW-ENE oriented folds formed during the Tertiary organic phases; they are composed mainly of secondary sediments. The southern limit of the Saharan Atlas is masked by a series of accidents constituting the South - Atlas flexure.

3.3.4.2Litho stratigraphy

a) The Primary

The Primary Age lands are mainly in the horst of Ghar Roubane and in the Mount of Traras. Primary formations are mainly schistose, quartzitic, granitic and metamorphic.

. In the Nedroma region, the formations are represented by volcanic and metamorphic lands covered by secondary formations.

b) The Secondary

It consists mainly of carbonate rocks sometimes including detrital elements from the primary reliefs on which they lie in discordance and transgression. Secondary lands are dominated by Jurassic

c) The Tertiary

- **The Eocene:** It is represented, in the region of Sebaâ Chioukh, by cracked sandstone with clay cement alternating with marl.
- **The Miocene:** It is a thick series of marl containing several detrital levels.
- **The Pliocene:** They are lacustrine limestones of the lower valley of wadi Mouilah.

d) Quaternary

They are alluviums and colluvions rubefied, slightly encrusted, and having calcareous spots in the profile. These lands correspond to identical colluviums, resting on non-indurate gravel.

3.3.5Potentialities in Water

3.3.5.1 Superficial

Table 3.4 Characteristics of Dams

Dam name	District	River name	Watershed area (km^2)	Year of commissioning	Volume Flow (Hm^3/y)	Initial capacity (Hm^3)	Effective volume (Hm^3)	Usage	Rate of sedimentation (%)
Beni Bahdel	Beni Bahdel	Tafna	1016	1952	73,8	63	49,72	AEP-IRR (Irrigation of GPI Maghnia)	11.9
Meffrouch	Terni	Nchef	90	1963	18	15	13,99	AEP (Tlemcen)	3,3
Sidi Abdelli	Sidi Abdelli	Isser	1137	1988	61	110	135,20	AEP -IRR (Tlemcen - Ain Tmouchent –Sidi Bel Abbes)	3,6
Boughrarra	Boughrarra	Tafna	4000	2000	84	177	149,47	AEP	0
Sikkak	Bensekrane	Sikkak	326	2004	25	27	27	AEP-Irrigation Tafna Isser perimeter (on project)	0

Source: ANBT

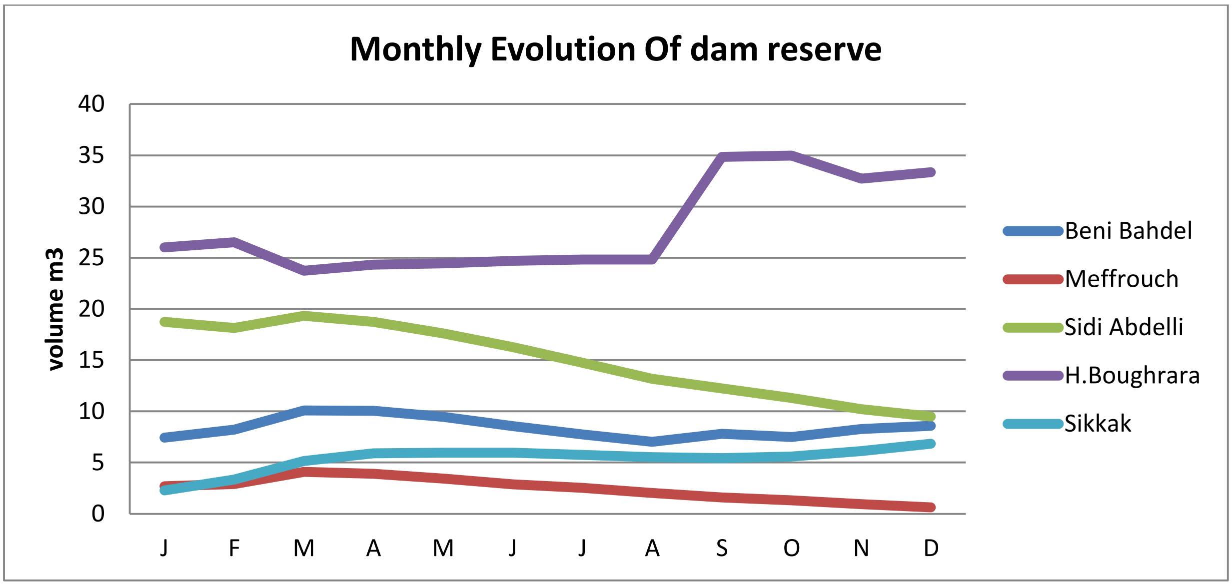


Figure 3.13 Monthly evolutions of dam reserves (2004-2005)

NB: The Ain Youcef Dam (Sikkak) was commissioned in 2004

Table 3.5 Volume of Dams

Basin	District	Name	Lifting capacity 2004 Hm³	Dam Volume 2004 Hm³	Dam Volume 2005 Hm³	Filling rate %
Tafna	Beni Bahdel	Beni Bahdel	54,63	6,89	8,56	15,66
	Terni	Meffrouch	14,99	2,99	0,68	4,53
	Sidi Abdelli	Sidi Abdelli	106,61	19,31	9,59	8,99
	Boughrarra	Boughrarra	175,45	24,00	33,28	18,96
	Ain Youcef	Sikkak	27	0,95	6,69	24,77
TOTAL DAM = 05			**378,68**	**54,14**	**58,80**	

Source: ANBT 2005

The reserves available at the Tafna Basin dams are small relative to the total capacity.

a) Mobilizations from Dams

Table 3.6 Mobilizations from Dams

Basin	District	Dams name	Initial capacity Hm^3	Lifting capacity 2004 Hm^3	Regulated Initial VolumeHm^3/year	Mobilization Hm^3/year	
						Supply	irrigation
Tafna	Beni Bahdel	Beni Bahdel	63	54,63	48	7,567	0
	Terni	Meffrouch	15	14,99	14	4,440	0,019
	Sidi Abdelli	Sidi Abdelli	110	106,61	30	12,593	0
	Boughrarra	Boughrarra	177	175,45	60	12,044	0
	Ain Youcef	Sikkak	27	27	25	0	0
TOTAL = 05			**392**	**378,68**	**-**	**36,644**	**0,019**
						36,663	

Source: ANBT 2005

▪ The volume allocated for drinking water supply, industry and irrigation is 36.663 Hm3 / year (States of Tlemcen, Ain Tmouchent and Sidi Bel Abbes);

▪ The large irrigated area of Maghnia is irrigated partially and occasionally by the Beni Bahdel dam.

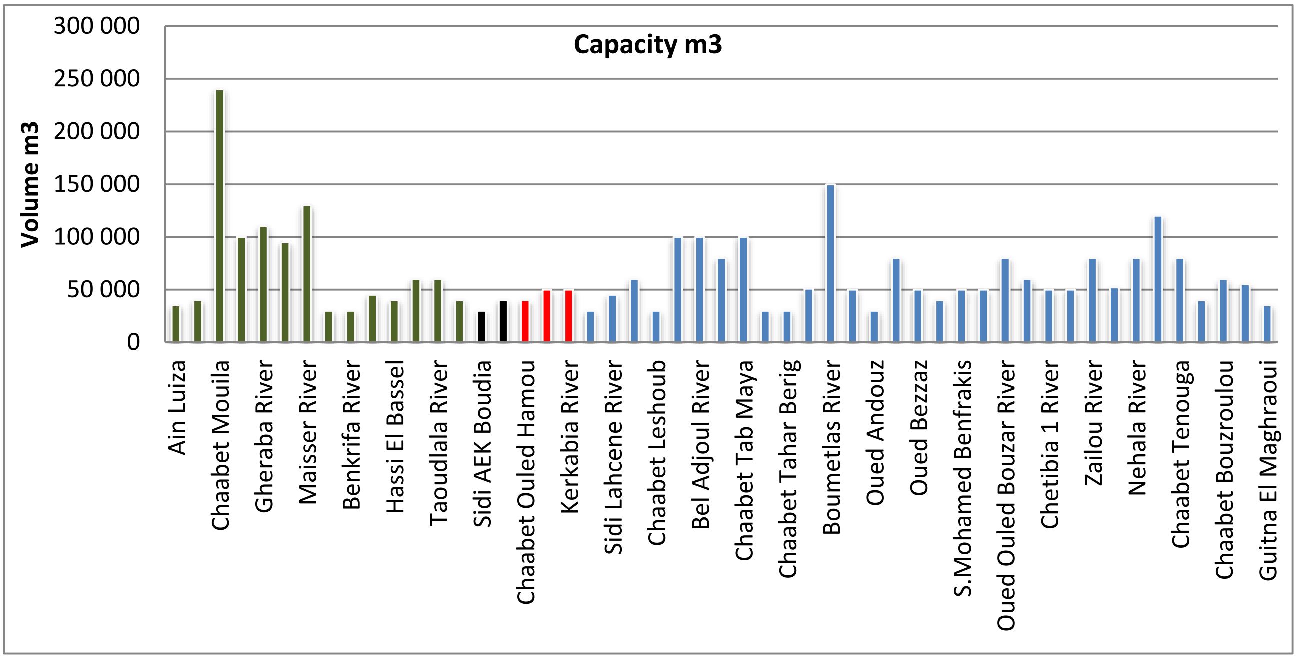


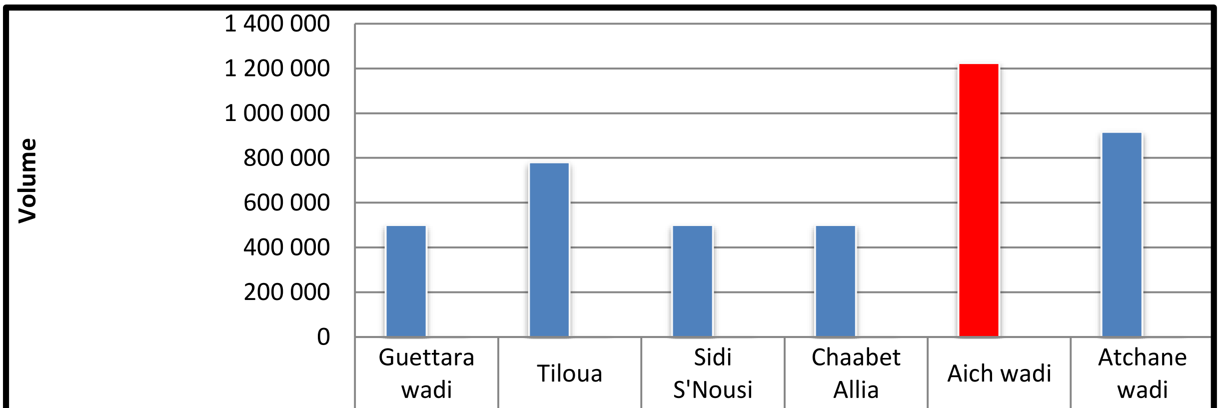
Figure 3.14 Hill Reservoir Characteristics (2004-2005)

There are 51 hill reservoir on all the basin with volume capacity of 3 263 000 m^3 but only 14 small dam are in service with capacity 1 055 000 m^3 moving 389 000 m^3/year, this water is using for drinking water and irrigation with an irrigation surface of 43.5 Ha wish is so low in comparison of total capacity.

2 dams have been destroyed and 3 others have been moved.

The rest of the dams (37) need maintenance because they are full of soil sediments coming from the soil erosion of the neighbor lands.

b) Mobilizations from Small Dams



	Guettara wadi	Tiloua	Sidi S'Nousi	Chaabet Allia	Aich wadi	Atchane wadi
Capacity m3	500 000	781 000	500 000	500 000	1224000	916 000
Surface to be irrigated HA	100	100	40	20	0	100

Figure 3.15 Mobilizations from Small Dams 2000

The total volume of the small dams is **4 421 000 m³** for a total irrigation area of **360 Ha,** Aich wadi is not working for now because it's damaged.

c) Pumping from the rivers in the State of Tlemcen

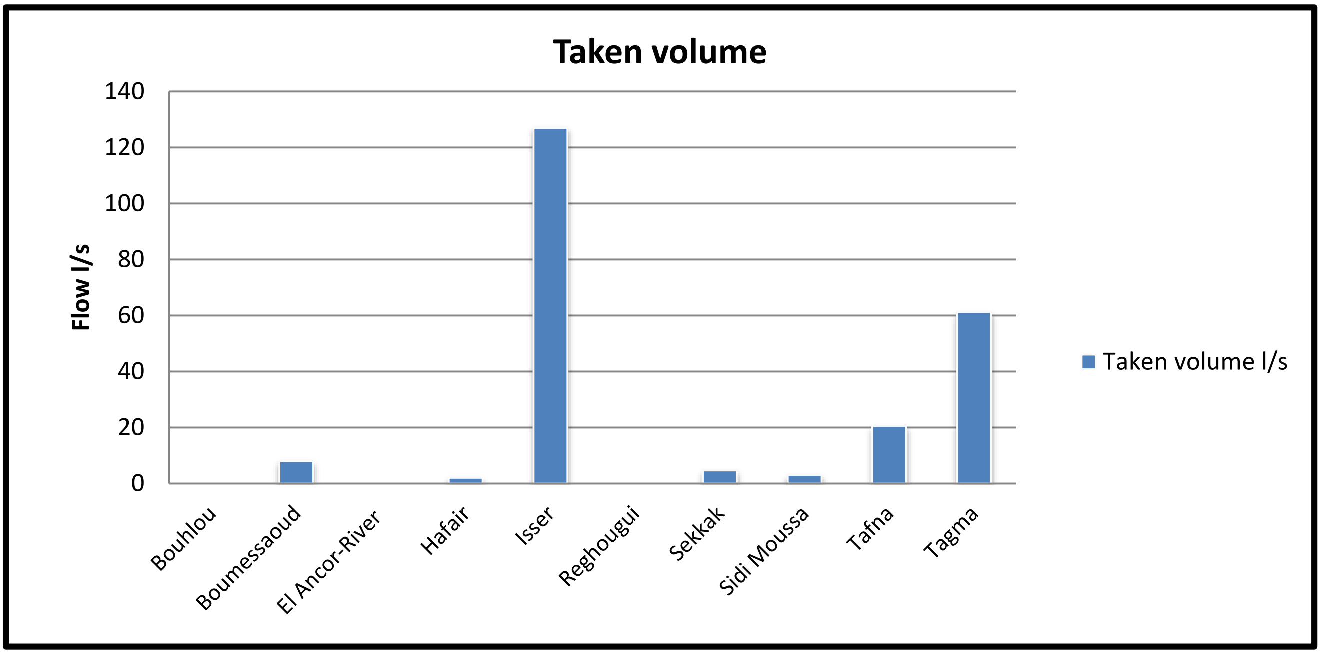


Figure 3.16 Pumping from the rivers in the State of Tlemcen 2006

d) Transfers from the Tafna Basin

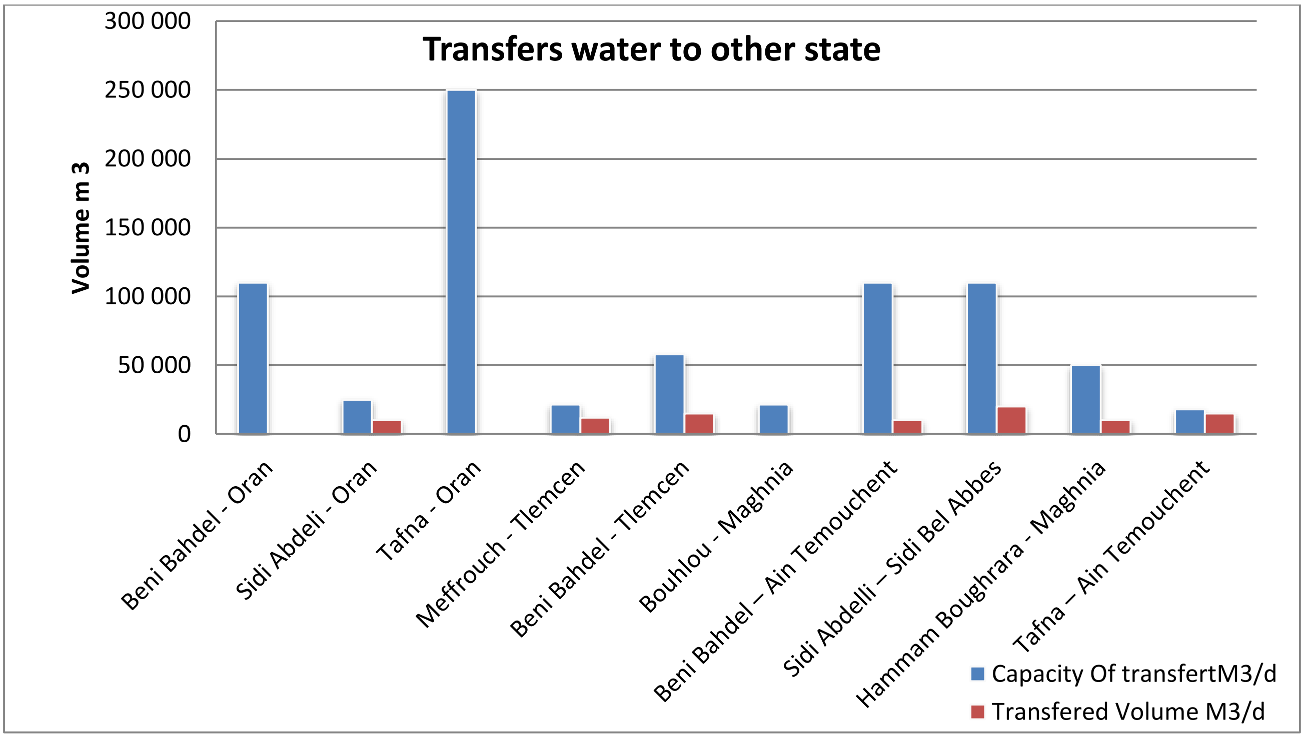


Figure 3.17 Transfers from the Tafna Basin 2005

3.3.5.2 Underground

3.3.5.2.1 Identification of Hydro geological Units

Table 3.7 Identification of Hydro geological Units

Basin	Ground water and aquifers	Potentiality Hm^3	Volume operated Hm^3/ year	assignment	Observation	Water quality
Tafna	Tlemcen mounts	30	24	AEP-IRR	Many illicit wells	Good
	Plain of Maghnia	15	14,15	AEP-IRR-IND	Overexploitation by illicit wells	Good
	Months of Traras	6,5	3	AEP-IRR	Has not been studied	Good
	Plain of Gossels	0,8	0,38	AEP - IRR		Medium
	Valley of Tafna	0,6	0,6	AEP-IRR	Sampling for irrigation	Medium
TOTAL		**52,9**	**42,13**	**-**		**-**

Source: DHW

The surface water of Sidi Bel Abbess is superimposed, at the end of the Basin, with the tablecloth of the limestone of the Tlemcen Mountains; however in a reduced space. The total volume taken from boreholes, wells and springs are 1,243 l / s (39 Hm3 / year). This volume is mainly used for drinking water supply and agriculture (data from DHW 2005).It should be noted that there are thousands of unregistered wells whose samples are unknown but which caused the aquifer to draw down.

NB: The volume of water exploited (Table 3.4) represents an inventory of groundwater withdrawals in different years (1996-1997-2000-2001). Mineral waters are taken into account in the quantification of groundwater resources such as Mansourah II water.

3.3.5.2.2 Inventory of Mobilization Structures

a) Integrated Drilling in the Basin

Table 3.8 Integrated Drilling in the Basin: (47 Drilling 607.5 l / s)

State	Wells number	Flow operated/s	Type of use	Water quality
Tlemcen				Good - Medium
S/Total Basin	**43**	**581,5**	**Drinking - IRR**	
S/Total State	**54**	**656,5**	**DRINKING - IRR**	
Ain Tmouchent				Medium
S/Total Basin	**04**	**26**	**DRINKING**	
S/Total State	**30**	**301,3**	**DRINKING**	
TOTAL TAFNA	**47**	**607,5**	**DRINKING**	
TOTAL States	**84**	**957,8**	**DRINKING**	

Source: DHW

b) Integrated wells in the basin

Table 3.9 Integrated wells in the basin: (83 Wells 70.15 l / s)

State	Wells number	Flow operated l/s	Type of Use	Water quality
Tlemcen				Good - Medium
S/Total Basin	**79**	**66,15**	**DRINKING - IRR**	
S/Total State	**119**	**169,95**	**DRINKING - IRR**	
Ain Tmouchent				Medium
S/Total Basin	**04**	**04**	**DRINKING - IRR**	
S/Total State	**38**	**42,22**	**DRINKING - IRR**	
TOTALTAFNA	**83**	**70,15**	**DRINKING - IRR**	
TOTAL States	**157**	**212,17**	**DRINKING - IRR**	

Source: DHW

c) Integrated sources into the basin

Table 3.10 Integrated sources into the basin: (16 Sources 57 l / s)

State	sources number	Flow operated l/s	Type of Use	Water quality
Tlemcen				Good - Medium
S/Total Basin	**16**	**57**	**DRINKING**	
S/Total State	**18**	**57**	**DRINKING**	
Ain Tmouchent				Medium
S/Total Basin	**0**	**0**	**DRINKING**	
S/Total State	**04**	**16**	**DRINKING**	
TOTAL TAFNA	**16**	**57**	**DRINKING**	
TOTAL States	**22**	**73**	**DRINKING**	

Source: DHW

3.3.5.2.3 Evaluation of the volumes operated by State

Table 3.11 Evaluation of the volumes operated by State

State	Mobilization structure	Number	Operated volume l/s
Tlemcen	Drillings Wells sources	54 119 18	656,5 169,95 57
Ain Tmouchent	Drillings Wells sources	30 38 04	301,3 42,22 16
TOTAL	**Drillings** **Wells** **sources**	**84** **157** **22**	**957,8** **212,17** **73**
GENERAL TOTAL		**263**	**1 243 l/s** **39 Hm^3/year**

Source: DHW

The 146 integrated water points in the basin, divided into 47 drillings, 83 wells and 16 sources total 734.65 l / s (23 Hm3 / year).

This number of water points is much lower than the actual number of points in the Tafna basin

3.3.5.3 Unconventional

3.3.5.3.1 Inventory of desalination plants and mobilized volume

The two existing desalination plants are located outside the basin (two stations in Ghazaouet with a capacity of 2 x 2,500 m3 /day, other two desalination plants are Souk Tlata and Honain with a capacity of 400 000 m^3/day. Desalination was a solution to face the dry period that Algeria is facing; there are 12 other plants produce more than 2 million m^3/day.

3.3.5.3.2 Inventory of Purified Water Reuse Facilities

Table 3.12 Inventories of Purified Water Reuse Facilities

Localization	**Date of commissioning**	**Capacity (Eq/Hab)**	**Treated Volume**	**Type of treatment**	**Purified water allocation**	**administrator**
Sidi Abdelli Sidi Snouci	Nearing completion	12 000	0	natural Lagoon		ONA
Tlemcen (Ain El Hout)	2005	150 000	31 000	Activated sludge	Sikkak wadi	ONA
Maghnia	2000	150 000	24 000	Activated sludge	erfou wadi	ONA
TOTAL	**-**		**55 000 m^3/d 20,075 Hm^3/y**	**-**	**-**	**-**

Source: DHW 2006

NB: The volume of treated water is discharged directly into wadis

3.3.5.3.3 Inventory of facilities for the reuse of industrial treated water

Table 3.13 Inventory of facilities for the reuse of industrial treated water

District Code	Name of district	Localization	industrial Branch	Treated Volume (m^3/y)	Purified water	situation
1301	Tlemcen	SOITEX	Textile	438 000	saf saf wadi	Functional
		ENTC SONELEC	Electrical and telephone cable	87 600	Saf Saf wadi	Functional
1304	Remchi	EMIS	Jus	116 800	Tafna wadi	-
1327	Maghnia	ERIAD MAIS	Maize flour	438 000	El Abbes wadi	-
		ENCG	Fat body	292 000	El Abbes wadi	Functional
		ECVO (CERTAF)	Ceramic	233 600	erfou wadi	Functional
		ENOF	Betonies	146 000	erfou wadi	-
1335	Sebdou	DENITEX	Fabric and jeans	584 000	Tafna wadi	Functional
TOTAL BASIN			-	**2 336 000**	**Wadi**	-

Source: DHW

NB

- Table 27 shows the volume of major industries processed at the Tafna basin level;
- The majority of industries have been identified.

3.3.5.4 Synthesis of water resources

Table 3.14 Operational volumes

Designation	Number	Surface Resources s Hm^3/year	Underground Resources Hm^3/year	non-conventional Resources Hm^3/y	Total Hm^3/year
Dams operated	05	36,663	-	-	36,663
Water resources	146	-	39	-	39
Treated Volume (WWTP)				22,411	22,411
TOTAL		**75,663**		**22,411**	**98,074**

Source: DHW ANBT

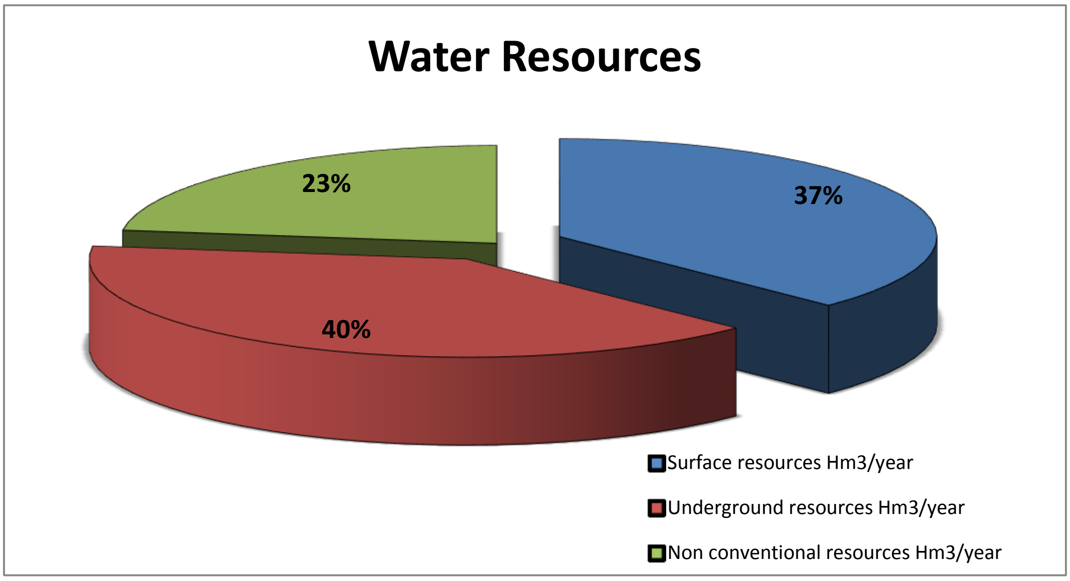


Figure 3.18 Syntheses of Water Resources 2005

3.3.6 Listing of water points

a) Drilling

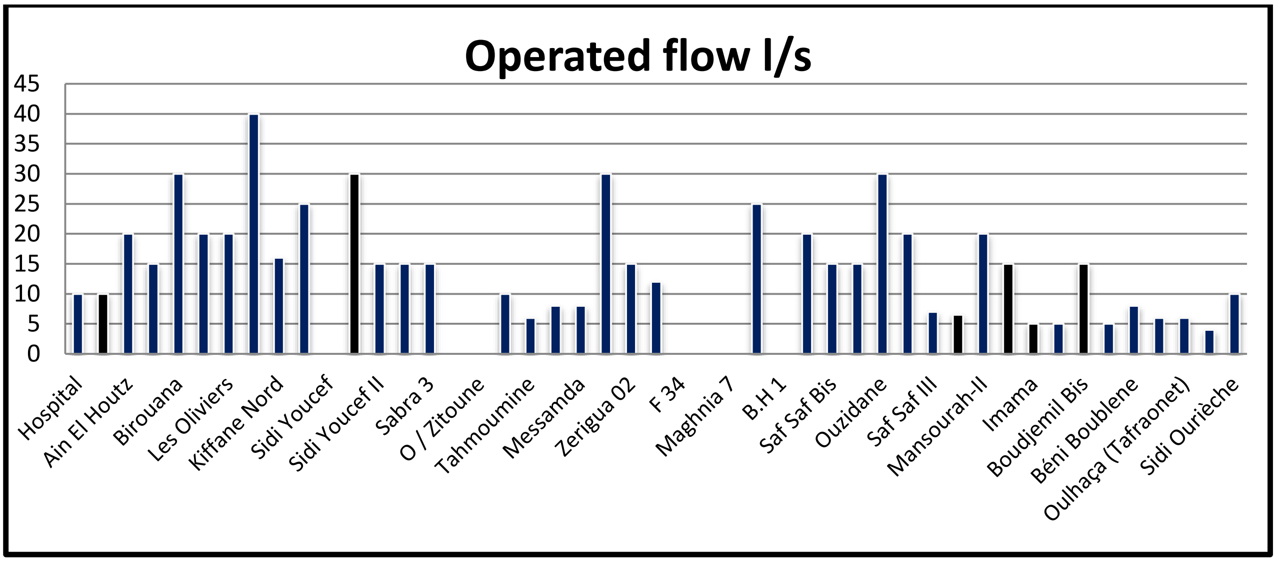


Figure 3.19 Drilling: (47 Drilling 607.5 l / s) 2005

The dark color is for the dry ones, the total flow pumped is 607.5 l/s.

b) Wells

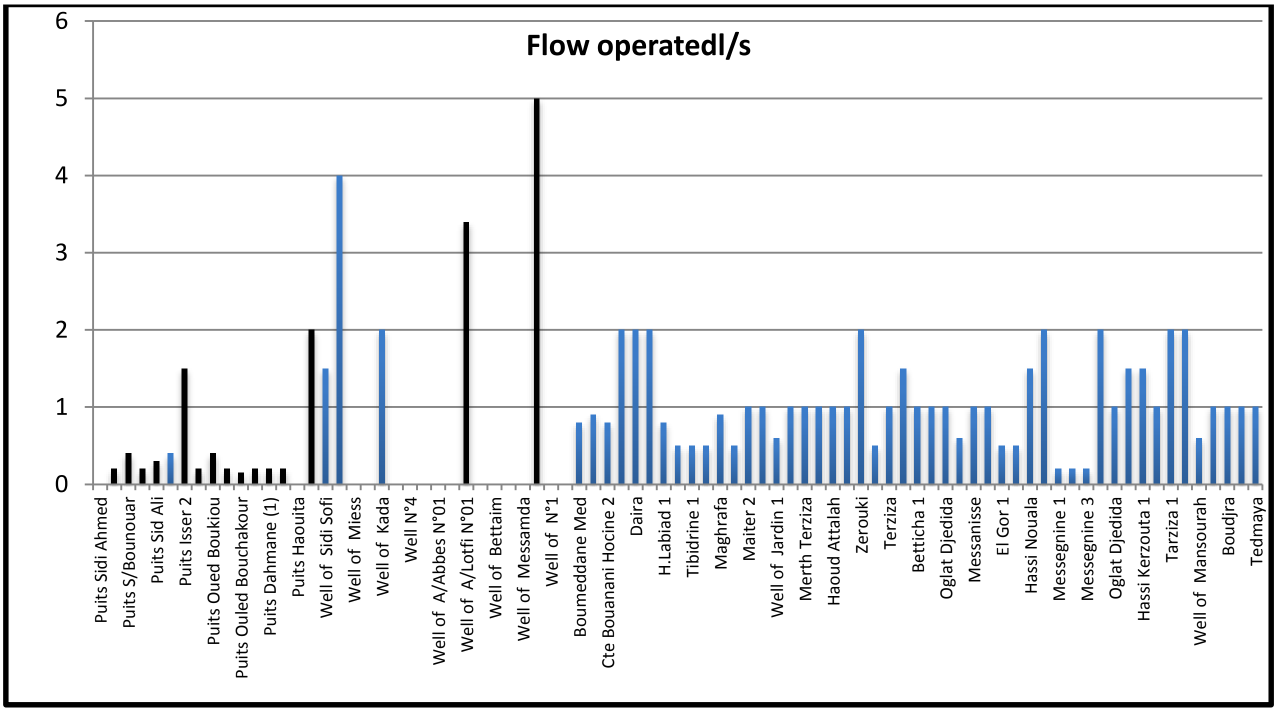


Figure: 3.20 Wells: (83 Wells 70.15 l / s) 2005

There are 83 well 30 are not operated the total flow is 70.5 l/s, the black ones dose not function.

c) Sources

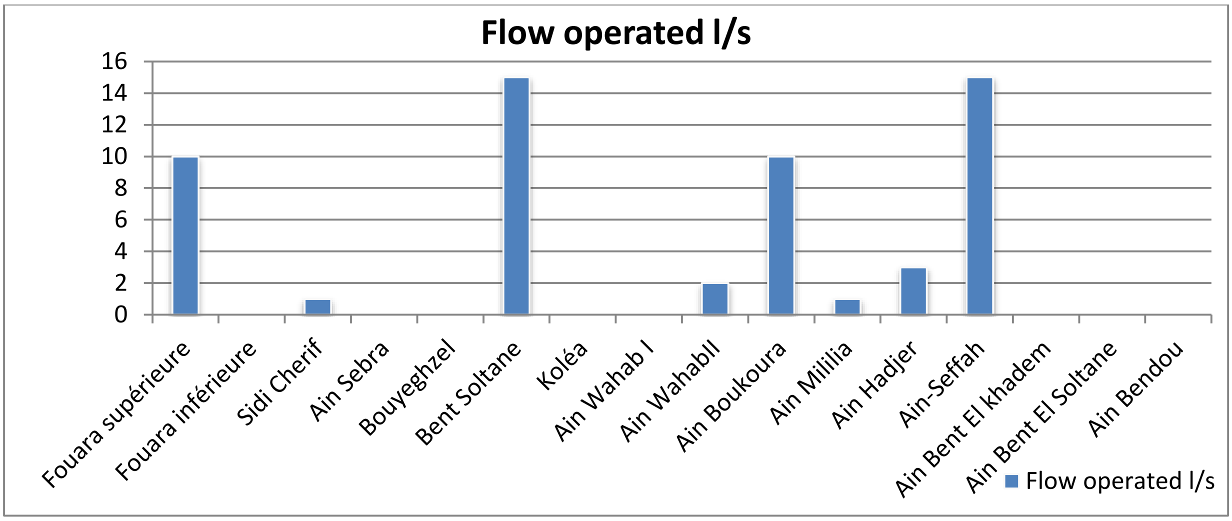


Figure 3.21 Sources: (16 Sources 57 l / s) 2005

There are 16 sources with a flow of 57 l/s.

3.3.7 Conclusion

The Tafna basin is considered the water tower of the Western States (Tlemcen, Oran, Ain Tmouchent and Sidi Bel Abbess) with its five dams (Beni Bahdel - Meffrouch - Sidi Abdelli - Hammam Boughrarra and Sikkak) taking the Tafna and its hydrogeological units (Tlemcen Mountains, Plain Gossels, Traras mountains, Maghnia plain and Tafna valley). Nevertheless, a deficit remains at the levels of domestic, agricultural and industrial users. To reduce this deficit it is planned in addition to the resort to unconventional resources (desalination of seawater) the realization of a new transfer from the waters of Chot Chergui. In fact, the capacities of several hydrogeological units show a sharp drop in piezometric levels and a significant reduction in operating flows. Also, in the context of a more rigorous management policy, we express a special opinion on the quantitative and qualitative protection of this resource. In the face of climate change, the new policy of seawater desalination can be a sure and expensive solution, but a solution that is needed in the face of chronic deficits. The exceptional drought that has raged in recent years across western Algeria calls for more moderation in the exploitation of the underground and superficial resource

3.4Inventory of soil recourses

3.4.1 Introduction

Soil resources are limited, unequally distributed and susceptible to degradation by land misuse, mismanagement and climate change. Climate change, i.e., high atmospheric carbon dioxide concentrations (_400 ppm), along with increasing air temperatures (2–4 _C or greater) that persist for an extended period of time, will significantly affect soil properties and fertility, food quantity and quality, and environmental quality. This is because the atmospheric Carbon (C) Cycle is dynamic and responsive to climate change. In addition, accelerated weathering of the rocks and minerals in soils are exacerbated by high atmospheric CO2 concentrations (_400 ppm), temperatures, intensive rainfalls, heat waves and extended periods of drought. Although weathering has the ability to decrease carbon dioxide concentration (through increasing the inorganic carbon (IC) pool in soils via carbonate mineral formation), it can also disturb the balance between biotic and abiotic C cycles within soils. This disturbance affects the distribution of C into "less stable soil pools; increasing containment mobilization that might significantly alter soil microbial activity, plant productivity, life in soils, and C and elemental cycling [. . .] the as well as elemental balances in rivers, lakes and oceans." (Qafoku, p. 117). Changes in the carbon dioxide concentration in soil affects the organic matter content of soils and soil quality, resulting in soil degradation. Soil degradation reduces the output of agriculture and the efficiency of inputs. In addition, this decline in soil quality might increase land's vulnerability to degradation including "crusting, compaction, accelerated erosion and salinization" (Qafoku, p. 10). Climate change thus leads to soil-related consequences that include "significant/dramatic changes in soil properties, surface water and groundwater quality, food (national) security, water supplies, human health, energy, agriculture, forests, and ecosystems" (Qafoku, p. 114).

In addition to that, research has also shown that climate change causes adverse impacts on humanity and agro-ecosystems and thus food security, as it increases the likelihood of climate-related disasters such as droughts, floods and heat waves. This affects the drying–rewetting cycles of the land, which in turn, directly affects the "microbial nitrogen (N) turnover rates in soil by changing the water content and the oxygen partial pressure” (Qafoku, p. 1). These changes might increase the likelihood of nitrification that will lead to nitrate formation, and depending on the soil type, nitrates might enter groundwater streams and significantly reduce the availability of N pools in soil. The impoverished soil in turn affects food security as it causes a reduction in quality and quantity of crops, thereby lowering the availability of food for the population. Changes in the N content in the soil have the potential to affect soil nutrient levels that get taken up by plants, and this can result in yields having low tissue concentrations of trace elements. This can, in turn, lead populations that rely solely on such crops for nutrients to suffer from micronutrient deficiencies as they lack alternative dietary choices to compensate for the lack of nutrient intake from these crops.

Research has shown that damage to soil is irreversible when beyond a certain threshold, as it is a non-renewable resource. Damaged soil might thus be a more imminent and immediate problem to society than the depletion of fossil fuels, as it not only affects food production but also the emission of greenhouse gases and the quality and quantity of water (Shahid, S.A. 2014). This is because the three systems i.e., land, water and atmospheric conditions, are interconnected and integrated. Thus, it is clear that the soil factor plays a vital role in ensuring food security. However, climate change has also altered the carbon concentration and the nutrients present in soil and this has in turn affected crop production (i.e., quality and quantity), water resources and hence food security (Saidul, I. and Andrea 201, T. W. 2017).

3.4.2 INVENTORY OF SOIL RESOURCES

3.4.2.1 Inventory of Pedagogical Studies

3.4.2.1.1 Soil Categories

On the basis of the criteria adopted by the ANRH (Soil Science Service), soils suitable for irrigation are classified into three categories of irrigated development Category I - Category II and Category III .Soils are considered suitable for hydro - agricultural development on the basis of their physic - chemical properties (depth of soil, porosity, permeability, salinity, drainage, active limestone) as well as various standards recommended by FAO. These norms are based on the nature and intensity of the constraints (geomorphology, topography, climate, etc.), without taking into account the water potential.

There are usually five (05) categories of soils:

a- Category I:

In this category are included

• Deep soils;

• Medium to fine textured soils;

• Well-structured and well drained soils;

• Soils with regular topography and low slope;

These are soils of priority development, presenting no major problem of planning. They are fit for all cultures.

b- Category II:

Soils in this category are usually:

• Deep or medium deep;

• Medium to fine texture;

• Well-structured to medium depth;

• With the possibility of a poorly drained level at medium depth that can cause the formation of a perched groundwater after irrigation;

• A regular topography or weakly wavy, low slope.

These soils are suitable for all crops with restrictions for certain shrubs. They are especially favorable to industrial crops. They present minor problems of development (stone removal or surface remediation).

c- Category III:

This category includes soils:

• Deep or medium deep;

• Medium, fine or very fine texture;

• Well-structured to medium depth;

• Soils that may have salinity or hydromorphy characteristics (with the presence of a groundwater at a depth of one meter);

• Soils with regular topography or moderately wavy, the slope can go up to 05%.

These soils are reserved for crops rotation. The essential landscaping problems are drainage after irrigation, and desalting.

d- Category IV:

Soils of this category are:

• Variable depth;

• Coarse to very fine textures;

• Their structure may be unfavorable;

• Their load in important inclusions;

• They are sometimes salty or hydromorphic with the presence of a shallow aquifer;

• Regular topography corrugated; the slope can reach 10%.

These are soils that present major development problems such as drainage, desalination, leveling. The cultural suitability of these soils is often reduced to a few cereals, fodder and vegetables. Dry development is advisable.

e- Category V:

This category includes non-irrigable soils for the following reasons:

• Insufficient soil depth;

• Presence of shallow crust;

• Holomorphic and hydromorphic pronounced;

• Slope too steep, rugged terrain;

• Soils occupied by infrastructure (road, construction) dam basin.

3.4.2.2 Areas of Irrigable Soils.

a- Resources in Mapped Soils

Table 3.15 Resources in Mapped Soils

Scale study	Areas (Ha)
1/100 000	0
1/50 000	16 351
1/20 000	33 751
1/10 000	0
TOTAL	**50 102**

Source: ANRH 2001

Studies are usually done at scales 1/20 000 and 1/50 000

b) Inventory Soil Resources

Table 3.16 Inventory Soil Resources

Soils categories	Areas (Ha)
I	5 367
II	8 487
III	13 991
IV	7 292
V	6 404
Total area (Ha)	**41 541**
Irrigable area (I+II+III)(Ha)	**27 845**

INF: ANRH 2001

3.4.2.3Situation of pedological studies in the basin

a- Areas of irrigable soil in the Basin

This table brings together the main information of the inventory of agro-pedological studies carried out by ANRH at different years as well as their distribution by soil categories and by cartographic scales.

Table 3.17 Areas of irrigable soil in the Basin

State		Tlemcen								Total Basin area (Ha)
N°		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Studies		**Maghnia & Extensions**	**Ext. Maghnia perimeter**	**Plain of Zriga**	**Tafna high valley**	**Lower Tafna Isser**	**Plain of Hennaya**	**Plateau of Abdelli**	**Plateau of Abdelli**	
Mapping scales	**1/50 000**	0	0	0	0	0	7 790	8 561	0	16 351
	1/20 000	14 136	1 831	2 070	3 600	7 600	0	0	4514	33 751
Soils categories	**I**	3 351	32	130	0	943	523	0	388	5 367
	II	3 643	189	470	600	2 365	407	0	813	8 487
	III	6 421	164	370	700	2 607	3 385	0	344	13 991
	IV	451	1 346	485	1 520	301	2 520	0	669	7 292
	V	270	100	615	780	1 384	955	0	2 300	6 404
Irrigable soils I+II+III (Ha)		**13 415**	**385**	**970**	**1 300**	**5 915**	**4 315**	**0**	**1 545**	27 845
ANRH implementation		1965	1975	1965	1973	1973	1971	1973	1993	-

The irrigable areas of the Tafna basin, according to ANRH agro-pedological studies, are estimated at 27,845 hectares. (See Map No. 02): Site Plan for Soil Studies.

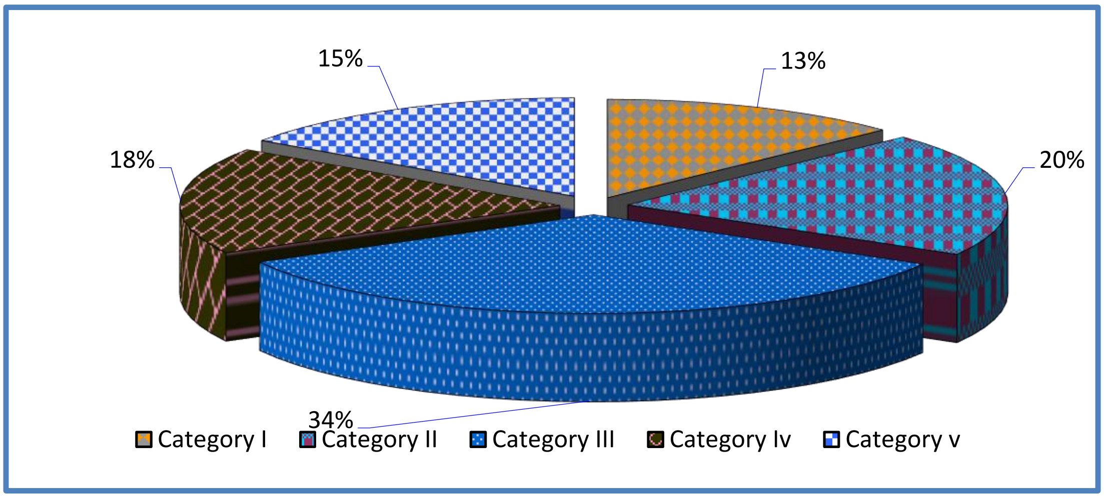


Figure 3.22 Distribution of Area by Soil Categories

3.5 Food resource

The agricultural policies implemented in Algeria in the last three decades have been characterized by a lack of continuity. The 1960s was marked by an experiment in self-management and a policy of partial reconversion of the production system. The 1970s saw heavy-handed institutional involvement by the State in managing the sector and in agrarian reform. The 1980s repaired the damages and tried to ensure the smooth transition toward a market economy. The encouragement of private agriculture, the liberalization of the system and the withdrawal of the State in the context of the structural adjustment program in the early 1990s has nevertheless not succeeded in improving the sector's performance.

General characteristics of agricultural and food development of Algeria

3.5.1 The first years of independence (1963-1966)

In the early years of independence, Algeria inherited an agriculture that accounted for more than 20% of gross domestic product, occupied more than half (55%) of the labor force, and exported more than 1.1 billion of DA annually, which accounted for one-third (33%) of the country's total exports. These exports largely covered food imports (0.7 billion DA per year). The contraction of local demand - following the departure of the European population, which accounted for a quarter (25.3%) of the urban population and concentrated close to 80% of the money income -

as well as the closure of external markets, revealed large agricultural surpluses (wine, citrus fruits, fresh fruits and vegetables, barley, sheep meat). In these first years, agriculture ensured the financing of part of the imports, relayed from 1967 onwards by hydrocarbons. The so-called self-managed public sector, organized on about 3 million hectares of former colonial lands recovered by the State, provided at that time 75% of the gross agricultural production. The private agricultural sector, made up of more than 600,000 farms, provided the rest.

3.5.2 The industrialization process

Beginning with the implementation of the 1st plan (1967-69) and conducted until the end of the 1970s at a steady pace - more than half of the investments will be devoted to industry - the process of industrialization will transform the data economic and social conditions of Algeria. The desorption of unemployment, particularly strong in rural areas with 65% of unemployed workers, should, according to the development plan adopted, reduce the demographic pressure on the land (more than 2.7 million active in agriculture for less than 7.5 millionHaof UAA in 1960) in order to obtain an increase in yields per active (or cultivated ha) and thereby overall growth in agricultural production. The development model adopted gave the industry a key role in meeting these objectives: providing productivity factors and absorbing the surplus agricultural labor force.

Agricultural intensification induced by intermediate consumption (mainly industrial inputs) was expected to increase production per hectare and to provide food at market prices compatible with the income levels of the population and accumulation goals.

3.5.3 The implementation of economic programs during the last two decades (1970 and 1980)

It has generated much higher employment, income and consumption growth rates than the growth of the agricultural sector. The overall investment of Algeria will increase from 10 billion DA in 1967 to 34 billion DA for the four-year plan (1970-73), then to 110 billion during the third plan (1974-77) and 550 billion for the five-year plan 1984-89. Algeria will spend over the decade 1970-79 more than half of its GDP on accumulation. This high rate of investment will change the employment, income and food consumption situation of the population. During the 1970s, the growth rate of non-agricultural employment was around 8% on an annual average. The employed labor force will increase from 1.7 million in 1966 to 2.5 million in 1977, 4 million in 1988 and 4.3 million in 1990. Household monetary resources, available for consumption and savings, increased from DA 15.5 billion in 1969 to DA 181 billion in 1988. Expenditure on food consumption accounted for more than half of the budget. Households (55.7% in 1979-80 and 54.5% according to the 1988 consumer survey). The consumption of agricultural and food products has evolved as follows:

Table 3.18 Food consumption (consumption surveys) U = kg / per / year

	1967-1968	1979-1980	1988
Cereals	217	186	210
Dried vegetables	3.4	5.8	5.8
Sugar	14	16	22.1
Red meat	9	11.5	11.5
White meat	0.6	4.5	10.8
Eggs	0.5	1.1	3
Fish	1.3	2.2	3.4
Fresh vegetables	59.5	90.2	11.2
Potatoes	22	34.5	41.2
Fruits	28	33	34.2
Milk and it derivatives	34	65	78.4
Oils	8	15	15.5

The rate of natural increase of the population remained very high throughout the period 1967-87. Slightly above 3.2% / year during the 1970s, this rate declined significantly to 2.8% / year in the second half of the 1980s. The Algerian population estimated at 13.5 million inhabitants in 1970 amounted to 23.7 million in 1988 (+ 76%). Urbanization has had a significant influence on the development of food consumption (reduction of self-consumed production). The urbanization rate estimated at 31% in 1966 rose to 50% in 1987. More than 300 rural agglomerations gained urban functions between 1966 and 1989. 4. In the face of this overhaul of the Algerian economy and society, agriculture is undergoing major transformations. The agricultural productive potential and its evolution. The low area of arable land, a structure marked by unfavorable agro-pedological skills, excessive fallow, low irrigation and water mobilization rates appear to be the main features of the country's agricultural productive potential. Per capita UAA has fallen by 60% in thirty years. In 1990, Algeria had only 0.30 Ha of UAA per capita (compared with 0.73Ha in 1962), slightly lower than Morocco (0.35 ha) and Tunisia (0.63 ha). Beyond this ratio, it is necessary to emphasize the poor structure of this productive potential. Agricultural areas with favorable natural potential cover only 1.4 million ha, or barely 1/5 of the UAA.

A little less than a quarter of the land (2 million ha) has a rainfall greater than 450 mm and 40 to 50% of land depending on the year (dry or wet) are left fallow (bare and / or full). In arable areas (high plains), water is the main limiting factor. Insufficient natural resources and low agro-pastoral skills have not been offset by a process of agricultural intensification, accelerated development and / or increased soil irrigation rates. Irrigation covers 3 to 4% of the UAA (280 000 to 300 000 ha). Land amendment or development policies do not cover the loss of agricultural land resulting from urbanization and non-agricultural uses or various forms of erosion and land degradation (30 to 40 000 Ha / year). The investment effort made during the last two decades (1970-80) in the order of 2 billion DA annual averages has not allowed the enlarged reproduction of fixed agricultural capital (buildings and agricultural infrastructure, plantations, irrigation and drainage networks, livestock ...).

3.6 Crops

Climate change has also increased the frequency of climate-related disasters such as floods and droughts. Both have direct adverse impacts on crop production and food security. Global temperature rise has resulted in floods due to increasing sea levels caused by the melting of glaciers and the expansion of oceans. Sea-level rise (SLR) affects food security and food production as the rise in sea level can lead to increased flooding and saltwater intrusion into soil, groundwater and freshwater bodies. SLR can result in crop failure when the crops become submerged by the floodwaters that prevent aeration of the soil. Saltwater intrusion can also result in salinization and water-logging which causes land degradation, thereby making affected land unsuitable for the cultivation of crops.

It has been discovered that an SLR of 1.5 m in Bangladesh may flood about 16% of the country's land area and make it unsuitable for rice production. Droughts, many of which are caused by climate change, can result in crop failure as the lack of water available for agricultural production causes crops to die. This is evident in the significant drop in crop yields, i.e., maize yields in Italy and France dropped 36% and 30% respectively, during the severe heat season in Europe in 2003 (Farmar-Bowers**,** p. 225).

Droughts also affect soil quality, as they can lead to a decline in plant-available water capacity, making the land unsuitable for crop production. In addition, the rise in global temperatures caused by climate change might result in an increase in the growth of weeds and consequent use of pesticides. With rising temperatures, crops are faced with more intense attacks from pests and are more susceptible to diseases that threaten to wipe out the harvest. This is because rising temperatures generally create more optimal conditions for disease-causing organisms and pests, which will have adverse effects on crop growth, as these factors affect the quality and quantity of crops. It has been postulated by researchers from the Indian Agricultural Research Institute that there would be a "loss of 4–5 million tons in wheat production with every 1 _C rise in temperature throughout the growing period" (Qafoku, p. 219). Climate change thus affects food security, as increasing temperatures and conditions detrimental to crop production affect the quality and quantity of crops.

Another effect of climate change affecting crop production is change in atmospheric conditions such as the rise in GHGs—rising carbon dioxide levels. It has been postulated that carbon dioxide concentrations will rise from current atmospheric levels of about 385 ppm to about 500–1000 ppm by 2100 [30]. Elevated levels of atmospheric carbon dioxide are said by some to be beneficial to the physiology, growth and chemistry of the plant. It has been postulated that "a twofold increase in
CO2 will lead to a 10–15% increase in dry matter production provided that all other factors remain constant (Qafoku, p. 363). This is because increased carbon dioxide

allows for an increased rate of photosynthesis, thus allowing for an increased production of products (e.g., water, glucose and oxygen). However, it is important to note that the benefits of increased carbon dioxide levels, as mentioned earlier, are only possible if they are independent of any effects of climate change, i.e., rising global temperature and changes to nitrogen content in soil. Researchers at Stanford University have discovered that elevated concentrations of carbon dioxide in the presence of other effects of climate change will instead lead to a reduction in plant growth and nutrients.

Nitrogen changes in soil coupled with increased atmospheric carbon dioxide have the effect of making changes in plant tissue nitrogen and this can in turn affect the protein concentrations of plants.

There is a lack of surface area for crops to take up other nutrients and minerals, as elevated levels of carbon dioxide encourage higher levels of photosynthetic activity that leads to the formation of more nonstructural carbohydrates. This in turn takes up the space needed for the uptake of other minerals and nutrients such as calcium, magnesium, and nitrogen and phosphorous. Furthermore, rising global temperatures can cause heat injury and physiological disorders in crops, thus affecting the quality and quantity of crops produced. Climate change consequences affect carbon dioxide levels, as seen with the increased nitrogen concentrations in soils and rising global temperatures. It is evident that the effects of rising carbon dioxide levels are in fact detrimental to crop production. Crops are also adversely affected by climate change due to the altered weather conditions and seasons (due to increased global mean temperature) required to grow specific crops, e.g., growing of rice during the monsoon period. However, there are two sides of the effects of climate change on crop production. First, climate change can reduce the growing period of crops thereby allowing for more production cycles which in turn increases production output. Climate change can also reduce crop rotation period and enable more crops to be produced in a year. However, one of the downsides of climate change on crop production is that though there may be increased output due to reduced crop rotation periods, the increase in output might not be from crops that are of greater demand.

This is because some crops, especially rice, a source of staple in most Asian countries, require specific growing conditions.

3.7 The place of agriculture in GDP and employment

The share of agriculture in the creation of national wealth has fallen to less than 10%. During the 1980-89 decade, agricultural value added represented, in constant terms, 7 to 8% of GDP per year. Its place in the active population occupied in 1989 is only 23% (975 113 occupied in agriculture out of nearly 4.2 million) with a quasi-stagnation of agricultural employment between 1985 and 1990). 5. The growth rate of production (in physical terms) over the past decade, this rate has been around 5% for all agricultural products. However, we must note a differentiated growth according to the branches (plant and animal) and within the branches (between the production of staples: cereals, pulses, and milk and commercial productions: vegetables and fresh fruits, meat, fodder, eggs ...). While gross crop production accounted for an average of 70-75% of agricultural gross output during the 1960s, in 1989 crop production accounted for 49% of the gross farm value.

For cereals, production stagnated over the entire period 1967-1990.

Table 3.19 Cereal production - annual average U = 106 T

1967-1969	1970-1973	1974-1977	1980-1984	1985-1989	1990-1991
1,86	1,93	1,89	1,63	1,16	1,63

Source: National Office of Statistics (ONS) Average wheat production has declined as a result of severe drought in the last decade (1981, 1984, 1987, and 1989).

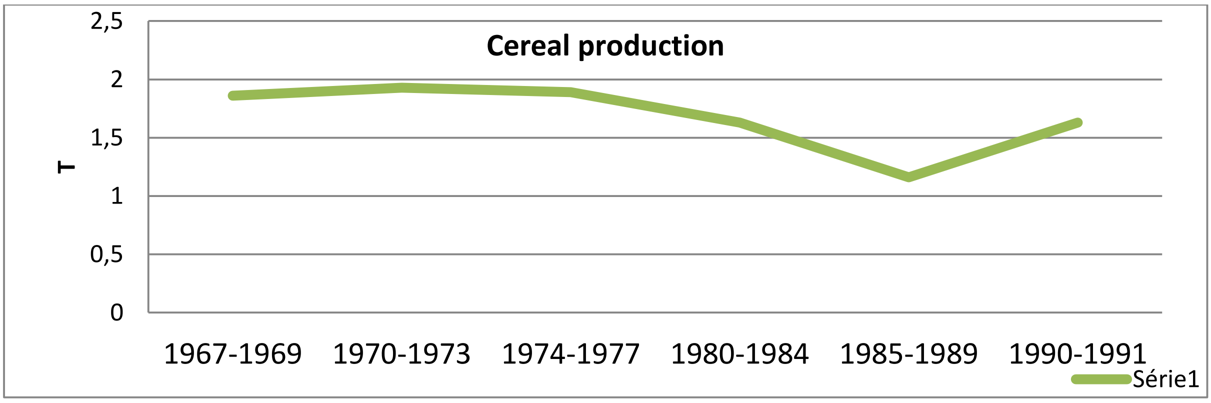


Figure 3.23 Cereal production - annual average U = 106 T

Table 3.20 Wheat production (1960-1990) U = 106 T

Annual Average for Wheat Production	1960-1969	1970-1979	1980-1988	1990-1991
	1,28	1,31	1,12	0,77

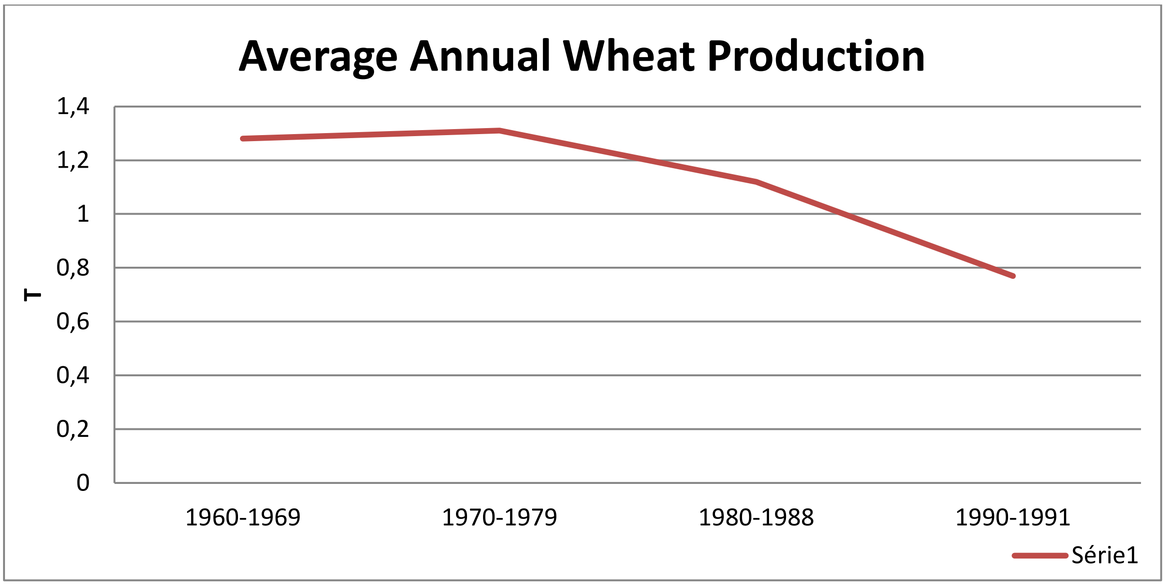


Figure 3.24 Average Annual Wheat Production- Source: ONS

- For pulses, the statistics show a very rapid decline in these productions. The coverage of consumption by domestic production rose from 60% during the period 1974-77 to 25% for the period 1985-89.
- Local milk production only covers 30% of consumption needs in 1985-89, compared with 70% in the early 1970s. The integration rate of local milk in the dairy industry's production, which was more than 72% in 1970, only 4% in 1990.
- Oleaginous productions, which represented 1500 T in 1970-74 and 1140 T in 1978-83, disappeared from the nomenclature of Algerian statistics, as the introduction and development experiments for sunflower, rapeseed and safflower were discontinued. The same is true for sugar beet and cotton crops.

Market developments have favored the cultivation of fresh vegetables and fruits (other than citrus fruits) as well as animal productions (meat and eggs).

Between the first plan (1967-69) and the fifth plan (1984-89), market garden areas were multiplied by 2.5. Production has risen from 741 178 T / yr in 1970-73 to 2.5 million T in annual average over the period 1984-89.

- Fruit production (pips and kernel) rose from 0.8 million tons during the first plan (1967-69) to 1.1 million tons in 1974-77 and oscillated around 2 million tons (or an annual growth rate of 9%) during the last five-year plan (1984-89). On the other hand, citrus yields decreased by 67%, from an annual average of 441 000 T over the 1967-69 period to an annual average of 263 000 T during the last five-year plan (1985-89).
- Forage production increased from an average of 0.35 million T in 1970-73 to 0.66 million T over the period 1978-83, reaching an average of nearly 1 million T over the period 1985-1989.
- The production of red meat increased 2.7 times between 1978 (76 000 T) and 1985-89 (205 000 T). That of white meat has been multiplied by 8.5 between 1968 (24 000 T) and 1990 (200 000 T), i.e. almost half of the total meat produced.
- Finally, consumption eggs increased from 12 000 T in 1973 to 125 000 T in 1990.

Another refined analysis, which distinguishes the evolution of production according to the legal sectors (public and private), clearly shows that it is in the private sector that the growth of commercial crops (fresh fruits and vegetables, red meats, eggs) was the strongest. The reconversions in favor of market garden crops, fruit, fodder and animal production are much accentuated within the private sector.

Table 3.21 Changes in Private Sector Production Structure Between 1980 and 1986 U = 103 ha

	1980	1986	Changing
Wheat	1098	858	-22
Barley	650	936	44
Dried vegetables	38	68	79
Fodder	94	331	252
Vegetables	134	201	50
Arboriculture	35	58	66
Dates	55	68	24
Olives	119	127	7
Figs	35	35	0
Citrus fruits	4	4	0
Vine productive	25	21	-16
Total	2287	2707	18

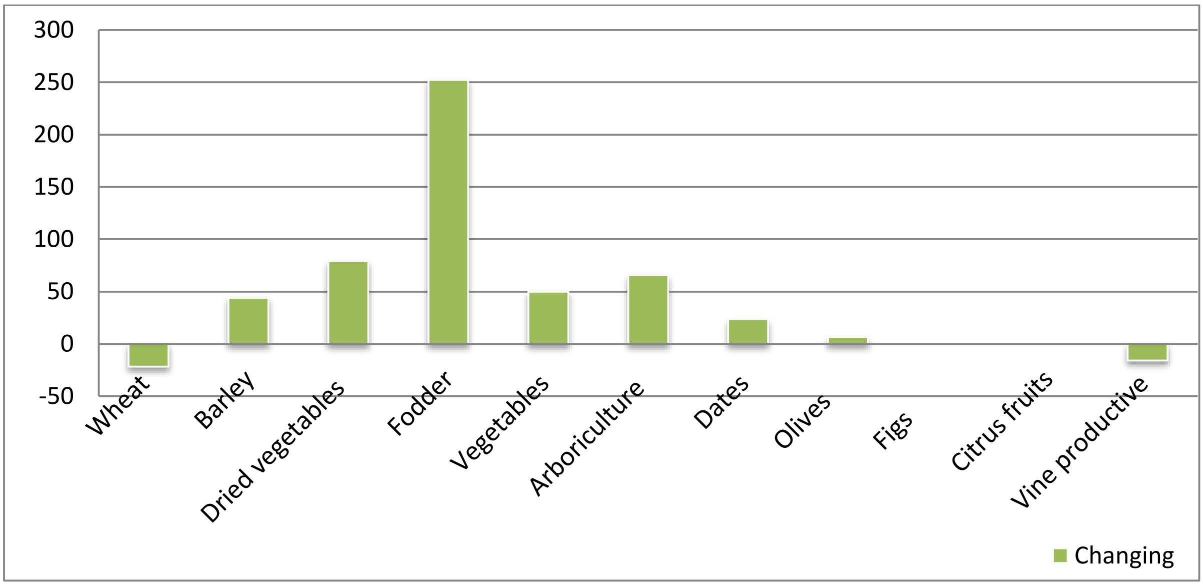


Figure 3.25Changes in Private Sector Production Structure Between 1980 and 1986 U = 103 ha

The relative price structure, favorable to these productions, has guided the production systems of the private sector. The ratio of cereals to meat remains largely favorable for meat (1/20).

3.8 Productive consumption in the agricultural sector increased sharply during this period

Fertilizer consumption increased from 40 000 tons of fertilizer in 1962 to 170 000 tones in 1980. In the last decade, consumption has continued to rise from 400 000 tons of fertilizer in 1980 to 606 000 T in 1986, before falling during the last 3 seasons (364 000 T in 1989) because of the significant increase in prices practiced by the fertilizer manufacturing and marketing company.

The tractor fleet increased from 25,122 units in 1973 to 60,000 units in 1984 and 82,120 units in 1989. This development also affected the combine farm which increased from less than 4,000 units in the early 1970s to almost Algeria has, compared to other Maghreb countries, the most favorable ratios in the consumption of inputs and equipment (Table 5).

Table 3.22 Comparative use of inputs and equipment (1984-85)

	Algeria	Tunisia	Morocco
Use of seasonal inputs (kg / ha)			
Use of certified cereal seed	28,3	16,5	14,8
Use of fertilizer	54,6	17,2	51,3
Mechanization, number of Ha cultivated by:			
Tractor	87	166	324
Plow and other equipment	40	94	N.D
Combine harvester (ha / machine)	503	905	N.D
Fertilizer spreaders	1203	1382	N.D
Seeders	803	1146	N.D
Sprayers	402	1175	N.D

Source: World Bank

This increase is explained by the fact that producers have benefited from the relative prices of equipment over the last few years (1974-84), with mechanization favoring lower crop costs. It can be seen that the growth rates of productive consumption of agriculture in industrial goods increased much more rapidly than the production capacity of domestic industries. Today, the use of imported inputs conditions the reproduction of the agricultural productive sector, particularly for fruit, vegetables and poultry products.

Table 3.23 Trends in Imports of Agricultural Factors (1963-90)

	1963	1973	1983	1988	1990
106 DA	200	700	1500	3300	2800
106 $ U.S	----	180	312	558	329

Source: National Institute of Studies and Global Strategy (INESG) and ONS

The import coverage rate for the main factors of production (livestock and agricultural factors of production) are respectively 90% for poultry products, 100% for phytosanitary products, 100% for veterinary products, 60 % for seeds of potatoes, 98% for vegetable seeds.

The input subsidy system, in effect during the period 1974-84, as well as the implementation of special plans of the Ministry of Agriculture (fruit plantations, intensification of cereals, potatoes, plastic culture, poultry plan, special programs of Villages and States...) was factors that encouraged farms to increase input consumption.

While the evolution of final agricultural production shows significant increases for some productions, the use of additional production factors did not lead to significant progress in yields. The latter, for the main crops, showed a tendency towards stagnation or decline throughout the 1967-89 periods.

Table 3.24 Evolution of yields per type of crop (1967-87)

Products	Growth rate in% per year
Cereals	0
Citrus fruits	2,2
Forages	3,2
Olives	3,1
Vegetables	0,9
Other fruits	3,3
legumes	2
Vineyards	5,5

Source: World Bank

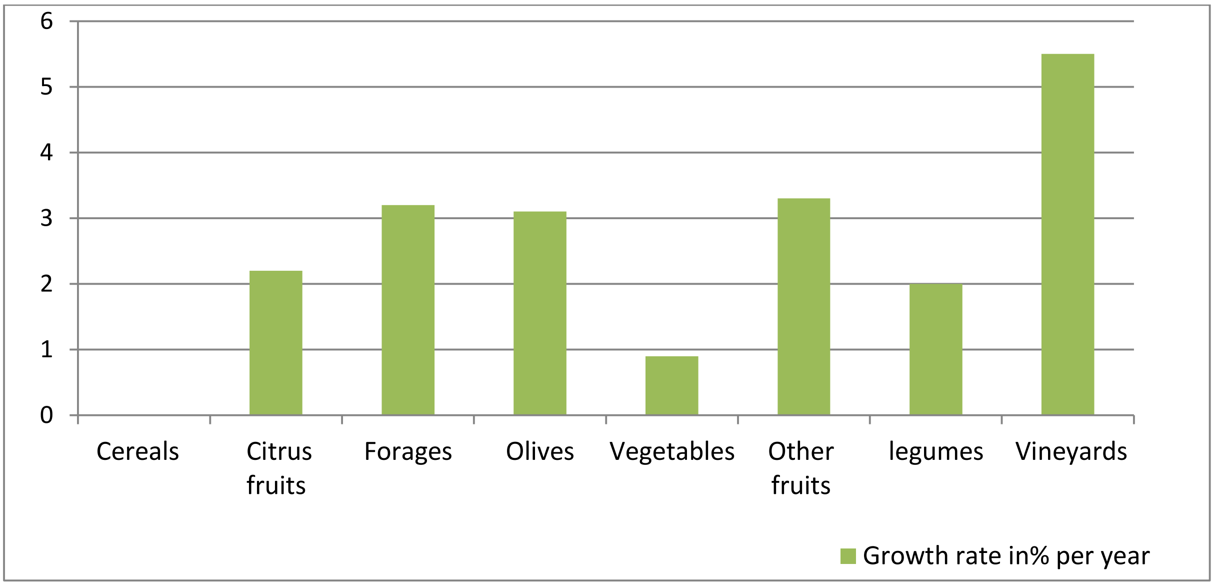


Figure 3.26Evolution of yields per type of crop (1967-87) Growth rate in% per year

3.9 The performance of final output was too low in view of the rapidly growing consumption needs of the population

As a result, the use of agricultural and food imports, which began at high levels in the mid-1970s, has become the main instrument for managing consumption and the national food ration. Food imports increased from an annual average of 0.8 billion DA during the 2nd plan (1970-73) to 3.8 billion DA during the 3rd plan (1974-77) to reach 7.8 billion DA during the first five-year period (1980-84) and 10.3 billion current DA annual average in 1985-89. In 1989, they accounted for approximately 25% of Algeria's imports (compared to 11% at the beginning of the 1970s). At the same time, agricultural exports fell by half in absolute value between the period 1970-73 and 1980-84, and amounted to only 183 million DA annual averages.

Table 3.25 Cost of food imports by commodity (at current prices)

	1967-1968	1979-1980	1988
Cereals	217	186	210
Fresh vegetables	59,5	90.2	11.2
Milk and it derivatives	34	65	78.4
Fruits	28	33	34.2
Potatoes	22	34.5	41.2
Sugar	14	16	22.1
Red meat	9	11.5	11.5
Oils	8	15	15.5
Dried vegetables	3,4	5.8	5.8
Fish	1,3	2.2	3.4
White meat	0,6	4.5	10.8
Eggs	0,5	1.1	3

Sources: INESG (1963-83); National Council for Agricultural Planning (CNP) (1988-89-90)

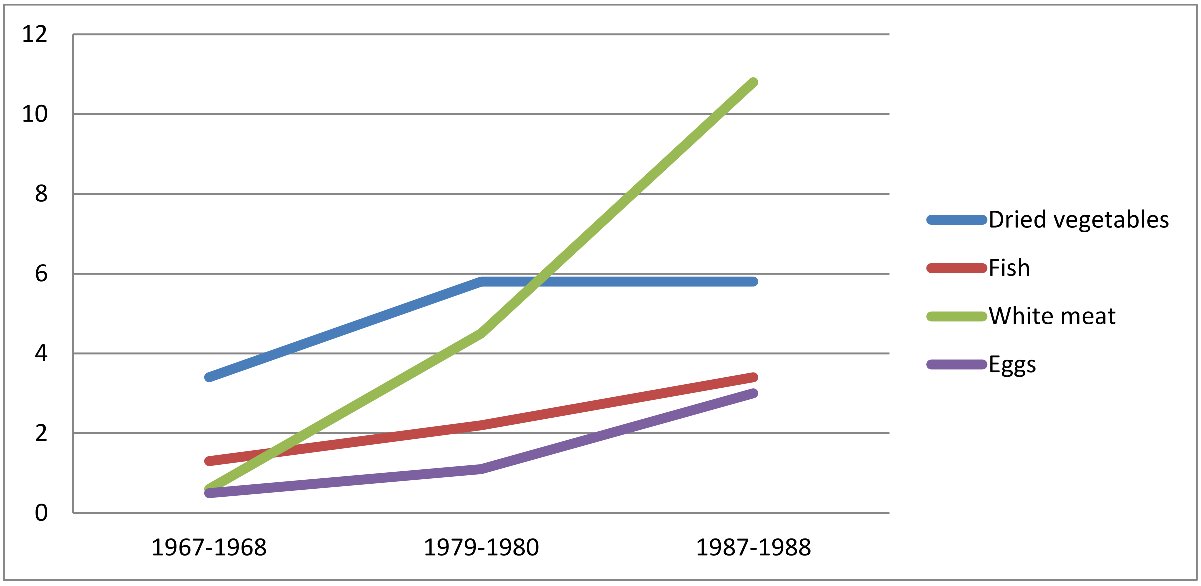


Figure 3.27Evolution of producer price indices of major products (1980 = 100)

Growth rate in% per year

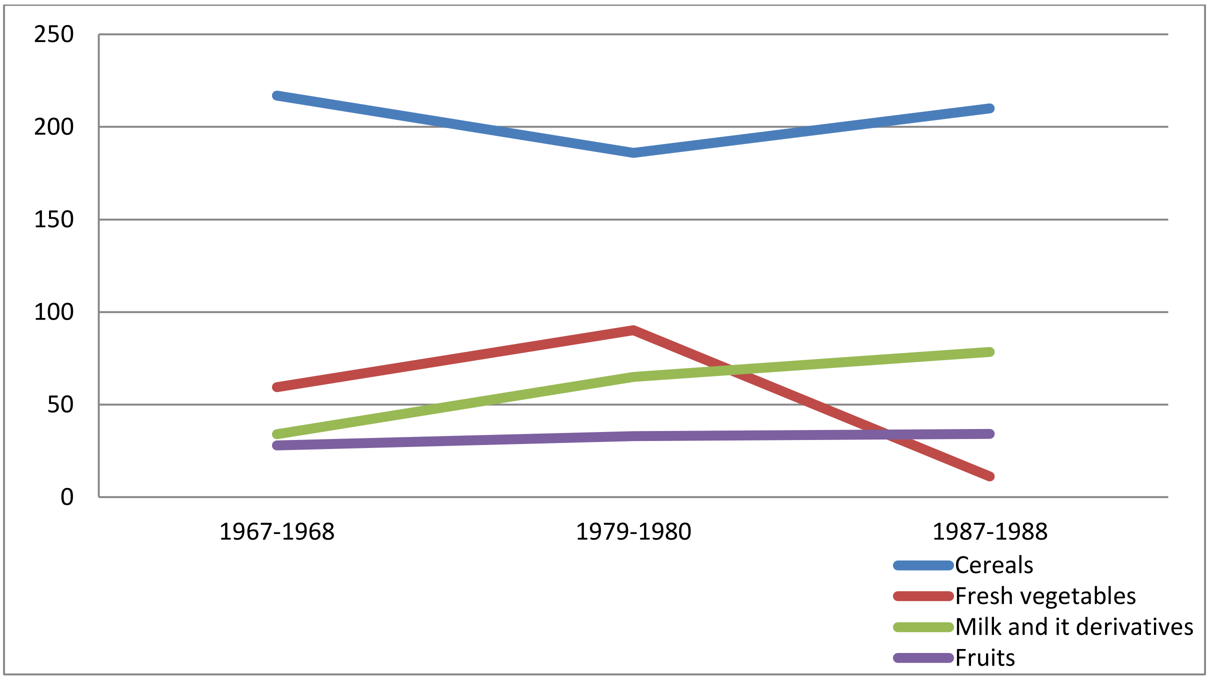


Figure 3.28 Food consumption (consumption surveys) U = kg / per / year (1967-1988)

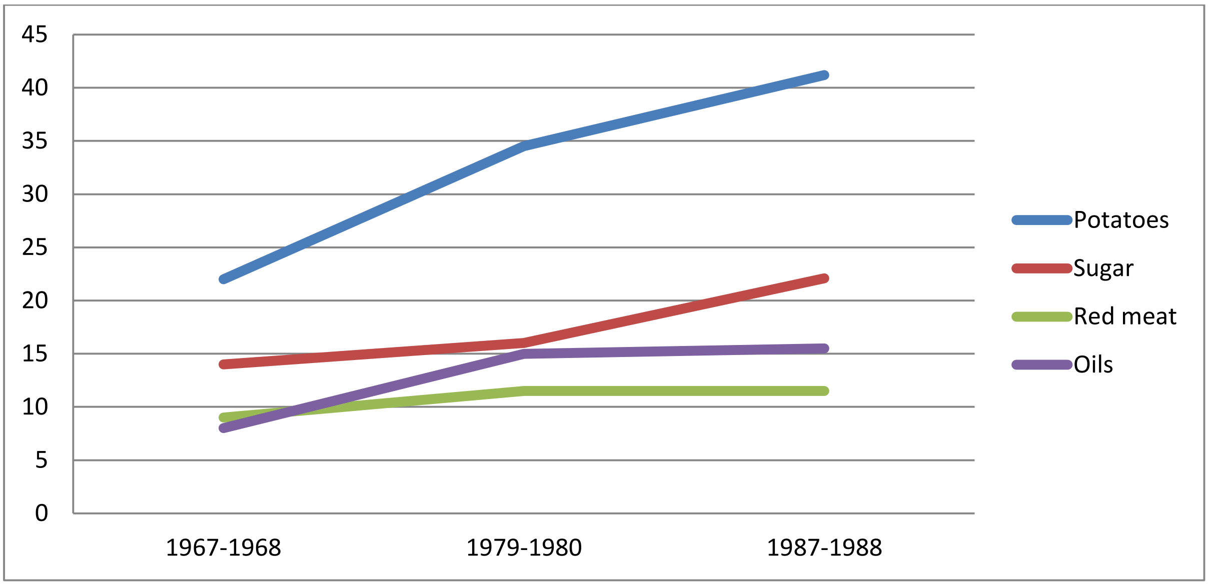


Figure 3.29 Food consumption (consumption surveys) U = kg / per / year (1967-1988)

Food self-sufficiency rates have deteriorated sharply for wheat and milk products, particularly during the 1980-89 decade.

Table 3.26 Food self-sufficiency rate (wheat and milk) 1966-89 U = 103 T

	Milk and Products related to				Wheat Products			
	1966–1970	1976-1979	1980-1984	1985-1989	1966-1970	1976-1979	1980-1984	1985-1989
Domestic production (A)	485	695	713	826	1238	1226	1075	1184
Imports (B)	205	587	1696	2168	558	2186	2270	4083
Availability (C) = A + B	690	1282	2409	2994	1796	3412	3345	5267
Self-sufficiency rate A / C %	70	54	28	28	70	36	32	22

Source: ONS

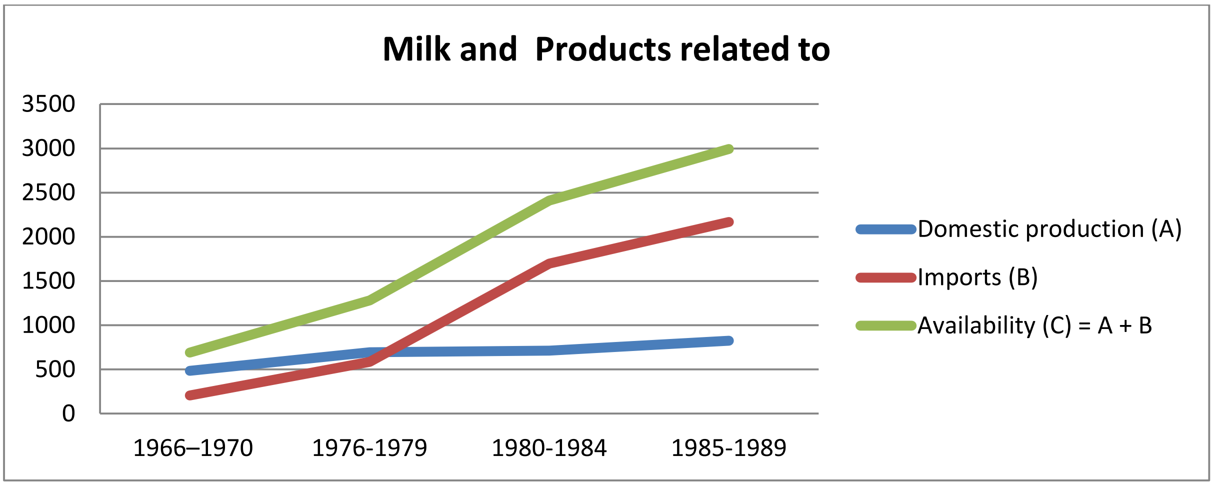


Figure 3.30 Food self-sufficiency rate (milk) 1966-89 U = 103 T

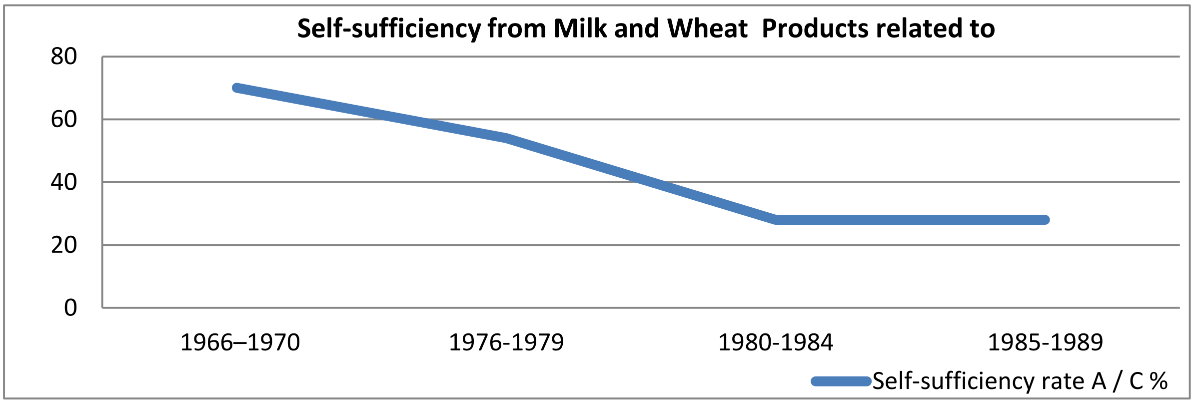


Figure 3.31 Food self-sufficiency rate (milk) 1966-89 U = 103 T

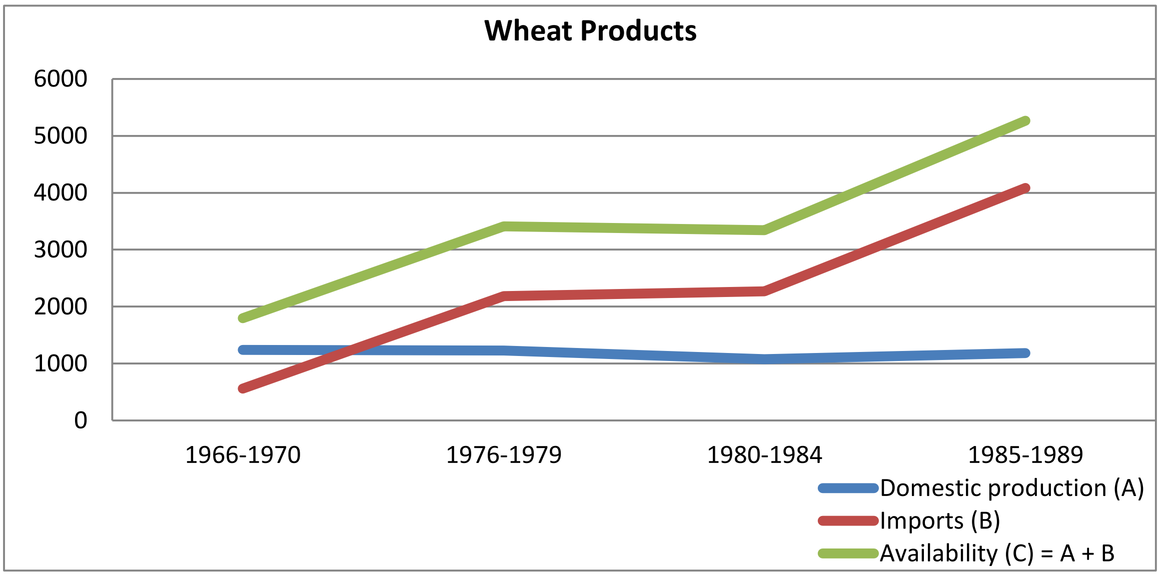


Figure 3.32 Food self-sufficiency rate (wheat) 1966-89 U = 103 T

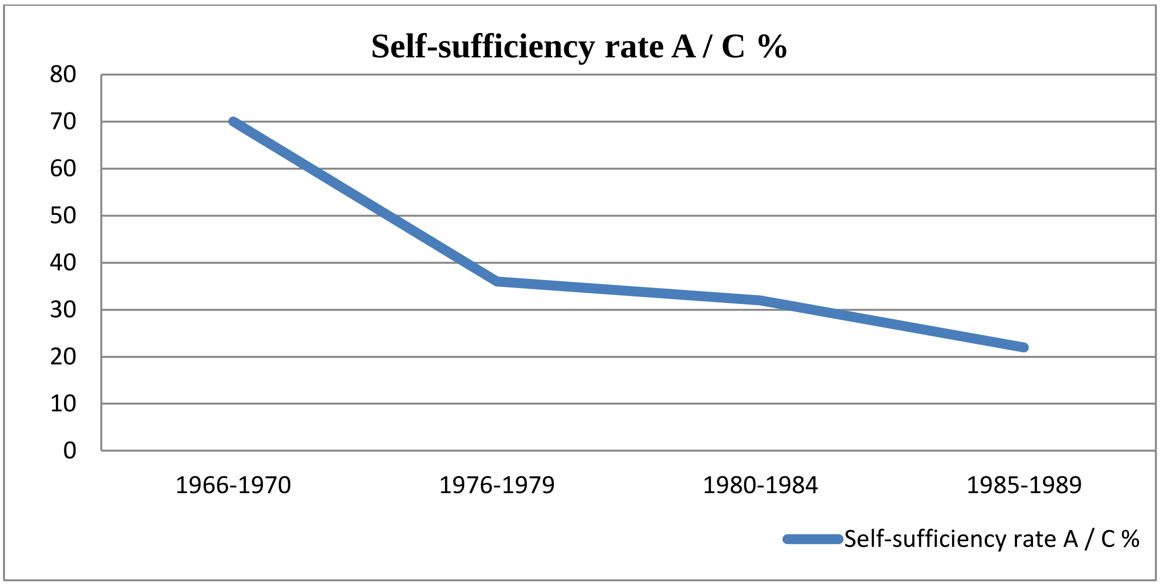


Figure 3.33Food self-sufficiency rate (wheat) 1966-89 U = 103 T

3.10 The local agro-food sector has been very closely linked to the performance of imports

Wheat collected by the cereals board (OAIC) peaks around 0.6-0.7 million T. The capacity of storage of agencies responsible for the regulation of the cereals sector and those of the crushing units of wheat (ERIAD) amount to 3.3 million T. The milk boards processed an average of 765 million liters of milk during the period 1984-88; local milk collected represents only 54.7 million liters, an integration rate of 7%. Local milk collection by the milk boards represented only 5% of marketing in 1990. The national sugar company has been permanently integrated into foreign markets since 1983 with the abandonment of the sugar beet business in Algeria. It is the massive imports of brown sugar that condition the operation of the factories of the sector. The same characteristic can be observed for the edible oil industry, which lost its agricultural segment in the first half of the 1970s and now imports crude oils for refining, local oilseed crushing and / or imported having been considered as a deficit for the company.

The operation of the agri-food production apparatus (IAA) is heavily dependent on imports (85% for crushing cereals, 100% for refining sugars and oils, 75% for animal feed production) (85% for tobacco, 100% for matches).

3.11 In order to protect the purchasing power of the population, consumer prices for staple foods were dissociated from producer prices and a price support fund was institutionalized in the 1970s

Of a relatively modest amount, due to the fall in prices recorded on the international markets in the 1980s and favorable exchange rate policies for the local currency, as of 1988 the amounts are brought to levels that weigh very strongly on the budget resources of the state.

Table 3.27 Compensation funds for support and subsidize price of production and consumption (1980-90) U = 106 current DA

Years	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Milk ($DA/10^3$ L)	2334	2 224	4 294	2 202	2202	2202	2202	1000	4000	14000	24000
Million US dollars	614	517	933	459	440	440	469	208	677	1840	2824

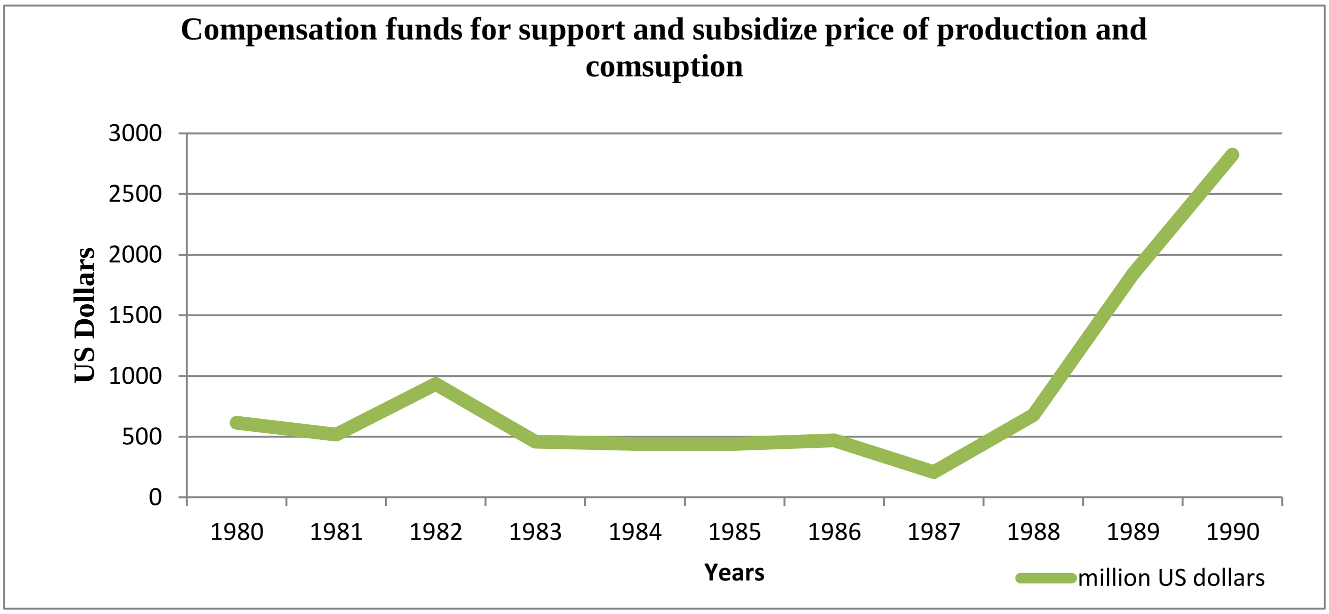


Figure 3.34 Compensation funds for support and subsidize price of production and consumption (1980-90) U = 106 current DA - Source: Finance Law

Subsidies amounting to less than 5% of GDP in 1989 would have been close to 6% of GDP in 1990. In fact, from the end of the 1970s, agriculture benefited from a continuous rise in market prices for agricultural products and price support for agricultural production.

Table 3.28 Evolution of producer price indices of major products (1980 = 100)

	1981	1985	1987	1990	Price 1980 DA/T
Milk (DA/10^3 L)	101	167	222	389	1800
Durum wheat	100	160	216	400	1250
Wheat	100	165	176	287	1150
Dried vegetables	100	143	167	300	3000

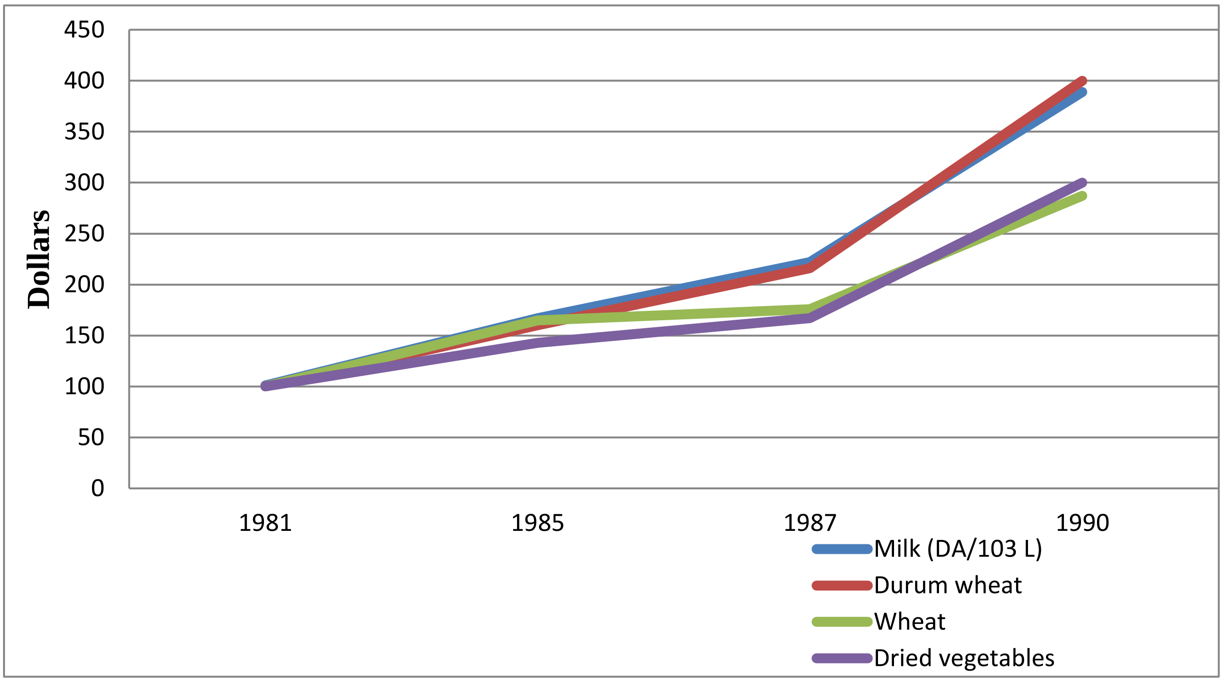


Figure 3.35Evolution of producer price indices of major products (1980 = 100) (Lentils, chickpeas, beans) - Source: Ministry of Agriculture

Transfers, via market prices or the compensation fund, made it possible to equip farms at lower cost during the 1970s and 1980s. This mechanization, however, did not have a decisive influence on agricultural productivity, yields and cultivation methods; the tools have not been accompanied by an improvement of technical supervision, routes and land structures. Revenues captured through this sector support policy have led to an improvement in the living standards of agricultural populations. This allowed a stabilization of agricultural assets in the sector and thus curbed the agricultural exodus to the cities. The best-fit farmers (especially those producing meat, fruits and vegetables), and the best-equipped farmers, benefited from substantial rents in the period 1970-1980 (over DA 45 billion according to the National Planning Council CNP), linked to a permanent imbalance of supply, compared to solvent demand. Also, the question of the productivity of the factors of production has been the main obstacle to agricultural development.

3.12 The process of agricultural reforms: steps, achievements, constraints

3.12.1 Economic reforms have introduced considerable changes in the structures and functioning of the agricultural sector

Indeed, to a state interventionist and interventionist policy - which extended to the day-to-day management of public agricultural holdings, cooperatives, offices and institutions of supply, financing and marketing - The market is gradually being replaced by the groups of producers in the farms (collective agricultural holding: EAC), farmers organized into autonomous cooperatives, managers of banks, offices, interest groups and agricultural chambers.

Since the beginning of the 1980s, market mechanisms and incentives have been used to free productive activities in the agricultural sector. The freedom of marketing regime and the freedom of prices for fruit and vegetables have been working for a decade.

The import of agricultural and food products (wheat, barley, cattle feed, selected cows, sheep flocks, etc.) to supply the market, as well as the control exercised over agricultural financing, were also privileged instruments of agricultural policy of State.

New guidelines applied in the first half of the 1980s correct discriminatory practices in the allocation of resources and capital goods to the private sector and relax the intervention mechanisms of this sector (freedom of transaction on land, access to ownership through development, freedom of creation of agricultural service enterprises, access to inputs including agricultural equipment and irrigation produced locally or imported ...).

A new input price policy is defined. The price system is gradually adjusted by adjusting it to market rules. The prices of fertilizers and agricultural equipment are released in stages and the subsidies allocated to the importing agencies (National Office of Supply and Agricultural Services-ONAPSA, PMA-EDIMA ...) are reduced. The principle of a price adjustment to the real cost of production guides the new price regime. The changes in input prices and interest rates of the Agricultural Bank for Agricultural Development (BADR) in the direction of the rise are accompanied by corrections in the system of producer prices paid to producers. A new reform of production and support structures for agriculture is adopted during the period 1987-90:

- Law 87-19 of 8/12/87 modifies the management of public lands and transfers the entire non-land assets to the EAC and EAI (individual agricultural holdings) created on the ex DAS (socialist agricultural domains);
- Law 90-25 of 18/11/90 completes the legal edifice and restores the traditional categories that governed the land law (property melk, wakfs, domaniale);
- Law 90-30 of 1/12/90 on the national domain introduces the distinction between the private domain of the State and the public domain of the State. The lands of the national domain are now classified in the private domain of the State and governed by the rules of private law (and thus become alienable, transmissible and sizable).

The new status of cooperation defined by decree 88-70 of 13/9/88 attempts to restore the key principles of cooperation (voluntary and voluntary membership of cooperatives, direct and autonomous management ...) and dedicates the withdrawal of state institutions in the conduct and management of the cooperative system created in 1972. The transition to autonomy of banks and public enterprises in the logic of global economic reforms is reflected in the definition of new rules for the management and operation of financing, distribution and marketing organizations. Commercialism and profitability are henceforth at the very heart of the relations maintained with user sectors and farmers. In this new context, the central administration and the decentralized structures have been granted new missions more focused on the technical support to the producers, the incentive to the increase of the agricultural production, the definition of the orientations of the agricultural development and the implementation of any action that may contribute to the achievement of the objectives of agricultural policy. The agronomic research apparatus itself required reorganization in the direction of a refocusing of its activity in accordance with the new concerns. In the same way, the agricultural training apparatus has been redeployed in order to better match the product formed to the theoretical needs of the sector. Finally, an agricultural extension system has been put in place at different levels to ensure the widest dissemination of technical information and to provide the necessary assistance to farmers.

3.12.2 Land structures

A. The application of Law 87-19 of 8/12/87 extended to 3,264 DAS existing in 1987. These employed nearly 138,000 permanent and 200,000 seasonal workers in an area of approximately 2.5 Mha of UAA. More than 28.000 production units occupying 2.3 million Ha have been created, divided into:

- 22 356 collective farms covering an area of 2 232 588 Ha and comprising 156,548 beneficiaries;
- 5 677 individual farms created on 55.969 ha. On the lands of the national estate were also installed 188 pilot farms occupying a total area of 187,799 Ha. These production units, which include 7,813 workers (including 898 managers), are responsible for carrying out the tests, disseminating them in case of success and popularizing the most efficient farming techniques.

B. The Land Guidance Act (Law 90-25 of 18/11/90) restores the legal categories governing the land regime (public lands, melk lands, wakfs lands). It defines the intervention instruments of the State and local authorities in the management of a land market freed from administrative and institutional supervision. Lastly, it organizes the methods of restitution of nationalized lands as part of the agrarian revolution (Ordinance of 8 November 1971). It is this last point that has actually been implemented in the context of the Land Guidance Act. Land litigation involved nearly 24,000 nationalized landowners or land donors between 1971 and 1975. C. The program of access to agricultural land ownership (law 83-18 of 13/8/83) resulted in the allocation of 338,000 Ha distributed to more than 60,000 beneficiaries. A brief review of the implementation of the program highlights the relatively slow pace of achievement (22% of allocated land is actually under cultivation). Within the Saharan areas 70% of the allocated land is concentrated; farmers often use non-renewable water resources and devote plots to cash crops required on the markets at particularly high costs.

3.12.3 The reform of the agricultural environment

A. The marketing

As early as July 1980, the freedom of trade in fruit and vegetables was restored and all the constraints related to the commercial function were lifted on the former agricultural public sector (authorized to freely sell on the market all agricultural products to except cereals and pulses). Supplementary texts were adopted in 1984 and 1990.

The EAC / EAI groups today refer to the market criteria, prices that are fixed to decide investment plans and development, culture plans and equipment. The orientation of production systems is now more regulated by the market. The freedom to market agricultural products (fruits, vegetables, fodder, meat ...) has influenced - via the system of market prices - on the overall volume of production. All studies show a displacement of resources (land, water, capital) in favor of commercial productions largely absorbed by the market. Rising prices influenced the overall volume of production more through a substitution effect than a yield effect. The reform of the marketing system combined with that of the structures (law 87-19 of 8/12/87) completely changed the role and place of the cooperative organizations and the

National Fruit and Vegetable Company (ENAFLA). Between 1987 and 1990, ENAFLA recorded a decline of nearly 60% of its sales volume expressed in physical quantities. ENAFLA's market share for fruit and vegetables is now around 3 to 4%. However, the current marketing system born of agricultural reform (text of July 1980, 1984 and 1990) has slipped into another form of monopoly. It gave birth to a cartel organization that seriously distorts the mechanisms of competition.

B. Supplies of inputs and equipment

The reform of the supply system aimed at improving the quality and quantity of input deliveries for the benefit of producers. The questioning of the monopoly, the transition to the commercialization of state enterprises (National Supply Office-ONAPSA, PMA-EDIMA, ONAB ...) were the main levers of this new procurement policy. The choice of a price truth policy for the purchase of agricultural inputs and equipment, accompanied by a dismantling of the subsidy system and compensation funds allocated to public production companies (SNVI, ASMIDAL, PMA ...) and services (ONAPSA) was the other instrument for implementing the reform.

The cooperative services were reorganized on the basis of the new texts and statutes (Decree 88-170 of 13/9/88).

In less than a year, all the old cooperatives (Agricultural Cooperative Specialized Services and Supply-CASSAP, CASSDEP, COPSEL ...) have been rebuilt. More than 600 cooperatives employing 14,000 workers and serving 450,000 members and users were established during the 1989-90 crop year. However, the establishment of supply co-operatives on the basis of voluntary membership, the mutual interest of the co-operators and the autonomous and democratic management has been compromised by the dirigisme, authoritarian and administrative form of "reconstruction" of the system.

The lack of representativeness has favored the emergence of pressure groups that control most of the activities of cooperatives and divert them from their initial vocation. The reorganization of the supply co-operatives seems to be accompanied by an erosion of the technical supervision and the level of qualification of the personnel. This deskilling translates into a loss of control of supply management systems. Technical acts related to the use of inputs (fertilizers, seeds, PPS) and agricultural extension are therefore absent from the functions of cooperatives.

In terms of management, there is a significant decrease in the level of activities, the volume of investment and the transactions carried out. This decline in activity is linked to several factors, the most important of which are:

- The instability of the collectives of the EAC / EAI whose rights have not been confirmed by the administration as part of the remediation of the land dispute;

- Cash and financing difficulties for farmers;

- Shortages and breaks in supply registered with delivery organizations;

- The excessive rise in prices which has compressed the demand of the farmers.

Also, the financial and material difficulties as well as the absence of managerial frameworks are thus today an obstacle to a redeployment of the cooperative system. The supply system is broken down into several cooperative service organizations.

There is a high degree of specialization in activities that are not always justified by agricultural development, so that operators are forced to increase the cost of approach, purchase and transportation transactions, and the cost of membership in the organizations that provide them specialized services. Some service agencies have diversified their services, bringing their offerings closer to the needs of farmers. However, the versatility of activities (which would be consistent with the trend towards diversification) is not the rule.

The ONAPSA, a public office, has retained most of its prerogatives in the sector. It acts as a privileged partner of CASSAP and private distributors and ensures imports through budget appropriations and external credits made available by state institutions. He is confronted today with a series of constraints that hinder the achievement of his missions.

The fundamental question that remains (and which concerns ONAPSA as well as the other organizations involved in supply chains) is the lack of organization of its partners and professionals by sector. The difficult trade-offs that these organizations are forced to make are a source of conflict with cooperatives and farmers.

C. The trend observed in recent seasons is a decline in input consumption

There was a 10% decline in the distribution of seed potatoes between 1988 (129,315 T) and 1990 (111,011 T). The volume of fertilizer supplies increased by 27% between the period 1980-84 and the period 1985-87 (a period characterized, as we know, by the implementation of an intensification plan). The abandonment of the intensification program, the budgetary difficulties of the new farms resulting from the 1987 reform, and the drop in deliveries will have a direct impact on the level of supplies, which fell by almost half between 1985-87 (626 000 T) and 1988 (349 000 T distributed to users on an annual average). It is within the grain farms that these decreases are the strongest. The same trend is observed for phytosanitary products, which dropped by more than 36% between 1987 and 1989, with deliveries increasing from 14 866 T to 9 546 T. If the organization of distribution, the dysfunctions of cooperatives and the structural aspects has weighed down on input consumption levels, it should be noted that the upward trend in input prices, combined with the financial constraints of farmers, has contributed to drastically reducing farmers' demand.

3.13 Price policy

With the exception of cereals and pulses, all producer prices are now governed by price freedom. In order to encourage the development of certain crops deemed strategic with regard to the country's food coverage and / or export objectives, the

State, through collection and / or marketing agencies, guarantees the prices of certain products (potato, onions, citrus fruits, dates).

The producer prices stopped at the beginning of the 1990-91 crop year, however, recorded a significant shift (which should be quantified) in relation to changes in costs and operating expenses.

The annual rates of increase of some agricultural equipment (plowing and harvesting) have been 40 to 50%, or even nearly 100% over the past two crop years. For cereals, with the exception of wheat, which recorded substantial increases in producer prices (8% for durum between 1990 and 1991 and 12% for common wheat), other cereals (barley and oats) registered a stabilization of their prices. The potato records a price increase which varies between 7.14% (year 1989 compared to 1988) and 23% (1989-90); the price of onions stagnated between 1987 and 1989. There was a 33% increase in 1990 for this product.

The prices of the factors of production have increased more strongly in recent years in relation to the policy of price and exchange rate truth (the State imports a large mass of agricultural inputs, materials and industrial products used by agriculture.). Fertilizer transfer prices increased by 10% between 1987 and 1988, by 30% between 1988 and 1989, and by 100% between 1989 and 1991 for most items. The prices of agricultural plastic films, plant protection products, wire, agricultural equipment and seeds recorded the same sharp increases over the last two seasons. Rising prices for agricultural equipment led to the adjustment of prices for services. T

The price of plowing, mowing, seeding and threshing doubled between 1990 and 1991. The costs of motor-cultivation, transport and harvesting by the CASSAP motocross sections - where they exist - have not stopped increase since the dissolution of the communal agricultural multipurpose cooperative services-CAPCS (1984).

Between 1984-85 and 1990-91, the price of services offered to farmers multiplied by five because, here too, the break with the principle of the monopoly of services provided by the ex CAPCS was followed by a speculative phenomenon. (Content and previously controlled by the CAPCS) and this, regardless of the price adjustments made by the State on agricultural equipment. It is therefore important to note a clear trend towards the level of prices paid by farmers and the prices received. There are farmers with land, financial resources and equipment.

The allocation of agricultural equipment decides on the reproduction of the farm, but also on the diversification of the sources of income (rent), taking into account the evolution of the service price system. The marked increase in the prices of factors of production and services is undoubtedly now part of a restructuring of farms and a change in the social conditions of the majority of farmers. No agricultural system can remain insensitive to such strong price changes and we risk, in the event that this accelerated upward trend continues, to witness not only a production freeze (because available resources, the rents of money oppose a refinancing of production) but also a deterioration of the material base of agriculture.

"Price freedom", aimed at combating the waste of scarce resources and achieving a better allocation of resources, thus reducing opportunity costs, risks in the absence of state intervention on the market. Market (products, equipment and services) to block the increase in agricultural production and productivity. It is thus opposed to the intensification objectives defined for certain strategic crops (cereals, for example) because the production costs of the intensification factors, provided by the farmers alone, are too high.

In situations characterized by a shortage of factors of production, an uncontrolled regime of the market for services, inputs and equipment can objectively lead only to the formation of monopoly prices unfavorable to agricultural producers.

3.14 Financing

The reforms undertaken in this area are characterized by a withdrawal of the State (via the Public Treasury) in the financing, the transformation of the BADR into a commercial bank governed by the principles of autonomy and commercialism, the increase of the rates of interest in accordance with the principle of price truth (rent of money) and by setting up different funds (national development agricultural guarantees fund ...) to promote investment and financial management of farms. The review of statistical data for the financing of short-term production reveals a fall of 25% on average in the four agricultural seasons of the reform (1987-88 to 1990-91) of the number of operators financed by the bank agricultural. The amount of loans increased from DA 5.3 billion in 1987-88 to DA 1.8 billion in 1990-91. The amount of the repayments also falls sharply between the two periods.

Table 3.29 Production financing short term loans (million DA)

Rural Loan	1987-1988	1988-1989	1989-1990	1990-1991 (June)
records	56082	61 076	46 199	31 950
Forecasts	7025	9400	5683	3005
Achievement	5330	7500	4012	18240
Refunds	4128	5600	2746	435

Source: National Planning Council

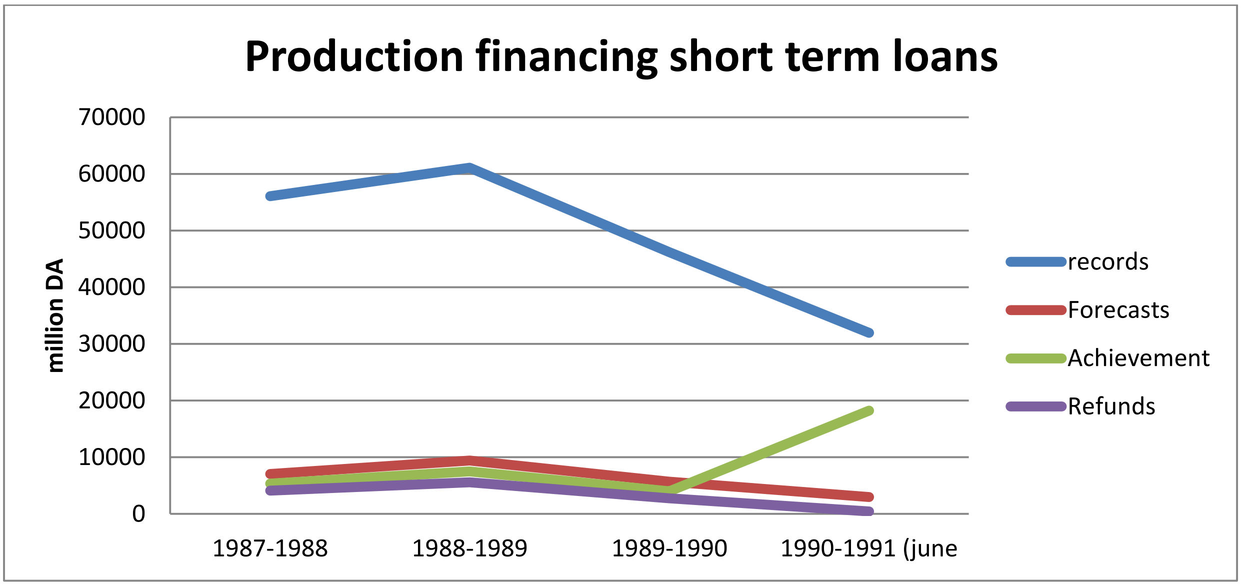


Figure 3.36 Production financing short term loans

The drop in forecast amounts can be partly explained by the withdrawal of the "labor and compensation expenses" that the BADR was funding to the former DAS. It should be noted, however, that the number of farms and beneficiaries that can access the credit given the new criteria decided by the bank (solvency, guarantee, repayments ...) tends to decrease very strongly. The deterioration of the situation is more pronounced for medium and long-term financing. During the period considered (1987-88 to 1990-91), the number of medium and long-term loan applicants (MLLs) increased from 19,484 to 2,216 and the amount of loans decreased by DA 1.4 billion in 1988 to 191 million DA in 1991.

Table 3.30Medium and long term financing (MLL) (million DA)

Credits MLT	1987-1988	1988-1989	1989-1990	1990-1991 (June)
RECORDS	19484	15 784	4 976	2 216
FORECASTS	1400	1128	404	191
ACHIEVEMENT	1100	850	203	182

Sources: Agricultural Bank for Agricultural Development; National Planning Council

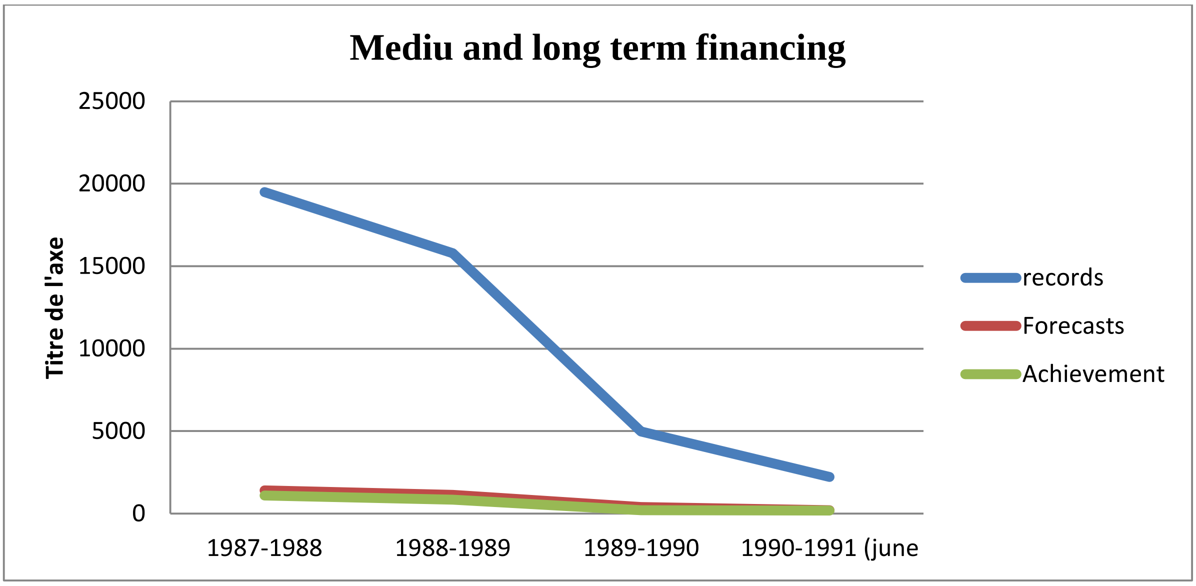


Figure 3.37 Medium and long term financing

The debt of the EAC / EAI is today very heavy under the double effect of the assumption of the transferred inheritance (17 billion DA) and credits not refunded since their installation. This debt has been aggravated by the new interest rates applied in recent years (short-term interest rates have been raised from 4-6% in 1986 to 15% in 1990-91) and , rediscounted quarterly, accumulate by creating a multiplier effect that significantly increases the debt service. With regard to development and investment actions, several funds have been created as part of the agricultural reforms:

- The national fund for agricultural development (law n ° 87-20 of 23/12/87 on the finance law for 1988) is intended to finance the equipment of poor small farms, to promote and develop productive activities in poor areas and landlocked and to finance farms not eligible for commercial credit;
- Subsidies registered during the 1990s (420 million DA) could not be used, as the allocation and management procedures for these funds proved totally ineffective in the field;
- The agricultural guarantee fund (Decree 87-82 of 14/4/87) to facilitate access to bank credit for private smallholders who cannot provide guarantees has not, in terms of its operation, achieved the objectives assigned to it;
- The provisions of Law 87-19 of 2 December 1987 that transformed the DAS into EAC / EAI, private agricultural holdings, upset the foundations of this fund. Endowed with an amount of 100 million DA fed by the contributions of the National Fund of Agricultural Mutual (CNMA) and the payments of the BADR, its mode of operation, like the insufficiency of the resources could not make it one effective instrument for the financial management of operators;
- The guarantee fund against natural disasters (decree 90-158 of 26/5/90) came into operation following the drought that affected the northern areas of the country during the 1989-90 campaign and floods southern wilaya (October-December 1990). The regional mutual of agricultural mutuality took care of the operations of compensation of the farmers concerned for an amount of 900 million DA. The demands expressed today by the operators are of a much larger volume than the current endowments.

3.15 The associative movement and the chambers of agriculture

They constitute in the agricultural reform project the new instruments for managing and supervising agricultural professions. Associations are considered both as partners of the State (representing the farmers and the various professions) but also as relays necessary for the realization of the agricultural policy of the State. The agricultural chambers (decree 91-38) have attributions that were entrusted to agricultural administrations (vocational training, studies, statistical surveys, development programs, etc.). Defined as public institutions of an industrial and commercial character, and vocationally oriented, they constitute the relay of the public intervention and the specific organization of management of the sector by the farmers. More than 450 associations and professional groups have been created (179 representing crop productions and 174 animal productions). The National Chamber of Agriculture and 40 wilaya chambers have been installed. The rush, with which this constitution was conducted, often under the impetus of administrative structures and the animation of administrative executives, has placed them in a difficult position that distorts their role and diverts farmers and their associations from exercising their rights responsibility.

3.16 Agriculture in the zone study

3.16.1 Main crops grown

- The dominant cropping system occupies 81% of Useful Agricultural Area (UAA). across the basin, and is represented by the association Cereals fallow field (rotational agriculture)
- The cereal sole represent 33.6% of the UAA.
- Forage crops and dried vegetables cultivated in crop rotation with cereals remain very little developed. They represent respectively 5% and 3% of the UAA
- Vegetable crops represent 4% of the UAA
- Arboriculture represents 6% of the UAA

Tables 3.31 Main cultivated crops and their areas

Vegetable cultivation (Ha)	Arboriculture (Ha)	Industrial crop (Ha)	Cereals (Ha)	Other crop (Ha)
13 011	7 723	49	380	1 265

Source: DSA

3.16.2 Agriculture Industry:

Industrial activity is organized around the following activity:

Food industry with a predominance mills

- Milk industry
- Olive oil industry

The industries having a monopoly character in the wilaya of Tlemcen are:

- CGM ex ENCG, oil mill located in Maghnia with a capacity of 620 T /day
- GIPLAIT located in Tlemcen

3.17 Large irrigation perimeters

3.17.1 Existing large perimeter

A) Presentation of the Perimeter of Maghnia

Because of its good soil characteristics and its water resources, the Maghnia perimeter was created in 1974. It represents the agro polis area of the wilaya of Tlemcen. The gross geographical area is approximately 11,160 Ha including a cadastral area of 5,280 Ha and an area equipped with 5,138 ha. The adopted irrigation system is sprinkler with water requirements estimated at 19.5 Hm^3 / year. The network has 200 km of pressurized pipelines, 17 boreholes and 2 pumping stations which operate mainly for AEPI.

Located in the wilaya of Tlemcen, the plain of Maghnia is a part of the plain of Angads. Delimited by the massif of Traras in the North, which isolates it from the Sea, the foothills of the Tlemcen Mountains to the South and to the East, its West-South

West limit is constituted by the Moroccan border line. The perimeter of Maghnia is limited:

• In the North, by the Maghnia - Port Say road, the Maghnia secondary road to Sidi Mohamed, the Industrial Zone boundary and another secondary road.

• To the East by the Tlemcen - Maghnia railway.

• South by the D101 road (Bazania - Zouidj El Berhal) and the Moroccan border.

• To the west by the D 63 (border crossing - road N ° 7) and the irrigable zones.

B) Presentation of Hydraulic Development

General diagram of the network

The hydraulic installation consists of pipes and a pressurized irrigation network to the terminal serving the user. The system is designed for downstream and on-demand control operation. In reality, because of the low water resource, the system operates according to rationing managed by the OPI (water tower).Originally the project included the following works:

• The Beni Bahdel dam and the Bouhlou accumulation basin. Located downstream of the dam, these structures are managed by the ANBT and for all uses (AEP - AEI and Irrigation).

• The main water supply (deadhead) from the Bouhlou storage basin to the breakwater N ° 2, (the breakwater N ° 1 is located on this section). This pipeline and the works downstream are managed by the OPI.

• The main water pipe from the BC2 to the buffer pool at the end of the perimeter. Two main branches are diverted to the two East and West pumping stations (SRE and SRO).

• The main pipes that derive from the water main and serve the different zones of the perimeter.

• The secondary and tertiary distribution pipes are connected to the mains and along which the terminals are placed.

• Two systems for collecting groundwater include a drilled well dropping into a ground basin. This basin feeds a recovery station that flows directly into the main water main network: the SRE station collects 10 drillings, and the SRO station collects 7 drillings.

• The buffer basin (BT), on the northwestern slopes of Maghnia, which is assigned the main role of control for the regulation of the network, the control is based on the levels of the water bodies in the basin itself.

• The needle valve, at point A is the main pipe, which is entrusted with the role of regulating the incoming flow of the load break N ° 2 (water from the Beni Bahdel dam).

During the 1980s, the project was supplemented by a strengthening of water resources from Wadi Tafna; He understands:

• KEF containment is a gravity feed (partly gallery) from the reservoir to the KEF pumping station.

• The KEF pumping station is a discharge line to a control tank.

• A line connecting the tank to the main water supply pipe with a connection (injection point) on it upstream of the BC2.

Types and characteristics of supply and distribution networks

The irrigation network consists of the following elements:

• The supply pipe, from the Bouhlou basin to the breakwater: total length of about 10 km, pre stressed concrete of Ø1 250 mm.

• The main pipe, which starts from the breakwater, crosses the perimeter towards the West. Another main branch derived (from point B), joins the buffer basin. The total length of these two pipes is about 12 km; they are pre stressed concrete from Ø 1,250 to Ø 500 mm.

• The other main pipes that derive from the main pipe serve the different zones of the perimeter. They are made of steel from à 98 to Ø 212 mm, and have a total length of 42 Km.

• The secondary distribution pipes derive from the main pipes represent the last derivations of the network. They lead to either an irrigation terminal or a hydrant outlet of each sector of the perimeter.

• These pipes are made of steel for diameters less than 200 mm, and asbestos-cement for diameters equal to or less than 200 mm. The total length of these pipes is 127 Km.

• The number of hydrants is 471. Each terminal has two or three outlets. Initially, each terminal was equipped with water meter, flow limiter and pressure reducer.

3.18 Recommended crop type

Based on the studies that have been done and depending on the soil class and the irrigation density, the crops that we could plant, are distributed as follows:

Table 3.32 Recommended crop type

Soils class	Agronomic Vocation	Irrigation density %	Recommended crops
I	Good	100	**Citrus and alfalfa**
II	Pretty good	80	**Citrus, market gardening, alfalfa, arboriculture**
III	Poor	60	**Arboriculture, cereals**
IV	**bad**	**20**	**Cereals**

In general, the irrigable area of 4,250 Ha has never been reached. The opportunity of soil by large group of speculation practiced is:

• Various arboricultural: 1,200 hectares

• Citrus fruits: 350 hectares

• Table vines: 80 hectares

• Forage and cereals: 2,620 hectares

3.19 Volumes distributed and irrigated areas

The areas irrigated and volumes distributed in recent years are as follows:

Table 3.33 Volumes distributed and irrigated areas

year	Distributed volume Hm^3	Irrigated area Ha	Water needs m^3/Ha
1974 - 75	26,55	2970	**8939**
1975 - 76	20,55	2290	**8974**
1976 - 77	19,55	2186	**8943**
1977 - 78	9,55	1068	**8942**
1978 - 79	5,55	620	**8952**
1979 - 80	16,40	1834	**8942**
1980 - 81	32,00	3634	**8806**
1981 - 82	1,20	434	**2765**
1982 - 83	1,10	423	**2600**
1983 - 84	2,50	679	**3682**
1984 - 85	3,20	758	**4222**
1985 - 86	5,50	915	**6011**
1986 - 87	11,00	1230	**8943**
1987 - 88	1,00	112	**8929**
1988 - 89	0,40	45	**8889**
1989 - 90	0,40	45	**8889**
1990 - 91	5,00	1200	**4167**
1991 - 92	3,00	600	**5000**
1992 - 93	3,3	186	
1993 - 94	No data	No data	**No data**
1994 - 95	No data	No data	**No data**

1995 - 96	6,0	340	**17647**
1996 - 97	No data	No data	**No data**
1997 - 98	No data	No data	**No data**
1998 - 99	No data	No data	**No data**
1999 - 00	0,2	64	**3125**
2000 - 01	5,2	700	**7429**
2001 - 02	3,2	500	**6200**
2002 - 03	3,1	500	**5714**
2003- 04	4	700	**5714**
2004 - 05	No data	No data	**No data**
2005-06	**1**	**100**	

During the first 07 years, the water needs are approximately constant at 8900 m3 / Ha, wish correspond to the region of citrus agriculture. The irrigated areas were therefore variable within the framework of a planned agriculture which fixed the areas of the cultures. Since 1981 we notice disturbances in water distributed and the irrigated area wish is the result of the start of the dry season where even the water needs have been greatly reduced. The management of the resource was an obligation to preserve the resource.

Nb: We observe the lack of data in some 90's wish correspond to the period of the civil war.

3.20 Conclusion

The collective network does not satisfy the demand for water to maintain the irrigation of these crops at a high level. The private drillings partially replace the collective network resource and have allowed the maintenance of the citrus crops. However, this situation is insecure because the aquifer is overexploited and its level has been reduced for 30 years for two reasons the first is the dray period that this area is facing and the second one is the unauthorized private drilling wish does not allow the evolution of this aquifer.

3.21 Diagnosis of Hydraulic Infrastructures (General Report of AGIR 2005)

The diagnosis of the Maghnia perimeter irrigation network is based on the following points:

• Collection of basic data needed for the study at OPI.

• A detailed inspection of the network.

Thus a series of survey works was carried out on the ground, during the period between February and April 2005, based essentially on the visual inspection of the state of the equipment and works of the irrigation network. The results of the diagnosis show that a large number of structures and equipment of the network and pumping stations are classified in degree 3 (work to be replaced).These results are analyzed in relation to the situation of very great shortage of water resources noted for more than 10 years which led to the impossibility for the Office to have the financial resources to ensure the maintenance of the works. In this situation the deterioration of the structures occurred over time according to their vulnerability and their utility:

3.21.1 Vulnerability of structures

In general, the network of buried pipelines and the main works of Civil Engineering are kept in state 1 or 2. There have been occasional degradations of the network due to breakages and voluntary taps. Pumping structures, irrigation terminals, hydrant valves, manifolds and equipment accessible in manholes are the most degraded

3.21.2 Utility for maintaining a water service

The only resource being that of KEF, it is the works allowing the distribution which are maintained in operation in particular of the pumping station. The two pumping systems SRE and SRO which are of no use are all classified in degree 3.

3.22 Recommendation

The programming of medium and long-term investments is dependent on the water resources that can be mobilized. These resources will have to be essentially those of the surface waters because the decline of the water table will continue because of the current private taking (not authorized for the majority). It is the survival of citrus orchards. In the short term the only justifiable investments are those which make it possible to improve the exploitation of the resource of the wadi Tafna (system of the KEF):

• Investments related to the safety of operating agents in electrified structures (Bouhlou catchment) which are maintained even if the water resource is not available.

• The minimum investments to safeguard the durability of the works that could be destroyed concern the control of certain wadi crossing points (erosion of foundations, settlement of supports). These investments must be evaluated in terms of insurance to keep the structure in good condition compared to the risk of destruction if nothing is done.

3.23 The right way of protection

For the operation of the pipelines, it is recommended to create access tracks that are parallel to them by ensuring the availability of the right of way throughout the route usable by an all-terrain vehicle. This supposes the acceptance by the farmers of the easements that were defined during the execution of the works. In general a simple driving grip is sufficient without realizing a track in the rules of the art. The sections traversing soils which do not allow circulating (clay soils with low lift) will be arranged in tracks in the following way:

• Disbursement of a layer of all coming from a thickness of 30 to 40 cm on the sections of non-floodable areas.

• Hedge in stones of 40 cm on the wadi crossings.

With regard to the banks, whose state of degradation is very advanced (strong erosion) at the wadi crossings and mainly at Wadi Méhaguène, we recommend to put in place a protection with gabions or possibly a retaining wall.

3.24 The large irrigation perimeters in Realization or Project

3.24.1 Tafna perimeter - Isser and Hennaya

A) Description of the study area

The study area consists of five (5) entities (Hennaya plateau - Isser valley - Tafna and Isser confluence - high, medium and low Tafna).

The lands of these spaces are located in the communes of Hennaya - Ain Youcef - El Fhoul - Remchi - Beni Ouarsous - Zenata - Fellaoucen - Ouled Riah - Ain Fettah - Hammam Boughrara in the wilaya of Tlemcen and Sidi Ouriach - El Emir Abelkader - Oulhaca and Beni Saf in the wilaya of Ain Tmouchent. The farms included in the project are those of the Wadi Isser, Tafna and Hennaya Plateau valleys.

B) Location of study areas

Table 3.34 Location of study areas

Studies zones	**State**							
	Tlemcen				**Ain Tmouchent**			
	Public		**Private**		**Public**		**Private**	
	Ha	**%**	**Ha**	**%**	**Ha**	**%**	**Ha**	**%**
Plateau Hennaya	3548,46	55,16	356,75	15,65	-	-	-	-
Valley of Isser	957,40	14,88	363,70	15,95	-	-	-	-
Confluence Tafna – Isser	1353,52	21,04	891,21	39,09	-	-	-	-
Mean and high Tafna	77,68	1,21	513,87	22,54	-	-	-	-
Low Tafna	496,50	7,72	154,54	6,78	570,11	100,00	994,89	100,00
Total studied area	**6 433,56**	**100,00**	**2 280,07**	**100,00**	**570,11**	**100,00**	**994,89**	**100,00**
Total area per wilaya	**8 913,63 (Ha)**				**1 765,00 (Ha)**			

Source: AGIR 2003

NB: The Hennaya plateau contains the largest area of elaborate studies.

C) Technical Characteristics

Table 3.35Technical Characteristics

Designation		**Unity**	**High and mean Tafna**	**Confluence Tafna - Isser**	**Valley of Isser**	**Low Tafna**	**Plateau of Hennaya**	**TOTAL**
Equipped area		Ha	583,78	2113,30	1310,08	1737,60	912,22	**6 656,98**
Irrigable area		Ha	734,89	2461,12	1508,29	2104,10	1128,62	**7 937,02**
Irrigated area		Ha	734,89	1952,53	1235,75	1737,60	943,84	**6 604,61**
Flow		L/s	0,53	0,56	0,56	0,66	0,65	**2,96**
Immediate drainage		Ha	123,89	233,82	210,24	553,6	-	**1 121,55**
Pipe network	Length	M	49724	56966	45657	77436	40878	**270 661**
Pumping station		Kw			114			**114**

Source: AGIR 2003

D) Hydrographic Network

The study area is crossed by a dense hydrographic system in Wadi Tafna (Appendix A and B).

The most important tributaries of Wadi Tafna are the following wadis:

• Isser ;

• Sikkak ;

• Ain Nekrouf ;

• Mouilah ;

• Zitoun ;

• Boukiou ;

• Dahmane ;

• El Diab and Ben Djelloul.

Impoundments of low capacity were made in the watershed. Many are silted and abandoned by their farmers. Most of the deductions dates back to the 1980s (1985/1986) .The existing or planned dams in the watershed are located on the Tafna, Isser and Sikkak wadis.

• On the Wadi Tafna we find the dam of Beni Bahdel which was supposed to feed initially and partially the perimeter of Maghnia, the Hammam Boughrara dam which records pollution problems.

• On Wadi Isser is implanted the dam of Sidi Abdelli.

• On the wadi Sikkak we have the dam of Ain Youcef whose exploitation has just started the dam Meffrouch.

E) Water Resources

The water resources project carried out as part of this project consists of analyzing and criticizing the results of existing studies on the regulation of inputs from the Hammam Boughrara and Ain Youcef dams with the verification and updating of the hydrological data sets available in the database. Region and also carry out simulations of regularization of the contributions of the two dams to be able to estimate the volumes intended for the various uses (irrigation, drinking water supply, etc). The volumes that can be regularized from the dams are given by the following table:

Table 3.3 Regularized volumes of Hammam Boughrara and Ain Youcef dams

Dam		**Hammam Boughrara**			**Ain Youcef**		
Total capacity Mm^3		**177**			**26,5**		
Initial impoundment		**Empty**	**Half filled**	**Filled**	**Empty**	**Half filled**	**Filled**
Regularized volumem^3		54,22	58,58	58,59	17,72	18,18	18,63
destination Mm^3	**IRR**	5	5	5	28,61*	28,91*	29,38*
	AEP	49	53 ,58	53,59	0	0	0

Source: AGIR 2003

NB: (*) Taking into account the recycled volume 10.95 Millionm^3 in the annual average contribution of the wadi Sikkak to the dam of Ain Youcef.

The water volumes that will be guaranteed 8 years out of 10.95 will be 5 mm3 from Hammam Boughrara dam and will vary from 17.72 mm3 to 29.38 mm3 depending on the initial level in the reservoir and the recycled water volume transferred, for the dam of Ain Youcef.

The water resources assessments for the perimeter showed that the objective of providing the theoretical needs by a volume of 39 Millionm3 is not achieved.

3.24.2Small and Medium Hydraulic (SMH)

a- State of Tlemcen

An inventory carried out in 1989 in the context of the program (perimeter agricultural per state) and the study of the hydro-agricultural development of 1993 brought out a state of 35 areas spread across 07 perimeters located in the rivers of Wadi Tafna and Wadi Isser. In general, these areas have good irrigation manner but today most of them are unexploited.Tlemcen holds 4.3% of the useful agricultural area of the national ensemble. It is presented in the set of appreciable agricultural indicators. The potential of these irrigable lands is estimated at 25 405 Ha, of which only 22 428 Ha is irrigated, almost 6.3% of the (UAA) useful agricultural area. This performance situation is the result of the low volume mobilized or allocated to irrigation. This situation is all the more aggravated by improper ways or irrigation practices that waste the resources.

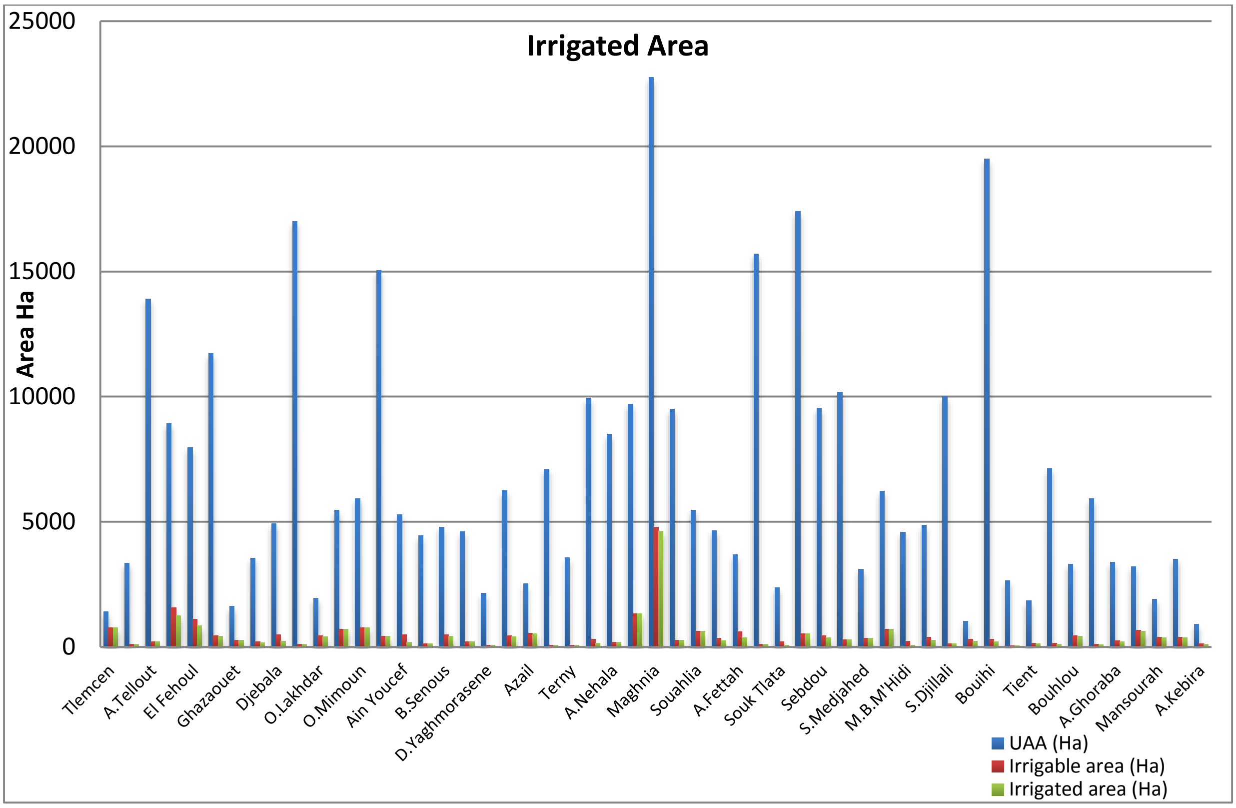


Figure 3.38Irrigated area

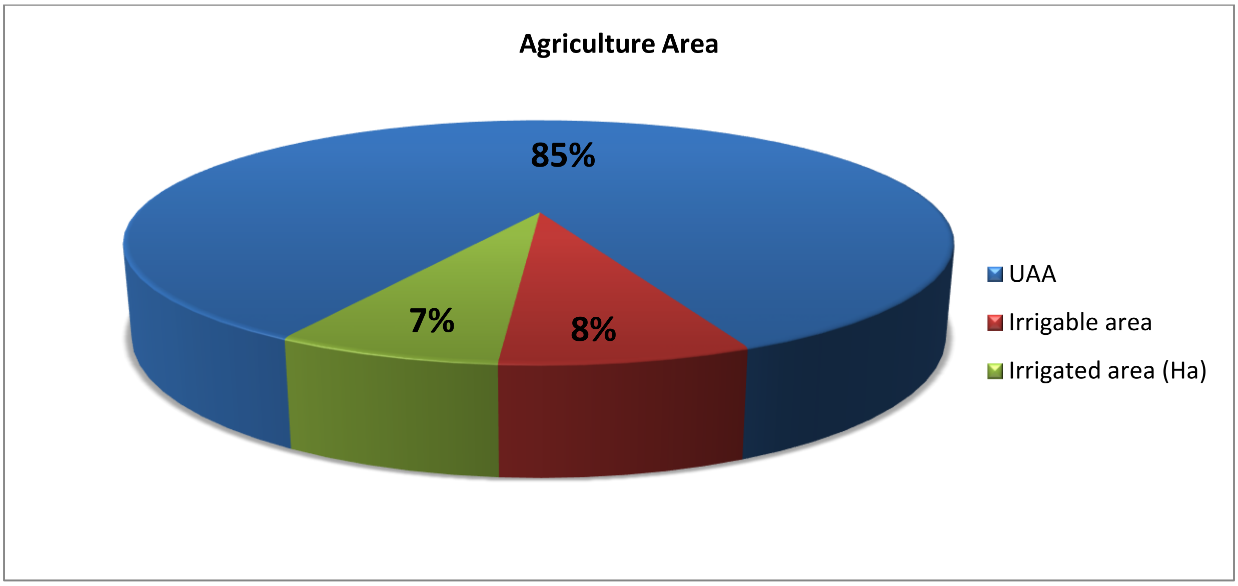


Figure 3.39Agriculture Area

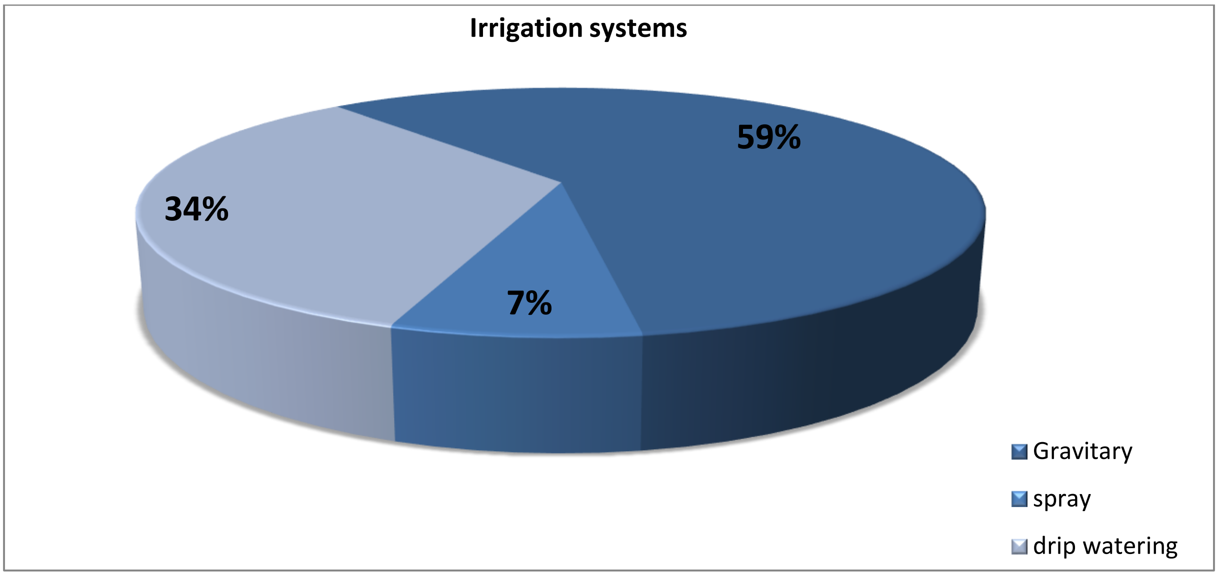


Figure 3.40Irrigation Systems

I- Inventory of types of water mobilization works and mobilized volumes

The information gathered from the hydraulics department of the Tlemcen wilaya reveals that a large number of sampling structures are intended for irrigation. A total of 1,472 drillings, 2,077 wells and 302 sources totalling 179.6 Hm3 / year are used to irrigate an area of 13,897 ha.

Table 3.37 Underground Resources

Name of the Area	Drillings			Wells			Resources			Assigned Volume	Irrigated area Ha
	Nbr	Vol Hm^3/y	Irr area Ha	Nbr	vol Hm^3/y	Irr area Ha	Nbr	Vol Hm^3/y	Irr area Ha		
Tlemcen	17	1,616	202	72	2,52	315	12	1,112	139	5,25	656
B.Mester	2	0,16	20	6	0,24	30	2	0,16	20	0,56	70
A.Tellout	5	0,32	40	20	0	80	3	0,776	97	1,10	217
Remchi	21	0,84	105	10	0,16	20	0	0	0	1,00	125
El Fhoul	29	1,248	156	13	0,12	15	50	0,24	30	1,61	201
Sabra	35	1,6	200	20	0,4	50	5	0,36	45	2,36	295

Ghazaouet	8	0,232	29	52	1,84	230	1	0,04	5	2,11	264
Souani	51	0,96	120	25	0,4	50	0	0	0	1,36	170
Djebala	9	0,24	30	125	1,32	165	6	0,08	10	1,64	205
El . Gor	19	0,116	14,5	53	0,812	101,5	0	0	0	0,93	116
O.Lakhdar	4	0,16	20	10	0,2	25	7	0,944	118	1,30	163
Ain Fezza	46	2,4	300	20	0,32	40	22	0,56	70	3,28	410
O.Mimoun	1	0,064	8	39	0,96	120	2	0,2	25	1,22	153
Amieur	19	1,04	130	13	0,08	10	12	0,2	25	1,32	165
Ain Youcef	11	0,6	75	15	0,24	30	3	0,08	10	0,92	115
Zenata	9	0,304	38	19	0,232	29	0	0	0	0,54	67
B.Senous	31	0,48	60	0	0	0	4	1,2	150	1,68	210
Bab El Assa	31	1,232	154	14	0,4	50	4	0,04	5	1,67	209
D.Yaghmorasene	1	0,016	2	35	0,416	52	7	0,032	4	0,46	58
Fellaoucen	1	0	0	20	0,064	8	0	0	0	0,06	8
Azail	30	0,44	55	0	0	0	1	0,4	50	0,84	105
S.Chouikh	10	0,216	27	10	0,072	9	10	0,208	26	0,50	62
Terni	1	0,08	10	12	0,216	27	11	0,192	24	0,49	61
Bensekrane	6	0,52	65	0	0	0	0	0	0	0,52	65
A.Nehala	4	0,784	98	15	0,56	70	3	0,2	25	1,54	193
Hennaya	34	2,48	310	88	2,88	360	3	0,2	25	5,56	695
Maghnia	622	27,792	3474	328	7,872	984	0	0	0	35,66	4 458
Boughrarra	14	0,616	77	26	0,624	78	0	0	0	1,24	155

Souahlia	43	70	155	70	1,36	170	0	0	0	71,36	325
M'Sirda F	1	0,064	8	12	0,256	32	1	0,048	6	0,68	46
A.Fettah	2	0,024	3	10	0,04	5	4	0,032	4	0,10	12
El , Aricha	31	0,448	56	42	0,408	51	0	0	0	0,86	107
Souk Tlata	3	0,048	6	10	0,264	33	3	0,024	3	0,34	42
S.Adelli	11	0,6	75	5	0,304	38	2	2,88	360	3,78	473
Sebdou	61	0,4	50	155	0,64	80	5	0,48	60	1,52	190
B.Ouarsous	2	0,096	12	50	0,208	26	2	0,008	1	0,31	39
S.Medjahed	30	1,2	150	11	0,264	33	21	0,336	42	1,80	225
B,Boussaid	137	4,816	602	12	0,288	36	0	0	0	5,10	638
M.B.M'Hidi	3	0,24	30	2	0,048	6	0	0	0	0,29	36
Nedroma	0	0	0	95	1,6	200	3	0,048	6	1,65	206
S.Djillali	11	0,072	9	61	0,864	108	6	0,016	2	0,95	119
B.Bahdel	0	0	0	0	0	0	4	0,32	40	0,32	40
Bouihi	17	0,136	17	148	1,616	202	24	0,016	2	1,77	221
Honaine	0	0	0	38	0,304	38	4	0,096	12	0,40	50
Tient	10	0,368	46	45	0,64	80	3	0,04	5	1,05	131
O.Riah	0	0	0	0	0	0	2	0,16	20	0,16	20
Bouhlou	3	0,194	24	25	0,56	70	1	0,4	50	1,15	144

B.Khaled	4	0,08	10	40	0,352	44	20	0,072	9	0,50	63
A.Ghoraba	2	0,064	8	2	0,032	4	2	0,32	40	0,42	52
Chetouane	14	0,56	70	32	0,464	58	8	0,88	110	1,90	238
Mansourah	10	0,96	120	20	0,64	80	8	1,36	170	2,96	370
B.Smiel	6	0,2	25	62	1,22	152	2	1,168	146	2,58	323
A.Kebira	0	0	0	70	0,792	99	9	0,136	17	0,93	116
TOTAL WILAYA	**1 472**	**127,126**	**7 295,5**	**2 077**	**36,11**	**4 593,5**	**302**	**16,064**	**2 008**	**179,6**	**13 897**
TOTAL TAFNA BASIN	**1 225**	**52,554**	**6 569**	**1 190**	**23,21**	**2 901**	**217**	**14,736**	**1 842**	**90,5**	**11 312**

Source: DHW 2006

II- Surface Resources

During the last five-year program, the wilaya of Tlemcen benefited from the realization of 07 small dams and 78 hill reservoirs to irrigate its agricultural lands. The majority of its infrastructure is either silted or deteriorated, but currently, about twenty structures and taken from wadis ensures the irrigation of the neighbouring lands.

Table 3.38Surface Resources

Name of the Commune	Hill reservoirs and small dams			Pumping from the rivers			Assigned volume Hm^3/y	Irrigated area Ha
	Nbr	vol Hm^3/y	Irr area Ha	Nbr	vol Hm^3/y	Irr area Ha		
Tlemcen	0	0	0	-	0,832	104	0,83	104
B.Mester	0	0	0	0	0,32	40	0,32	40
A.Tellout	1	0	0	0	0	0	0,00	0

Remchi	0	0	0	-	8,984	1123	8,98	1123
El Fehoul	0	0	0	-	5,136	642	5,14	642
Sabra	1	0,04	5	5	1,056	132	1,10	137
Ghazaouet	0	0	0	0	0	0	0,00	0
Souani	0	0	0	0	0	0	0,00	0
Djebala	0	0	0	3	0,16	20	0,16	20
El Gor	0	0	0	0	0	0	0,00	0
O.Lakhdar	0	0	0	35	2	250	2,00	250
Ain Fezza	1	0,12	15	1	2,36	295	2,48	310
O.Mimoun	1	0,16	20	43	4,824	603	4,98	623
Amieur	5	0,04	5	1	2,08	260	2,12	265
Ain Youcef	0	0	0	-	0,568	71	0,57	71
Zenata	0	0	0	18	0,528	66	0,53	66
B.Senous	0	0	0	1	1,752	219	1,75	219
Bab El Assa	0	0	0	0	0	0	0,00	0
D.Yaghmorasene	0	0	0	6	0,08	10	0,08	10
Fellaoucen	1	0,04	5	112	3,272	400	3,31	405
Azail	0	0	0	1	3,488	436	3,49	436
S.Chouikh	0	0	0	0	0	0	0,00	0
Terny	0	0	0	0	0	0	0,00	0
Bensekrane	0	0	0	50	0,64	80	0,64	80
A.Nehala	0	0	0	0	0	0	0,00	0
Hennaya	2	0,32	40	0	4,752	594	5,07	634
Maghnia	0	0	0	2	1,392	174	1,39	174
Boughrarra	0	0	0	2	0,84	105	0,84	105
Souahlia	2	0,04	5	0	2,352	294	2,39	299
M'Sirda F	0	0	0	65	1,592	199	1,59	199
A.Fettah	1	0,048	6	84	2,832	354	2,88	360
El Aricha	0	0	0	0	0	0	0,00	0

Souk Tlata	0	0	0	15	0,16	20	0,16	20
S.Adelli	3	0,536	67	0	0	0	0,54	67
Sebdou	0	0	0	2	1,44	180	1,44	180
B.Ouarsous	0	0	0	-	1,872	234	1,87	234
S.Medjahed	0	0	0	3	1,064	133	1,06	133
B,Boussaid	1	0,4	50	3	0,176	22	0,58	72
M.B.M'Hidi	0	0	0	30	0,16	20	0,16	20
Nedroma	0	0	0	3	0,512	64	0,51	64
S.Djillali	0	0	0	0	0	0	0,00	0
B.Bahdel	0	0	0	1	1,504	188	1,50	188
Bouihi	1	0	0	0	0	0	0,00	0
Honaine	0	0	0	0	0	0	0,00	0
Tient	0	0	0	1	0,024	3	0,02	3
O.Riah	2	0,68	85	0	0	0	0,68	85
Bouhlou	0	0	0	-	2,296	287	2,30	287
B.Khaled	0	0	0	-	0,24	30	0,24	30
A.Ghoraba	0	0	0	42	1,248	156	1,25	156
Chetouane	0	0	0	-	3,04	380	3,04	380
Mansourah	0	0	0	0	0	0	0,00	0
B.Smiel	0	0	0	25	0,32	40	0,32	40
A.Kebira	0	0	0	0	0	0	0,00	0
TOTAL WILAYA	**22**	**2,424**	**303**	**554**	**65,896**	**8 228**	**68,31**	**8 531**
TOTAL TAFNA BASIN	**18**	**2,384**	**298**	**431**	**60,616**	**7 568**	**63**	**7 866**

Source: DHW 2006

Vol Assigned: volume for irrigation (Hm^3/y)

Irr area: Irrigated area (Ha)

Nbr: number of water resource

III- Runoff-the-river sampling

To overcome the deficit of mobilization infrastructure and resource, the farmers have resorted to other means more judicious and more practical, to irrigate from catch on wadi (take derivation of Tafna, Isser, Sikkak, Boukiou, Zitoun, Bou Messaoud and Mouilah). But some of them do not work anymore because they have dried up.

Table 3.39Pomping from rivers (wadi)

Area Code	Basin Code	Name of the Commune	Name of the wadi	mobilized resourcesHm^3/year	Irrigated area Ha
1301	1607	Tlemcen	Reghougui-Saf Saf	0,832	104
1302	1605	B.Mester	El Ancor-Boumessaoud	0,32	40
1303	1605	A.Tellout	/	0	0
1304	1605	Remchi	Tafna-Isser	8,984	1123
1305	1607	El Fhoul	Isser-Sikkak	5,136	642
1306	1605	Sabra	Hafair	1,056	132
1307	401	Ghazaouet	/	0	0
1308	401	Souani	/	0	0
1309	401	Djebala	/	0,16	20
1310	802	El Gor	/	0	0
1311	1606	O.Lakhdar	Isser	2	250
1312	1606	Ain Fezza	Tagma	2,36	295
1313	1606	O.Mimoun	/	4,824	603
1314	1607	Amieur	/	2,08	260
1315	1607	Ain Youcef	Sekkak	0,568	71
1316	1605	Zenata	Boumessaoud	0,528	66
1317	401	B.Senous	Khemis	1,752	219
1318	401	Bab El Assa	/	0	0
1319	401	D.Yaghmorasene	Telata	0,08	10

1320	1605	Fellaoucen	/	3,272	400
1321	1604	Azail	Tafna	3,488	436
1322	1607	S.Chouikh	/	0	0
1323	1606	Terny	/	0	0
1324	1607	Bensekrane	Isser	0,64	80
1325	1605	A.Nehala	/	0	0
1326	1607	Hennaya	Sikkak-Ain El Hadjel	4,752	594
1327	1603	Maghnia	/	1,392	174
1328	1602	Boughrarra	/	0,84	105
1329	401	Souahlia	/	2,352	294
1330	401	M'Sirda F	/	1,592	199
1331	1605	A.Fettah	/	2,832	354
1332	802	El , Aricha	/	0	0
1333	401	Souk Tlata		0,16	20
1334	1606	S.Adelli	/	0	0
1335	1604	Sebdou	Sidi Moussa-Moumen-Kicole-Ramoule-Widane	1,44	180
1336	1605	B.Ouarsous	/	1,872	234
1337	1604	S.Medjahed	/	1,064	133
1338	1603	B,Boussaid	/	0,176	22
1339	401	M.B.M'Hidi	/	0,16	20
1340	1605	Nedroma	/	0,512	64
1341	801	S.Djillali	/	0	0
1342	1604	B.Bahdel	Tafna	1,504	188
1343	801	Bouihi	/	0	0
1344	401	Honaine	/	0	0
1345	401	Tient	Taima	0,024	3

1346	1605	O.Riah	/	0	0
1347	1604	Bouhlou	Bouhlou	2,296	287
1348	401	B.Khaled	Défali-Sidi Lakhdar-Nekhara	0,24	30
1349	1604	A.Ghoraba	Tafna-Dossif	1,248	156
1350	1607	Chetouane	Saf Saf- Sikkak	3,04	380
1351	1607	Mansourah	/	0	0
1352	1606	B.Smiel	Isser	0,32	40
1353	1605	A.Kebira	/	0	0
TOTAL WILAYA				**65,896**	**8 228**
TOTAL TAFNA BASIN				**60,616**	**7 568**

Source: DHW / 2006

IV Synthesis of the wilaya of Tlemcen

The irrigated areas of the wilaya are distributed in the TAFNA catchment area as follows:

NB: The areas irrigated by the underground resources are greater than the areas irrigated by the surface resources.

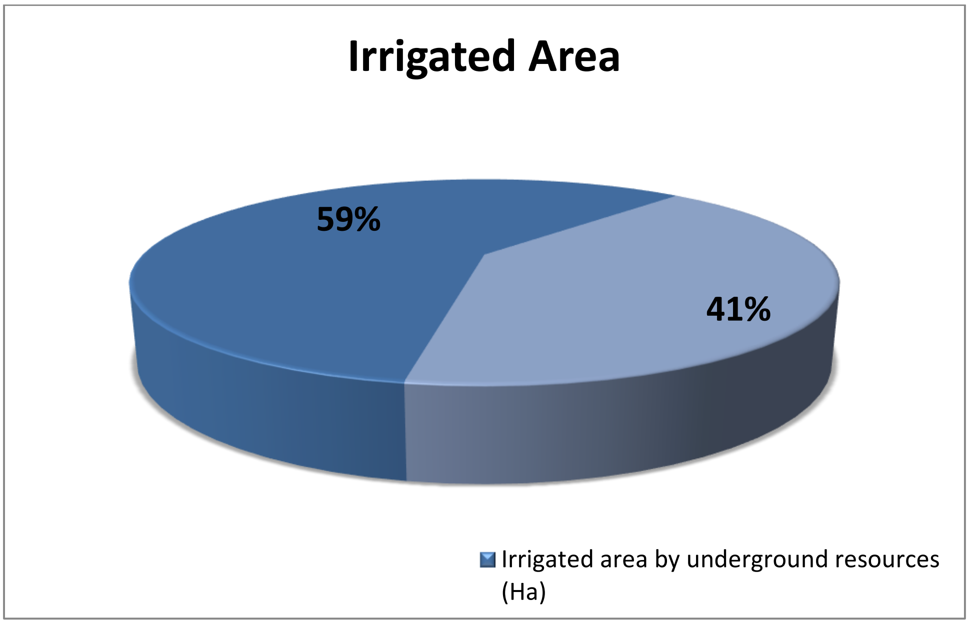


Figure3.41 Distribution of the Area Irrigated In Relation to the Water Resource

b- State of Ain Tmouchent

I- Irrigated area

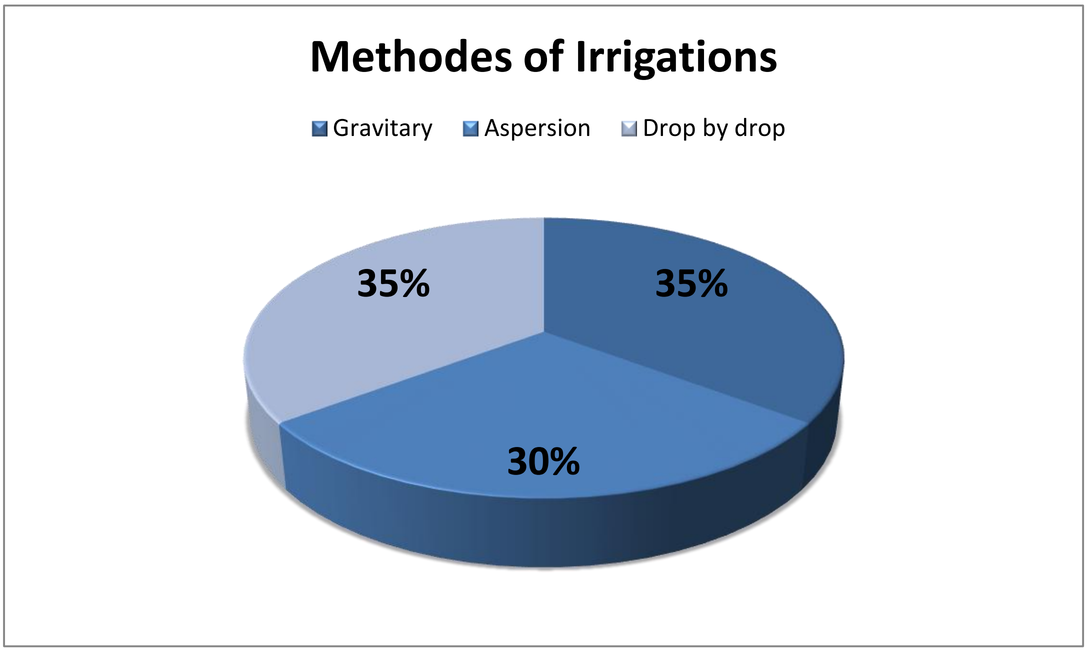


Figure3.42Contribution of Different Methods of Irrigations

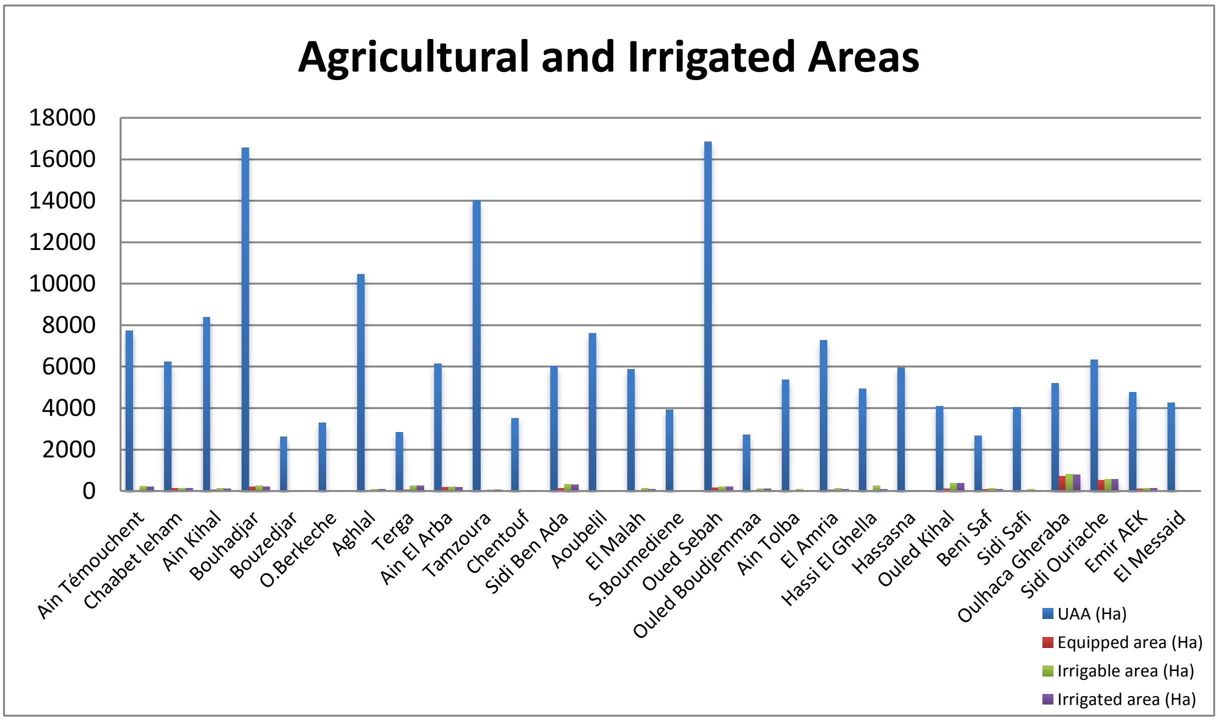


Figure 3.43 Agricultural Areas and irrigation Areas for the Plains 2005

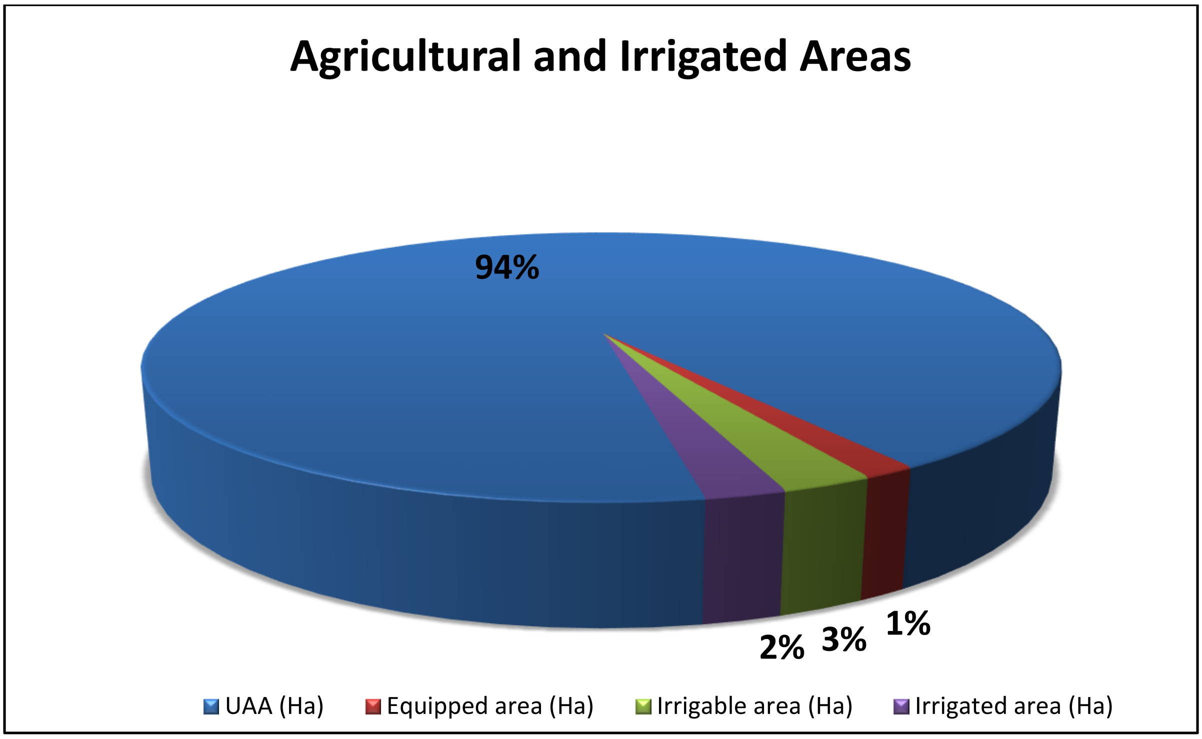


Figure 3.44 Agricultural Areas and irrigation Areas 2005

II- Inventory of types of water mobilization structures and mobilized volumes

Table 3.40 Underground Resources

Name of the Commune	Drillings			Wells			Resources			Assigned volume Hm^3/y	Irrigated area Ha
	Nbr	Ass vol Hm^3/y	Irr area	Nbr	Ass vol Hm^3/y	Irr area	Nbr	Ass vol Hm^3/y	Irr area		
A/Tmouchent	6		30,25	60		170,0	0		0		200,3
Chaabet leham	5	0,12	37	16		80,0	1		8	0,12	125,0
Ain Kihal	14	1,3	48	39	2	70,5	8		5	3,3	123,5
Bouhadjar	5		28	78		180,0	0		0		208,0
Bouzedjar	0		0	4	0,3	20,0	3	0,18	3	0,48	23,0
O.Berkeche	0		0	2		0,0	0		0		0,0
Aghlal	14	1,5	41	19	0,7	34,0	0		0	2,2	75,0

Terga	2		0	31	1,6	268,0	0		0	1,6	268,0
Ain El Arba	1	0,08	15	61		152,0	0		0	0,08	167,0
Tamzoura	6	0,7	12	35	0,3	68,0	1	0,03	3	1,03	83,0
Chentouf	0		0	2		5,0	0		0		5,0
SidiBen Ada	22		189	15		126,5	1		4		319,5
Aoubelil	0		0	4	0,18	5,0	1		0,5	0,18	5,5
El Malah	1	0,03	0	19	0,9	31,0	0		0	0,93	31,0
S.Boumediene	0		0	5		42,0	0		0		42,0
Wadi Sebah	7	0,9	50	67	0,3	93,0	1	0,02	2	1,22	145,0
O/Boudjemaa	2		19	104	6	326,5	0		0	6	345,5
Ain Tolba	2	0,18	3	7	0,2	24,5	2		1,5	0,38	29,0
El Amria	1	0,12	7	21	1,6	69,0	0		0	1,72	76,0
Hassi ElGhella	0		0	12	0,7	23,0	0		0	0,7	23,0
Hassasna	1		13	11		16,0	1		0		29,0
Ouled Kihal	1		0	7	1	60,5	0		0	1	60,5
Beni Saf	7	0,3	4	28	0,6	14,0	3	0,02	6	0,92	24,0
Sidi Safi	2	0,02	5	14		17,0	1	0,04	2	0,06	24,0
Oulhaca Gheraba	16	0,5	95	63	1,6	100,0	0		0	2,1	195,0
S/Ouriache	11	0,3	56	2	0,02	3,0	0		0	0,32	59,0
Emir AEK	2	0,03	3	1	0,01	1,0	0		0	0,04	4,0
El Messaid	0		0	3	0,2	4,0	1	0,02	2	0,22	6,0
TOTAL WILAYA	**128**	**6,1**	**655,25**	**730**	**18,21**	**2 003,5**	**24**	**0,31**	**37**	**24,6**	**2 695,8**
TOTAL TAFNA BASIN	**29**	**0,83**	**154**	**66**	**1,63**	**104**	**0**	**0**	**0**	**2,46**	**258**

Source: DHW 2005

NB:

Ass vol: Assigned volume for irrigation (Hm^3/y)

**Irr area : ** Irrigated area (Ha)

**Nbr : ** Number of water resources

Table 3.41 Surface Resources

Name of the Commune	Hills reservoirs			Small dams			Run of the river sampling			Assigned volume Hm^3/y	Irrigated area Ha
	Nbr	Ass vol Hm^3/y	Irr area	Nbr	Ass vol Hm^3/y	Irr area	Nbr	Ass vol Hm^3/y	Irr area		
A/Tmouchent	0	0	0	0	0	0	0	0	0	0	0
Chaabetleham	0	0	0	0	0	0	0	0	0	0	0
Ain Kihal	0	0	0	0	0	0	0	0	3	0	3
Bouhadjar	0	0	0	0	0	0	2	0	5	0	7
Bouzedjar	0	0	0	0	0	0	0	0	0	0	0
O/Berkeche	0	0	0	0	0	0	0	0	0	0	0
Aghlal	4	0	0	0	0	0	0	0	3	0	7
Terga	0	0	0	0	0	0	0	0	0	0	0
Ain El Arba	0	0	0	0	0	0	0	0	0	0	0
Tamzoura	0	0	0	0	0	0	0	0	0	0	0
Chentouf	0	0	0	0	0	0	2	0	22	0	24
SidiBen Ada	0	0	0	0	0	0	0	0	0	0	0
Aoubelil	0	0	0	0	0	0	0	0	0	0	0
El Malah	1	0	0	0	0	0	0	0	0	0	1
S.Boumediene	0	0	0	0	0	0	0	0	0	0	0
Wadi Sebah	0	0	0	0	0	0	0	0	0	0	0
O/Boudjemaa	0	0	0	0	0	0	11	0	50	0	61

Ain Tolba	1	0	0	0	0	0	0	0	0	0	1
El Amria	0	0	0	0	0	0	0	0	0	0	0
Hassi ElGhella	0	0	0	0	0	0	0	0	0	0	0
Hassasna	1	0	0	0	0	0	0	0	1	0	2
Ouled Kihal	0	0	0	1	0,7	118	0	0	0	0,7	120,4
Beni Saf	0	0	0	0	0	0	13	0	53	0	66
Sidi Safi	0	0	0	0	0	0	10	0	14	0	24
Oulhaca Gheraba	0	0	0	1	0,2	30	70	0	500	0,2	601,4
S/Ouriache	0	0	0	0	0	10	60	0	450	0	520
Emir AEK	0	0	0	0	0	0	15	0	120	0	135
El Messaid		0	0	0	0	0	0	0	0	0	0
TOTAL WILAYA	**7**	**0**	**0**	**2**	**0,9**	**158**	**183**	**0**	**1 221**	**0,9**	**1 572,8**
TOTAL TAFNA BASIN	**0**	**0**	**0**	**1**	**0,2**	**40**	**145**	**0**	**1 070**	**0,2**	**1 256,4**

Source: DHW 2005

III- Synthesis of the State of Ain Tmouchent

The irrigated areas of the wilaya are distributed in the TAFNA catchment area as follows:

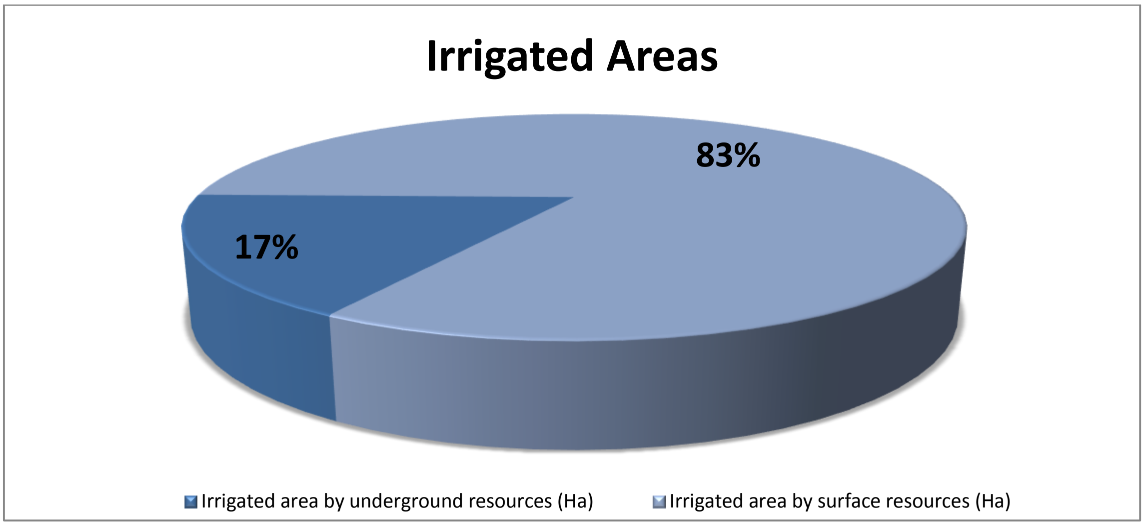


Figure3.45 Distribution of the Area Irrigated in Relation to the Water resource – source: DHW

NB: The area irrigated by the surface resources is greater than the area irrigated by the underground resources.

c- Synthesis of the Tafna Basin

I- Irrigated areas by irrigation systems

Table 3.42irrigated areas by irrigation systems

State Code	State	SAU (Ha)	Equipped area (Ha)	Irr area (Ha)	Irr area (Ha)	Irrigation systems		
						Gravitary	Aspersion	Drip Irr
13	Tlemcen	230 683		21 202	19 178	X	X	X
46	Ain Tmouchent	16 296	1 356	1 526	1 514,40	X	X	X
TOTAL TAFNA BASIN		**246 979**	**1356**	**22 728**	**20 692**	**X**	**X**	**X**

INF : DHW 2005 Ain Tmouchent DHW 2006 Tlemcen

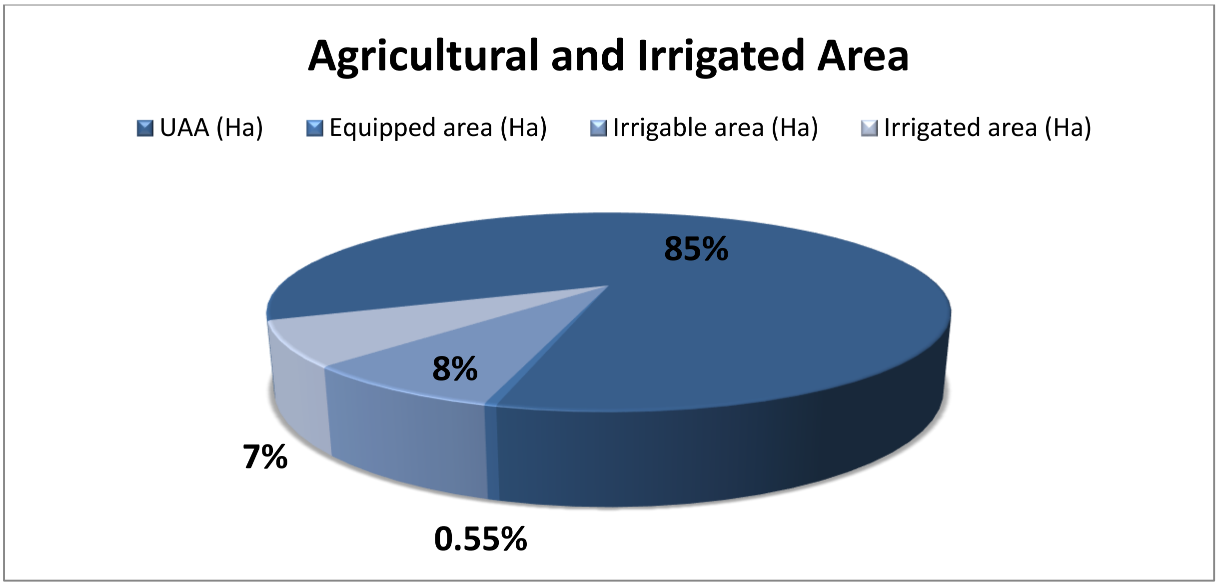


Figure3.46 Agricultural Areas and irrigation Areas 2005

II- Inventory of types of water mobilization works and mobilized volumes

Table 3.43 Underground Resources

Name of the Wilaya	drillings			Wells			Resources			Assigned volume Hm³/y	Irrigated area Ha
	Nbr	Ass vol Hm³/y	Irr area	Nbr	Ass vol Hm³/y	Irr area	Nbr	Ass vol Hm³/y	Irr area		
Tlemcen	1 225	52,55 4	6 569	1 190	23,21	2 901	217	14,73 6	1 842	90,5	11 312
Ain Tmouchent	29	0,83	154	66	1,63	104	0	0	0	2,46	258
TOTAL TAFNA BASIN	**1 254**	**53,38 4**	**6 723**	**1 256**	**25**	**3 005**	**217**	**15**	**1 842**	**93**	**11 570**

Source : DSA Camp 2005 Ain Tmouchent Source, DHW et DSA 2006 Tlemcen

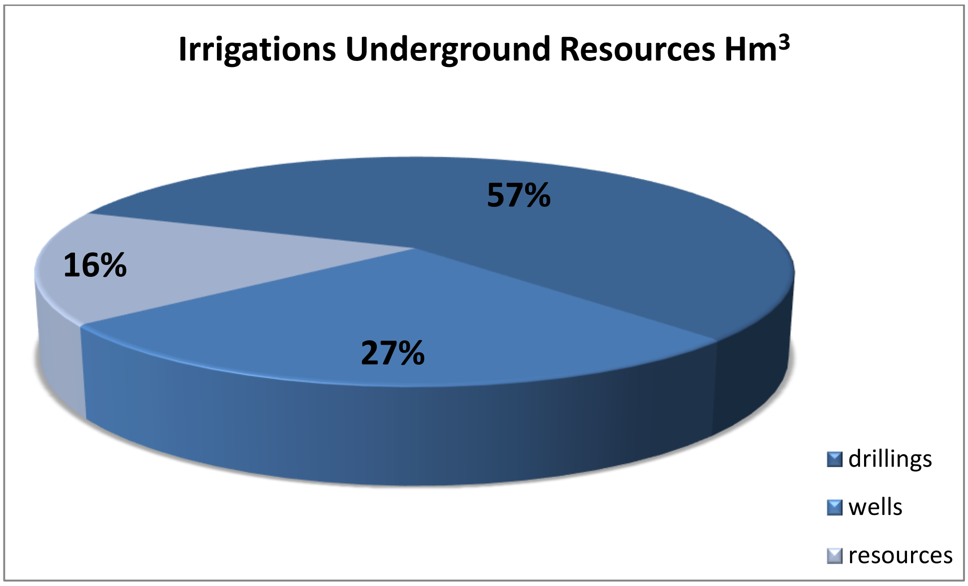


Figure3.47Irrigations Underground Resources Hm^3

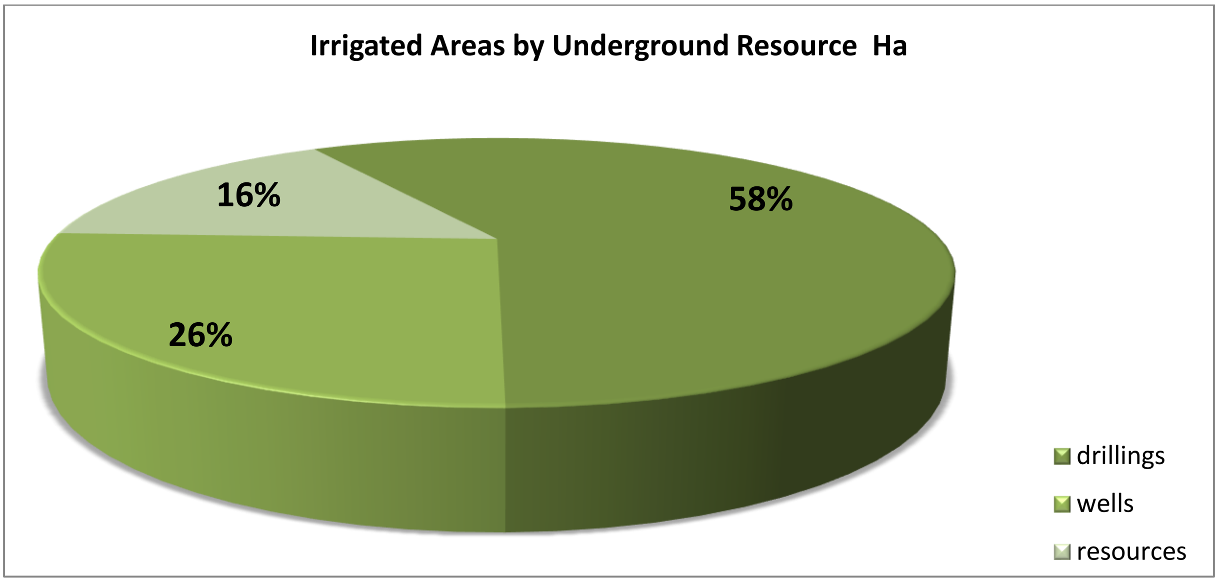


Figure 3.48Irrigated Areas by Underground Resource Ha

Table 3.44 Surface Resources

Name of the Wilaya	Assigned volume Hm^3/y	Irrigated area Ha
Tlemcen	63	7 866
Ain Tmouchent	0,2	1 256,40
TOTAL TAFNA BASIN	**63,2**	**9 122,4**

Source : DSA Camp 2005 Ain Tmouchent Source: DHW et DSA 2006 Tlemcen

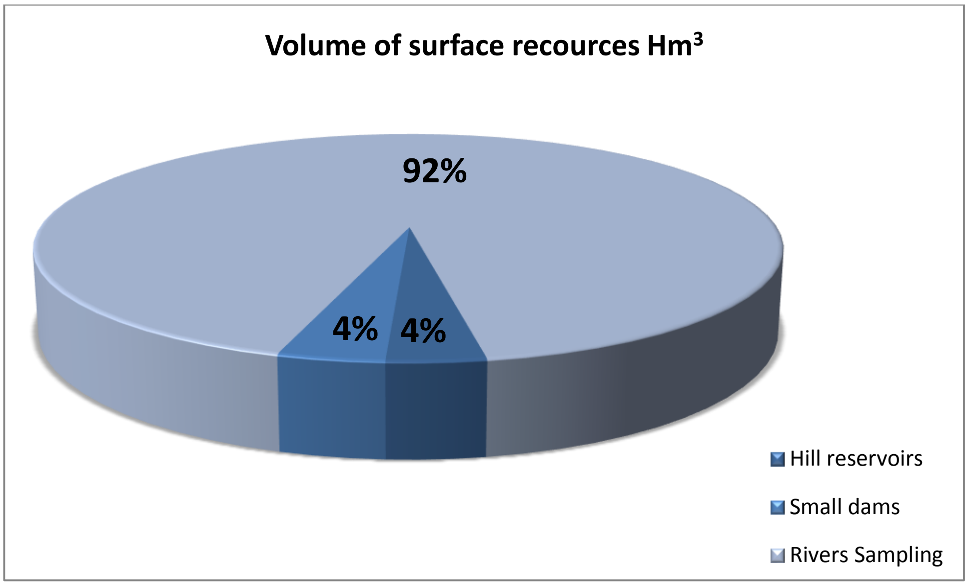


Figure 3.49Volume of surface resources Hm^3

NB: (*) Hill reservoirs + Small dams in the wilaya of Tlemcen)

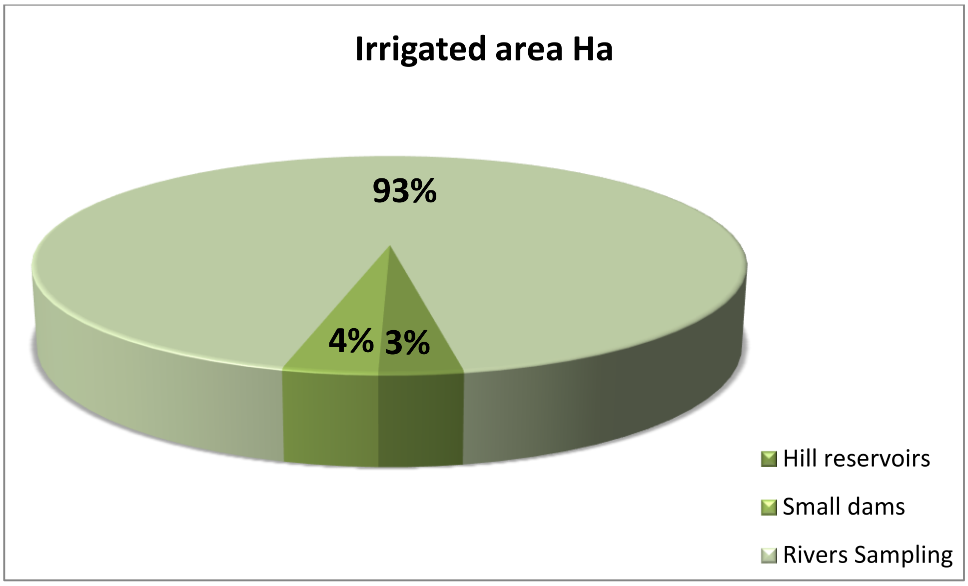


Figure 3.50 Irrigated area Ha

III- Distribution of the irrigated area according to the underground and superficial resources in the basin

Table 3.45 Distribution of the irrigated area according to the underground and superficial resources in the basin

Total irrigated area (Ha)	Irrigated area by underground water resources (Ha)	Irrigated area by surface resources (Ha)
20 692,4	**11 570**	**9 122,4**
100%	**56%**	**44%**

Source: ANRH

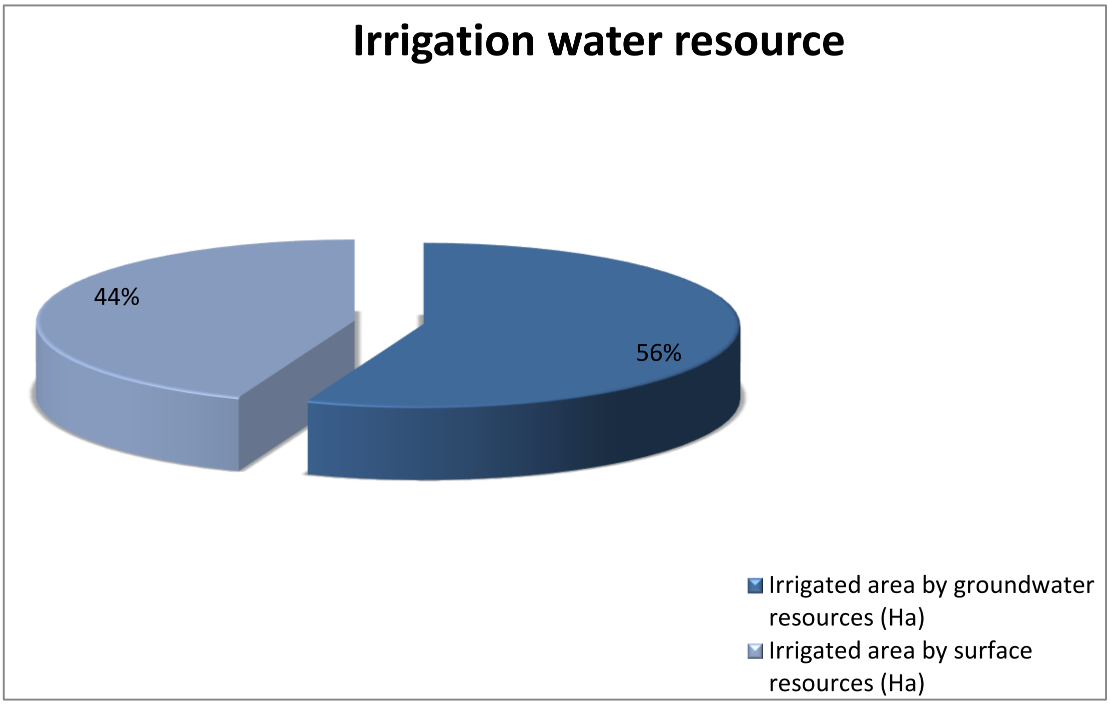


Figure 3.51 Distribution of Area Irrigated based on Water Resources

We find that the areas irrigated by the underground resources are larger than the areas irrigated by the surface resources in the Tafna basin. Irrigation works are generally silted and non-functional (hill reservoirs).

3.25 Conclusion

The semi-arid nature of the Basin and the high water demand for water resources suggest that agricultural development is fragile. The determination of the agro pedological value of soils across the basin has been approached from numerous studies of ANRH on several horizons. The synthesis of these different studies made it possible to draw sketches at different scales on 27 848 Ha of irrigable soils with different soil categories. As part of the cadastre inventory, areas and irrigation infrastructure, has highlighted the intensive exploitation of underground resources for irrigation with the sinking very well of wells and boreholes.

The exploitation of superficial resources is minimal; in fact the hollows are mostly untapped because of their siltation. This situation is the consequence of infrastructure management conditions, as well as the choice of the hill dam sites. These types of infrastructure should contribute to the increase of irrigated land. As a result, it is clear that the development of this economic potential requires sustained inter-sectoral efforts to achieve the objectives set by the government in agricultural development. The programmable actions are summarized by:

• Continuation of programs to rehabilitate existing hydro-agricultural infrastructures.

• Construction of hydraulic structures to mobilize new water resources in accordance with the regional plan for hydraulic development.

• Respect for PNDRA-PPDR agricultural development plans (according to agro-pedological skills and the availability of water resources).

• The introduction of modern and water-saving irrigation systems

• The treatment and reuse of wastewater for the development of peri-urban agriculture.

• Rehabilitation of the Maghnia perimeter irrigation network, and increased capacity to mobilize new resources.

• The mobilization of the treated wastewater from the Maghnia wastewater treatment plant for the Maghnia perimeter

• The mobilization of treated wastewater from the Tlemcen wastewater treatment plant for small perimeters located north of the Tlemcen urban group (SMH).

Chapter 4: Results and Discussion

4.1 Results

Based on the data that we had collected in my research internship and the analysis of the studies and research that have been done already in this area we tried to prove there is an impact of climate change on the rainfalls and variation of flow and solid flow. The studies have been made on 3 rainfalls station 4 hydrometric stations.

Rainfalls stations:

- M'LILIA HENNAYA, rainfalls data (1974 to 2010);
- ZAOUIA BEN AMAR, rainfalls data (1974 to 2010);
- DJEBEL CHOUACHI, rainfalls data (1976 to 2010).

Hydrometric stations: We had chosen 3 sub basin (16 05, 16 06, 16 07) and 3 Hydrometric stations (Appendix F).

- The outlet of the fist sub basin REMCHI station, flow data (1972 to 2005);
- The outlet of 2nd sub basin DJEBEL CHOUACHI station, data (1972 to 2005);
- Hydrometric station of WADI CHOULY, flow data (1970 to 2004).

Observations:

- Rainfalls data are for the maximum daily value registered in each year;
- Flow data show the water level in the rivers, the flow and solid flow, the concentration of solids in the flow and all this is registered per hour for 36 year;
- The most extreme events that caused flash flood were registered between 2000 and 2010.

Rainfalls stations:

Table 4.1: Results of Kendall Rate Test for rainfalls and P value

Rainfall Station	Kendall's rate	P Value
M'LILIA HENNAYA	0,047	0,701
ZAOUIA BEN AMAR	0,056	0,638
DJEBEL CHOUACHI	0,323	0,008

Using the software XLSTAT and after an analysis to the data of rainfalls and solid flow we got this results.

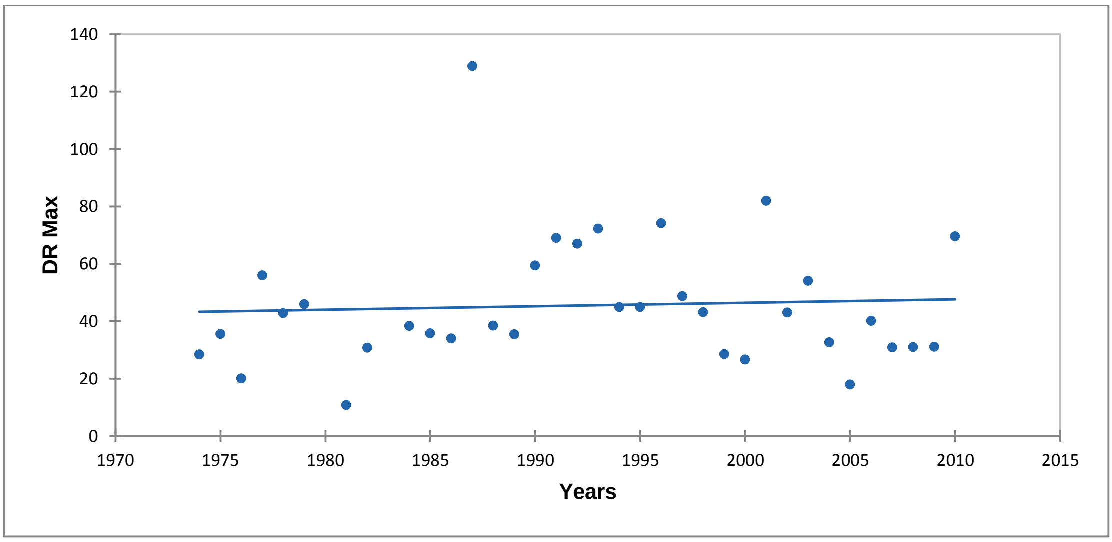


Figure 4.1: Results of Kendall Rate Test in the rainfall station of M'LILIA HENNAYA

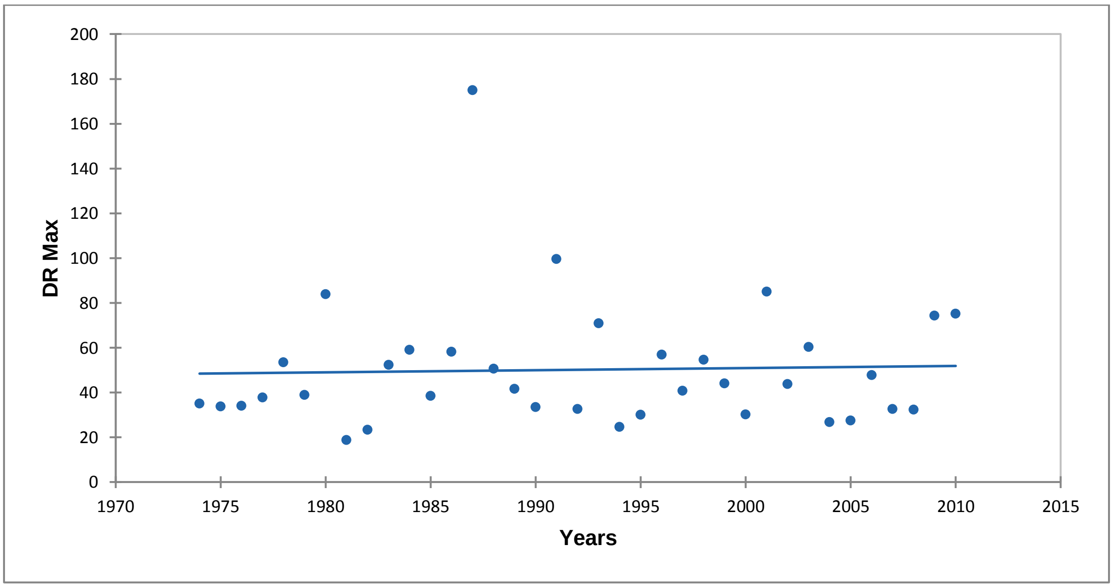


Figure 4.2: Results of Kendall Rate Test in the rainfall station of ZAOUIA BEN AMAR

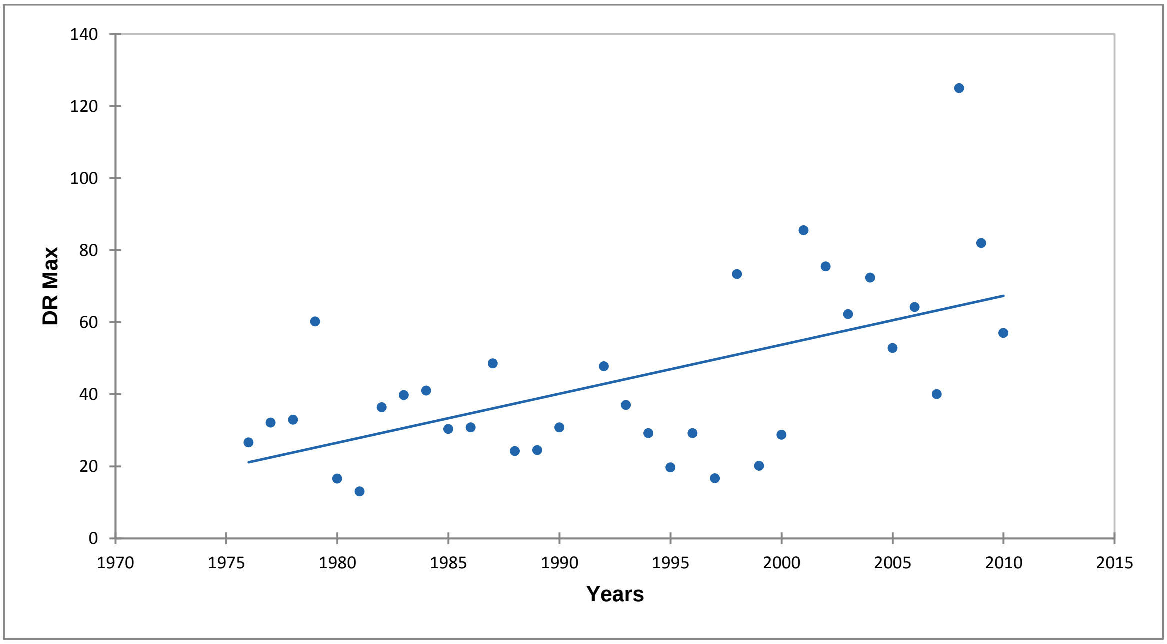


Figure 4.3: Results of Kendall Rate Test in the rainfall station of DJEBEL CHOUACHI

Hydrometric Stations:

Table 4.2: Results of Kendall Rate Test for solid flow and P value

Hydrometric Station	Kendall's rate	P Value
REMCHI	**0,210**	**< 0,0001**
WADI CHOULY	**0,134**	**< 0,0001**
DJEBEL CHOUACHI	**0,409**	**< 0,0001**

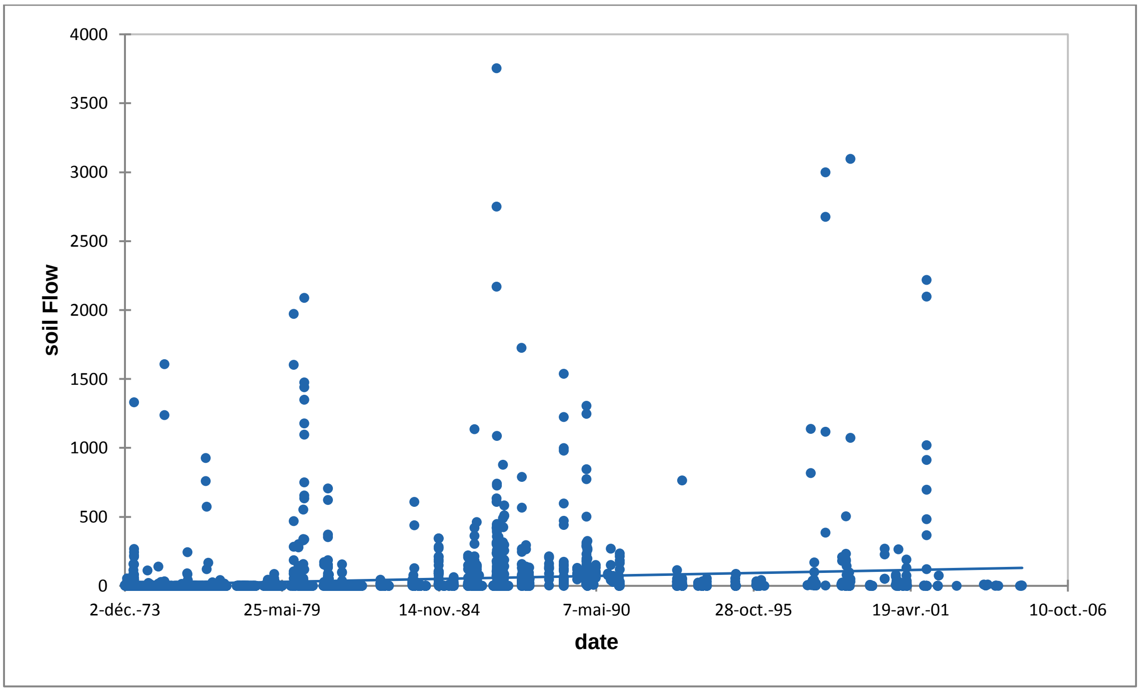


Figure 4.4: Results of Kendall Rate Test in the hydrometric station of DJEBEL CHOUACHI

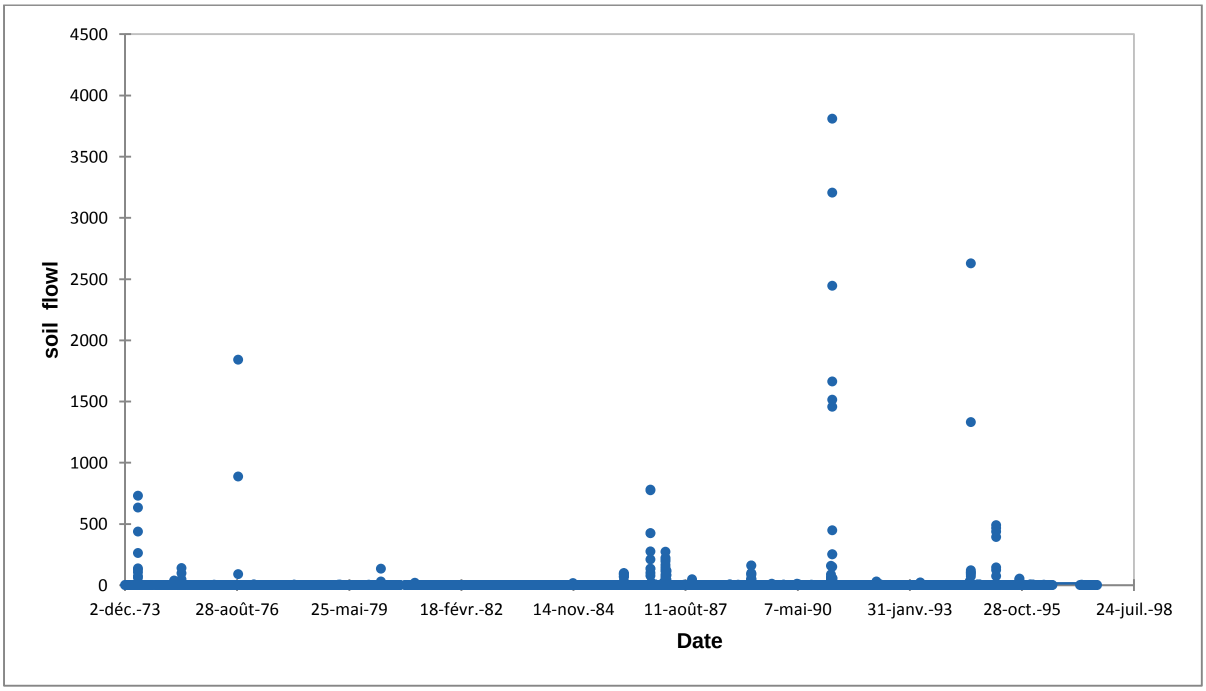


Figure 4.5: Results of Kendall Rate Test in the hydrometric station of WADI CHOULY

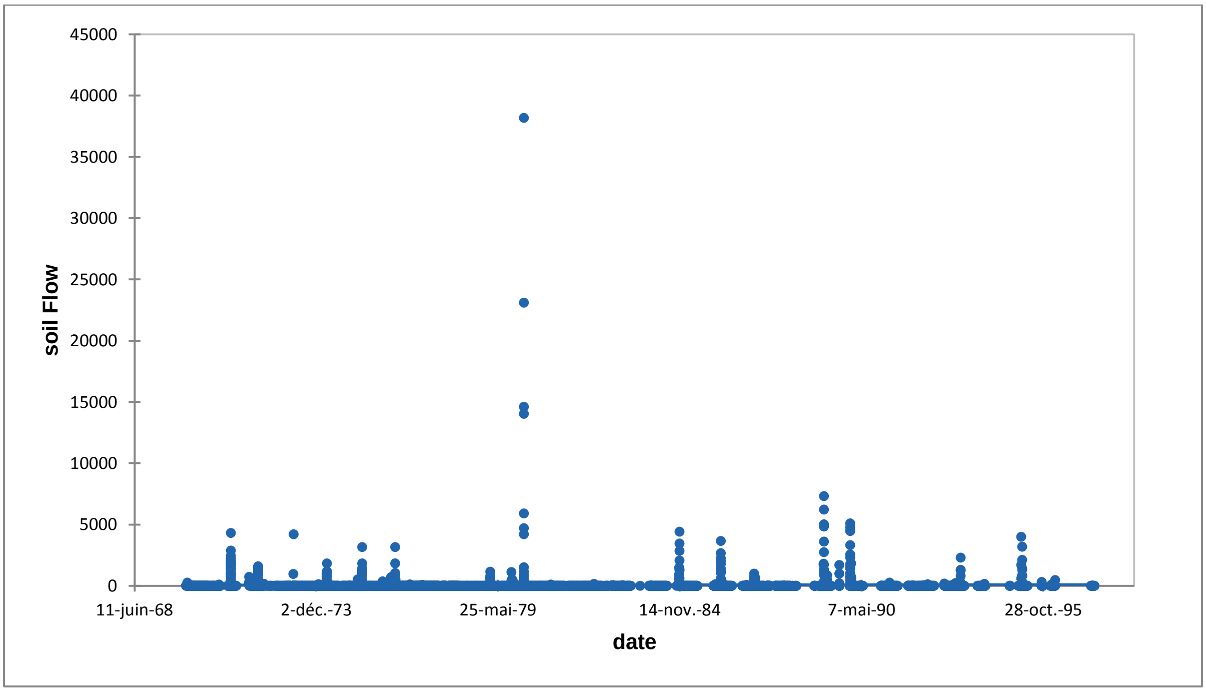


Figure 4.6: Results of Kendall Rate Test in the hydrometric station of Remchi

From the result of Kendall test for data Rainfalls (3 stations) we clearly see that the daily rainfalls trend is increasing (Tab1 and figure 1, 2, 3).

The same case for hydrometric stations, the result of Kendall test for data Solid Flow (3 stations) we clearly see that the Solid Flow trend is increasing (Tab2 and figure 4, 5, 6).

4.2 Discussions:

The daily maximums rainfalls data were registered for a period more than 36 years wish is good for climate study, the daily maximum rainfalls represent the extremes events of rain registered in one day, this extremes events of rain cause other extremes events called flash flood in our case and base on the maps of topography (map of slop appendix D and map of elevation appendix C) and hydrographic network (maps of hydrographic network appendix B and map of density of the hydrographic network appendix A) the area of our case study is favorable to flash flood and the phenomena of erosion, the flash flood cause a massif erosion and the data of soil flow registered show the quantity of soil moved and transport by the flood from the lands and rivers.

Other studies in this area the climate change and its impact:

- Professor TABET AOUEL Mahi who has a lot of works and papers on the climate change in the Maghreb Area
- Dr BOUTKHIL Morsli who is the director of the regional institute of forest annex erosion, he had work for more than 20 years on erosion in the same area that we are working on and he found out that:

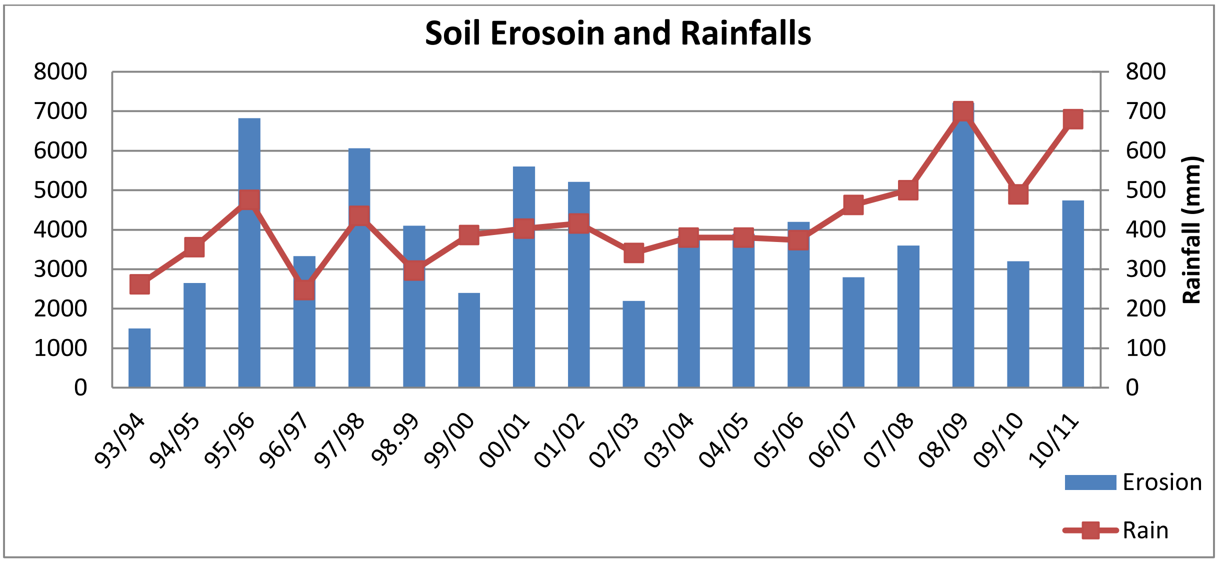


Figure 4.7: Amount of soil erosion and rainfalls (1994-2011) Source: MORSLI

The mean observation that we can get from this figure is the irregularity of rainfalls in this last 18 years and the same for erosion, when the amount of rainfalls increase the rate of erosion increase to and the opposite of it, that confirm that there is a clear relation between rainfalls and erosion in our study area.

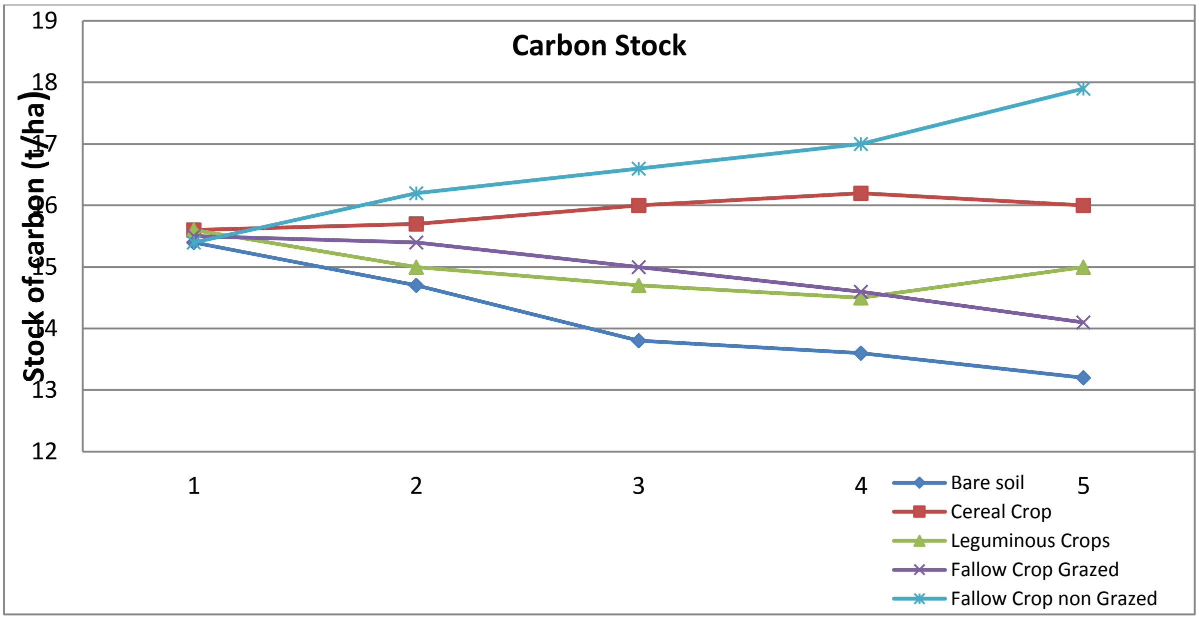


Figure 4.8: Evolution of carbon Stock in the different lad use Source: MORSLI

From this figure we observe the evolution of the carbon stock in the experimental sites in a period of 5 years with different practices of crops; the bare soil is losing a lot of carbon because of water erosion.

These results confirm the results that we got in our case study, for the erosion there is a clear increase in erosion rate and this is causing serious damage to the amount of carbon in the soil, this is influencing the fertility and the productivity of the soil wish leader to a serious question to food security

4.3 recommendations

4.3.1 Integrate food security and food security concerns climate change.

Policies and programs to address climate change and those that are necessary for sustainable food security must be complementary and not independent. The Climate change is one of the many threats to food security. In general, interventions aimed at strengthening the resilience of alimentary systems also contribute to adaptation to climate change. The efforts put into to increase spending on adaptation alone would be more effective if intended to increase spending on sustainable food security in general, giving particular attention to the particular and uncertain threats arising from climate change and requiring action today (public sector, private sector and other sectors). Farmers should be at the centre of these initiatives, and adapted approaches to the local reality should be developed that respond to the concerned community needs and who rely on their knowledge.

a) Immediately increase investment in food security and resilience to climate change

Even if climate change threats are not taking into account, it will take much larger investments to improve productivity and thereby achieve food security. These investments should also aim to improve the resilience of the food system as a whole.

Investment in physical infrastructure that allows producers to remain connected to markets and large urban areas to be supplied with food are essential to ensure the resilience of the food system as a whole and food security. In particular, investments are needed to improve transport and marketing infrastructure.

The likely increase in the frequency of extreme weather events will accentuate the risk of disruption of the supply networks, it will be crucial to diversify sources of supply. Intermediaries and retailers in the food chain may need access to larger reserve stocks. Investments are also needed to facilitate inventory management and reduce product losses food.

b) Re-focus adaptation and mitigation research to target a more complex set of objectives, and invest in public research on adaptation

Agricultural research should fully integrate aspects of adaptation to change climate change and the mitigation of its effects. Although research to increase yields essential to achieving broader food security objectives, it is necessary to essential to refocus research continuously and in an accelerated manner in order to more complex set of objectives to put in place a sustainable development food production system and cope with climate change. Neglected crop assessment, productivity fruit and vegetable crops, the effects of stress combinations, biodiversity and efficiency agricultural systems and the efficient provision of ecosystem services deserve increased attention.

Research on mitigation practices needs to take into account the impact of these practices on food security. A reorientation of research will require, from the outset, a significant commitment to farmers and intended beneficiaries, as well as a real dialogue that will help to understand their needs, taking into account the difficulty that may exist in seeking the views of women and disadvantaged groups.

c) Modernize extension services

There is an urgent need for modern, revitalized extension services, based on different financing models that can appeal to the public sector, the private sector and civil society to address the challenges of climate change for food Safety. To ensure adoption of technologies to improve productivity and adaptive capacity, extension programs should target those who take the management decisions. In the 21st century, an extension service needs to work closely with the research sector, the private sector and civil society, in order to strengthen the skills that will sustainably increase yields and meet the challenges of climate change.

d) Build capacity

Many countries lack physical, institutional, social, biological and to address climate change and the challenges of food security. It is investment in human capital, especially education and infrastructure health, to build resilience to food insecurity, to raise awareness of the risks inherent in climate change and respond effectively.

Information on adaptation and mitigation is an essential element in strengthening the resilience and the ability of people and states to anticipate and manage climate change. Climate change knowledge systems are dynamic, and new ones see the light of day as information and research data become available. Governments and other actors must restore their collection capacities more responsive and innovative information and put in place management and dissemination systems information about all hearings, with particular attention to groups more vulnerable. Systematic efforts to build these capacities are urgently needed.

4.3.2 Enhance the adaptive capacity of food systems at climate change

The adverse effects of climate change are already being felt in some regions, and in the long term, the consequences will probably be very negative for the whole planet. Resilience food systems must be strengthened at all levels, from the field to the landscape and the markets; it usually requires a comprehensive set of interventions, which must be contact information. Farmers and producers cannot succeed alone in adapting to change they must be supported by their government and the private sector, and Civil society organizations also have an important role to play. Adaptation to climate change will likely require the adoption of new practices and the modification of livelihood strategies of most, if not all, food producers, as well as other actors in the food chain, including farmers, retailers and intermediaries, the agri-food sector, the financial sector and civil society. It will require measures and follow-up by governments, international organizations and civil society organizations active in the field of security and sovereignty food, hunger and sustainable development. Accommodations must be clean to the local context. They must take into account socially disadvantaged groups, differences between men and women, and in particular the role of women as decision makers in food systems. Many of the recommendations made hereafter are said to be "no regrets" because, regardless of concerns about change climate change, they contribute in any case to sustainable food security. In any case, the effects of climate change give them a new urgency.

a) Base adaptation measures on an assessment of risks and vulnerabilities

Preventative adaptation to climate change requires regular risk assessment and vulnerabilities, updated as new information becomes available. The High and middle-income countries are increasingly doing this type of states that do not have the capacity must be able to benefit from external assistance. It is crucial to communicate carefully with policy makers, as well as with a wider audience, about the inevitable uncertainties.

b) Facilitate exchanges on practices

Examples of community-level coping strategies include the improvement of water management practices (e.g. building infrastructure to improve the efficiency of irrigation systems as well as the capture, storage and use of small-scale water scale), the adoption of practices to conserve soil moisture, organic matter and nutrients, the cultivation of short cycle varieties and the establishment of community-based seeds and cereals. In this respect, the main difficulties concern the dissemination of existing information and knowledge, the enhancement of human and social capacities and the putting in place policies in favour of best practices.

c) Promote greater diversity of crops grown and provide wider access to genetic resources

In an increasingly uncertain environment, diversifying production is one way to improve the resilience of farming systems. Effective adaptation will require access (both physical than legal, thanks to appropriate intellectual property rules) for existing crops, livestock and related wild breeds, or for varieties that may be used in the future. The genes of cultivated plants improving the drought and flood tolerance must be identified and shared. The characters relating to the stability of the yield of species under varying conditions constitute a particularly important, that better study and understanding is essential the research. Food producers, public and private sector institutions, researchers and governments must strengthen their cooperation and ensure the dissemination, distribution and creation of knowledge as well as the transfer of technologies to characterize, conserve and preserve genetic resources, both in situ and in seed banks and genetic material and related structures to facilitate adaptation to change climate. Everything must be done to limit the genetic impoverishment of biodiversity still existing, in situ as in gene banks. The adoption by all countries of the Treaty International Convention on Plant Genetic Resources for Food and Agriculture, as well as the urgent implementation of Articles 5 (conservation), 6 (sustainable use) and 9 (rights of farmers) would be positive developments in this regard. Measures to develop markets for underutilized species and to raise consumer awareness of the importance of a varied diet would help increase agricultural biodiversity. The Commission genetic resources for food and agriculture could consider defining priorities and to develop an action plan for the conservation and use of genetic resources in the context of adaptation to climate change. The question of knowing whether current intellectual property rights regimes favour or hinder the development and the use of improved plant and animal varieties and agricultural biodiversity is currently debate. The Committee on World Food Security (CFS) could recommend to the Group experts to carry out a study on the issue of genetic resources, and including intellectual property rights and farmers' rights.

d) Make weather forecasts available to farmers

One of the great challenges of climate change is likely to be dealing with cycles more variable weather. Access to weather forecasts can help farmers to better cope with this increased variability and extreme events, provided that the information is communicated in time to those who need it. Information technologies and Well-designed and well-resourced communications (ICTs) can to establish this link with the national meteorological services.

e) Develop integrated land use policies

Effective adaptation to climate change will make it even more necessary to develop integrated land use policies. With the evolution of precipitation patterns (and the frequency of extreme events) and the seasonal flow of rivers, it will still be more important to optimize water resources in watersheds and aquifers. Passive measures such as the preservation of forests and mangroves can be revealed just as important as active interventions. Mechanisms like REDD (Reduction of emissions caused by deforestation and forest degradation) and other means of payment for ecosystem services should also be among the tools used to improve the resilience of ecosystems and communities to change climate. Urban and peri-urban agriculture can also play a major role in adaptation cities.

f) Facilitate farmers' access to financial services

In order to enable farmers to make the necessary changes to their systems, governments must facilitate smallholders' access to financial products. It suits in particular to provide them with better access to credit and insurance programs to cover these investments and better manage the financial consequences of the risks weather.

g) Promote an international trade regime that incorporates the concept of security food and contributes to the resilience of food systems

As a result of the 2008 food crisis, the issue of food security has new importance in the agricultural trade negotiations. The concept of access to products today, it is considered as important as the traditional concept of access to markets. Current WTO provisions and rules in the area of food security unclear or non-existent, and the Doha negotiating mandate offers little margin for manoeuvre to make progress on these issues. In addition, due to climate change, will be even more difficult to achieve food security, and it is clear that world food will have a decisive role to play in a world facing this phenomenon. Integrate all these important issues into future agricultural trade negotiations would be a step in the right direction.

h) Prioritize interventions proposed in national action programs for adaptation to climate change

It is very important at the global level to adapt agriculture to climate change and have national adaptation plans. National Adaptation Programs of Action, which have been submitted to the UNFCCC by the Least Developed Countries (LDCs), draw attention to the priority investment in agriculture and food security. They provide a starting point for prioritizing national investments. The priority measures identified by LDCs in their National Adaptation Programs of Action must be financed and implemented. Countries need to build on the experience of these programs to develop their national adaptation plans.

i) Establish food and water security in inland areas

To achieve food security in the context of climate change, it will be important to put in place drought contingency funds and regional reserves cereals and grain storage facilities at the household level. It is essential to pay greater attention to improving the water supply management than water demand management, in order to strengthen the water security of crops, livestock, households and the industrial sector. A sustainable system of security of water supply must be put in place for each agro-ecological region; he a participatory water management system should be established, involving family farms, so that local communities have an interest in conserving water and use it in a sustainable and equitable way.

j) Strengthen the resilience of populations to a risk of water scarcity accentuated by climate change

Water is a limited natural resource and a public good essential to life and health; it is indispensable for the realization of the right to adequate food. The CSA and the governments must promote and develop research and support programs in favour of universal access to sufficient and good quality water in rural areas. It is necessary to build on participatory methodologies and the leading role that can be played by communities in developing effective and equitable means for the collection, storage, management and distribution of clean water, respecting and protecting biomes, preserving the natural resources and stimulating the recovery of degraded areas.

k) Climate change and water in coastal areas

Nearly one-third of the world's population lives along the coast. The sea level rise will have likely to have adverse impacts on both coastal agriculture and livelihoods communities living in these areas. Studies and preventive actions are needed to prepare coastal communities to cope with rising sea levels and intrusion of saline water. Preventive action plans to ensure the safety of ecosystems and livelihoods in coastal areas should include:

- ✓ Shielding natural mangrove along the coast, in compatible agro-climatic zones;
- ✓ The use of salt tolerant varieties for rice and other crops;
- ✓ The development of systems of land and water management for agro forestry and coastal aquaculture; and conservation and the use of halophytic plants, which are adapted to high salt concentrations. Of the relevant organizations, such as the Consultative Group on International Agricultural Research (CGIAR), could be encouraged to support and participate in such initiatives. Nearly 97 percent of the world's water resources are seawater; explore the possibilities for seawater agriculture, which would imply the multiplication of agro-aquaculture farms. The cultivation of halophytes of economic interest and breeding salt-resistant fish species will contribute to enhancing food security and secure the livelihoods of coastal communities. We therefore recommend launch of a scientific movement on seawater agriculture for the prosperity of the zones along the coasts and in small islands.

4.3.3Develop low-emission agricultural strategies that do not do compromise food security

If nothing is done, any increase in food production will automatically result in an increase in emissions; however, many solutions exist to eliminate the link between food security and emissions. When considering the establishment of policies and mitigation programs in agriculture, we must focus on those who do not negative impacts on food security. Fortunately, many of these solutions create synergies between mitigating the effects of climate change and improving food Safety.

A considerable amount of emissions from agriculture can be reduced through more efficient use of resources (especially land, livestock and fertilizers) and good management practices which, in most cases, also improve productivity and strengthen resilience. Public policies and programs should target the development and dissemination of these practices and systems. The mitigation measures chosen should not increase vulnerability to food insecurity. Incentive based systems that target the most vulnerable while reducing emissions and building resilience to climate change, have multiple advantages.

a) Limit land use change to agriculture

Land-use changes that are rich in surface carbon (mainly forests), which most are converted to arable land or pastures, are the second most important source of release of CO2 into the atmosphere, just behind emissions from fossil fuels. It is almost always more efficient to improve the yield of land already cultivated, to reduce the GHG emissions from agriculture, than to expand the area. Put an end to most conversions of forests to cropland should be a priority mitigation goal. Any new land earmarked for production must be in accordance with the good practices described below.

b) Adopt farming and grazing practices that prevent the loss of soil carbon, to allow the construction of carbon banks and to prevent land degradation

The organic carbon content of farmland is largely dependent on management practices to which they are subject. With carefully selected agro ecological practices, degraded lands can be rehabilitated and thus contribute to food security, adaptation to climate change and its mitigation by increasing carbon sinks. He unpolluted urban organic waste must be repatriated to agricultural land in order to improve agricultural productivity and mitigate climate change, taking into account the direct costs and indirect effects of this operation. Policies and programs that make nitrogen use more efficient have benefits, by simultaneously reducing expenditures on agricultural inputs, direct and indirect emissions of GHGs, and the damage to the environment outside of exploitation.

c) Improve the management of farm animals and their manure

Emissions from livestock farming are likely to grow rapidly as a result of population growth and changing diets. Improve productivity to allow farmers to significantly reduce GHG emissions per unit of production (meat and milk) must be a priority. Manure and slurry processing bio energy / biogas and fertilizer using methanizers has multiple advantages: lower net emissions, substitution of emissions, and better supply of energy sources and improving the quality of fertilizers. Further studies are needed in this field.

d) Improve water management in rice paddies

By changing irrigation regimes, emissions from paddy fields, while saving water without reducing yield.

e) Evaluate and compare farming systems

There is an urgent need to better assess and compare different farming systems, taking into account all emissions, direct and indirect.

f) Manage food consumption to reduce to reduce emissions linked to alimentary systems

We must be more attentive to the role that a change in diet can play to roll back the demand for GHG-intensive commodities. Governments must promote modes responsible consumption, the efficiency gains along the food chain and the reduction of food waste. The private sector should be encouraged to develop products and distribution systems that generate less GHG emissions.

g) Assess the contribution of different types of bio fuels to the mitigation of climate change and food security

Quantifying the effectiveness of bio fuels in terms of GHGs is an extremely complex exercise, which suffers from many uncertainties because of the direct and indirect use of energy for irrigation, inputs, transport, processing, especially nitrogen for bio fuels first generation, and the associated reduction in carbon stocks in the case of converting forests, wetlands or other carbon-rich lands for crops for bio fuels. Concerns were also expressed about the impact of bio fuels on other environmental challenges, including biodiversity, as these conversions land are often accompanied by a shift to monoculture, intensification of deforestation, risks to nature reserves, increased pressure on water reserves and problems related to water quality. Efforts to evaluate the contribution of different types of bio fuels to mitigation are important and need to be prosecuted.

h) Help farmers adopt practices that offer multiple benefits

Farmers must be helped to adopt practices that enhance their resilience and safety and which are long-term beneficial to the climate. To do this, they must be able to benefit from an enabling environment, including services and institutions for support, such as extension services. Moreover, even if this news practices will offer them better incomes in the future, obstacles to their initial cost, as well as the income to be renounced and the increased risks that occur during the transition period. These costs must be covered. It was hoped that carbon finance mechanisms could provide new sources of finance, from issuers in developed countries to farmers, in exchange for reduction of carbon emissions or storage. However, experience has shown that these mechanisms were difficult to implement and were not suitable for small-scale farming because of the small size of the farms, which drives up transaction costs, increases the difficulty and cost of the evaluation and reporting of results and the price instability of the carbon. Among the financial tools, different mechanisms are examined, whether or not based on markets (voluntary carbon markets, green funds, etc.). Regardless of the type of support or incentives to improve the efficiency of the food system and to internalize externalities related to GHG emissions and sinks, it is recommended that the mechanisms to take into account both the situation of smallholders and the need to prioritize measures that improve food security while contributing to mitigation.

4.3.4 Gather information locally, share information knowledge at the global level and reorient research for aim for a more complex set of objectives

The information available to facilitate the development of policies and programs aimed at mitigate the effects of climate change on food security are now cruelly and national authorities should step up their efforts in this area. However, it is also essential to collect international data on climate change and its effects, in order to obtain better information on communities, populations and vulnerable regions.

Lessons learned at the local level will be much more valuable if they are shared. The knowledge already acquired by farmers about the practices that work in their environment today could prove invaluable in the future for other farmers around the world. But some of the consequences of climate change are field of recent human experience, and efforts to produce systematic data and targeted are essential to provide an effective response. Census and sharing knowledge generates benefits that transcend borders, which is why they need to be coordinated at the international level and not just the subject of national programs. The quality and the quantity of biophysical data need to be significantly improved, economic and social opportunities available to policy makers. The difficulties are among others following:

- ✓ to link existing and future data sources, building on global standards for metadata;

- ✓ make use of modern technologies (ICT, remote sensing) to collect data in real time;
- ✓ enable data collection disaggregated, including at the intra-household level, in order to identify factors of social vulnerability to food insecurity and issues related to adaptation and mitigation; and
- ✓ Improve the data, from collection and analysis to their use for the development of policies.

a) Collect more biophysical data

The plants and animals that enter our diet are characterized by great genetic diversity. However, their performance has not been systematically evaluated in different agro climatic conditions. The experimental data available to us should be supplemented by the collection of additional information on these yields and new tests must be carried out in order to identify the characteristics of these returns outside the types of climate we are currently experiencing. The quality of existing data on the climate evolution is uneven, with some countries performing better than others in collecting and diffusion. More data needs to be collected, and much more, freely available.

b) Monitor current practices and results

Adaptation is a learning process. Much can be done to adapt agriculture to climate change by building on what is already known about social, economic and social aspects, biophysical aspects of food production. The skills and knowledge that are adapted to one region may be important for another region in the region in future. The effects of adaptation and mitigation measures need to be rigorously determine their impact in the different relevant areas and on food security, in order to ensure that they do not have undesirable adverse consequences. Collection and dissemination at large scale of this information is essential, and ICTs offer unprecedented opportunities.

c) Improve information on communities, populations and vulnerable regions

Significant information gaps impede our ability to understand consequences of climate change on regions or vulnerable groups. To be effective coping requires a better understanding of who the vulnerable are and where they live.

d) Improve models that promote understanding of the effects of climate change on agriculture

It is essential to improve the models and to integrate information on communities, vulnerable populations and regions. Climate models generate large amounts of data on the possible effects of climate change in the future, but these are not always summarized so that they can be useful in understanding its potential effects on agricultural production systems and vulnerable populations. The models that link climate change to biophysical effects, and then to human well-being, to be considerably improved. Small investments would be enough to provide policy support makers around the world.

It is essential to build capacity in the use of different models and scenarios and to better understand their limitations and the uncertainties they entail.

e) Organize the sharing of experiences and knowledge at the regional level

Adaptation planning is driven by countries, but with regard to medium and In the long term, it is necessary to promote exchange of views, the sharing of experiences, cooperation, coordination of transboundary issues (water, genetic resources, fisheries, transboundary pests and diseases ...) at regional and sub regional levels.

f) Reorient research to target a more complex set of objectives

See recommendation 5.1.1.b

4.3.5. Facilitate the participation of all stakeholders in the decision-making and implementation

Attempt to solve the problem of food insecurity and climate change requires concerted and coordinated engagement and action by many actors - farmers, the private sector, public actors at the national and international levels, civil society and non-governmental organizations (NGOs). This is a real challenge, given the character of these actors, who sometimes have conflicting interests, and the need to work in a long-term perspective while most of them must first get worry about the short-term consequences.

a) Encourage debate on the respective roles of the public and private sectors in safeguarding food security in the context of climate change

All sectors of society influence by their actions the evolution of food security and climate. An important question for the future is how these different sectors can mobilize their efforts in the same direction, both in terms of food security and climate change, and how they can complement each other. Climate change requires more focus on long-term issues and on environmental and socio-economic vulnerabilities. In view of the controversies the evolving roles of the public and private sectors in promoting security in the context of climate change, it would be wise to promote a wider debate on the real effectiveness of public-private partnerships by examining the experiences on the ground. The participation of the affected communities should be ensured, including the organization of prior and informed consultation on the risks and the direct and indirect effects on resilience small farmers and rural communities.

b) Involve all stakeholders in public sector decisions

Changes on the ground, which are necessary for both adaptation and mitigation, will be undertaken by many actors along the marketing chain, producers to consumers. The public sector creates and sets the conditions under which private sector decisions are made in the form of policies and programs. Civil society importance because of its multiple roles, which range from controlling the actions of the government and the private sector to the integration of diverging interests, through Institutional. Activities to address climate change must be carried out in giving explicit attention to the needs of the poor; he is particularly important to highlight the role of women as decision-makers in agriculture, because they are an integral part of the process of planning, designing and implementing policies and programs to address the challenges of food security in the context of climate change.

c) Encouraging the exchange of information between public authorities and promoting technology-sharing partnerships to ensure that the value of public goods and knowledge gained locally benefits all

International cooperation between governments, as regards best practices adaptation and mitigation measures, as well as the transfer of sustainable technologies, is essential to reduce the effects of climate change on food security. Regional programs on climate change and food security can be implemented in the context of regional integration initiatives. Lessons learned from successful national programs that can operate at the regional level can be shared and help countries to develop their own programs. But the lessons learned in a region today could be important for other regions in the future. Institutions capable of disseminating knowledge at the international level will be necessary for both adaptation and mitigation.

d) Improve transparency and enhance civil society participation for more equity and efficiency

Transparency of public sector decisions in the context of policies and adaptation and mitigation programs is essential to improve equity and efficiency. The participation of farmers, fishermen and foresters allows them to contribute to methods that promote the efficient use of resources. The participation of the company allows other groups likely to suffer the consequences of climate change, directly or through the action of other actors, to be better informed about potential activities and guide the process to achieve more equitable results. Governments must also ensure that all stakeholders can hear their voice, in order to ensure the transparency of the process, the exchange of information and experiences on relevant issues related to policies and interventions in food security and climate change.

4.3.6 Recommendations to the CSA

a) Take into account the recommendations on climate change in the Global Strategic Framework for Food Security and Nutrition

The CFS is in the process of developing a Global Strategic Framework for Food Security and nutrition. We strongly encourage him to make recommendations in this report of the key elements of this Framework.

b) Encourage more explicit recognition of food security in activities of the UNFCCC

In recent years of UNFCCC negotiations, it has become clearer than Mitigation and adaptation measures for agriculture were needed. At the Seventeenth Conference Parties in Durban, the negotiators sought input from member countries and observers on matters relating to agriculture, with a view to taking a decision at the eighteenth Conference, Doha (December 2012). A program of work of the Subsidiary Body on UNFCCC Scientific and Technological Advice, with a clearer presentation of the benefits and the disadvantages of different adaptation and mitigation measures as well as the synergies possible with food security, could provide a framework for organizing ongoing research and encourage new research relevant to the negotiations. We recommend the implementation of this program. We also recommend that more important progress should be made into contributions to the Workplace Loss and Damage Program, highlighting the adverse effects of climate change on agriculture and security food. Finally, the CFS should ask the UNFCCC to task national governments to report on the contribution to food security of initiatives and policies that are proposed in the framework of the National Action Plans for the fight against climate change and national adaptation plans. Developed countries have already agreed, through the Copenhagen Accord and the Cancun Agreement, to framework of the UNFCCC, to provide financial support for adaptation activities in developing countries development. The CFS must endorse this position and encourage countries to shape their support so that it also promotes sustainable food security.

c) Supporting climate change adaptation and mitigation in international trade negotiations

The World Trade Organization (WTO) has initiated a negotiation process to improve the global trading system (Doha Round). Given the increased variability of the agricultural production resulting from climate change and the fact that trade flows have the potential to mitigate some of the climate shocks to agriculture, we recommend that the CSA encourages the WTO to take into account the outcome of the negotiations that recognize this role. Similarly, we recommend that the CFS encourage the WTO to support a reform of trade policies that facilitate mitigation, rather than hinder it.

d) Strengthen the role of civil society

The CFS enjoys a unique status within the United Nations system, having regard to the official role it gives to civil society. We encourage the CSA to strengthen existing participation channels such as its Advisory Group and to support a greater number of related civil society activities action, such as the events organized in conjunction with the official sessions of the CFS and other United Nations bodies, in particular the UNFCCC conferences, in order to give more the reports issued by the High-Level Group of Experts and the decisions taken by the CSA and encourage debate around these reports and decisions.

e) Support the establishment of a data collection and sharing mechanism, on climate change and food security

The consequences of climate change do not stop at borders. Its effects cannot be taken into account only if data collection is coordinated at the international level, based on mutually agreed global standards on metadata. Important synergies can be found by coordinating security data food and climate change for the benefit of the most vulnerable regions and vulnerable. CSA to facilitate dialogue on efforts to improve data collection for climate change and food security (HLPE Rome, 2012).

5 Conclusion:

Climate change is a major concern for all countries, directly or indirectly. Only a global vision is able to cope with this new scourge. Southern countries such as the Maghreb are hit hard. Each country must put in place a response strategy.

The work carried out on precipitation and runoff over several years on the Tafna Basin has made it possible to better understand the phenomenon of climate change and its impact on runoff and erosion.

These results are close to those obtained at the Maghreb level. However, the average annual erosion does not reflect the extremes that are reflected in the scale of some intense rain events. Some exceptional rainfall events have caused significant damage.

The major risks are related to exceptional runoff, which is recorded especially in the fall when optimal runoff conditions are met. These runoffs especially on clay soils are at the origin of spectacular degradations that often mark the landscape for several years. An intense rain event can produce more than 30 to 40% of the annual erosion.

All runoff that causes land exports is at risk and is continually involved in soil stripping and degradation of soil fertility. Erosion strongly and steadily alters the thin organo-mineral layer of the soil surface which is the essential source of fertility and an element of resistance to erosion. Although it is a stripper, erosion reveals a selectivity mainly of organic carbon.

Climate change will affect all four dimensions of food security, namely food availability access to food, stability of food supplies, and food utilization. The importance of the various dimensions and the overall impact of climate change on food security will differ across regions and over time and, most importantly, will depend on the overall socio-economic status that a country has accomplished as the effects of climate change set in.

The people who are projected to suffer the earlier and the worst impacts from climate change are the most vulnerable populations, with livelihoods depending on agriculture sectors in areas vulnerable to climate change. Understanding the cascade of risks, as well as the vulnerabilities to these risks, is the key to frame ways to adapt. Reducing vulnerabilities is the key to reducing the net impacts on food security and nutrition and also to reducing long-term effects. Increasing resilience of food security in the face of climate change calls for multiple interventions, from social protection to agricultural practices and risk management.

Actions by different stakeholders are needed in the short term to enable responses in the short, medium and long term. Some medium- and long-term responses will need immediate enabling action and planning, and immediate implementation of investments, especially those investments that require longer time frames to be developed and arrive in the field: forestry, livestock breeding, seed multiplication, innovation and knowledge transfer to enable adaptation.

BIBLIOGRAPHY

- 2017. Hoffmann, T., Schlummer, M., Notebaert, B., Verstraeten, G., and Korup, O.: Carbon burial in soil sediments from Holocene agricultural erosion, Central Europe, Global Biogeochem. Cy., 27, 828–835, https://doi.org/10.1002/gbc.20071, 2013a.
- Albergel J., Mansouri T., Zante P., Ben Mamou A. et Abdeljaoued S., 2006. Organic carbon in the sediments of hilldams in a semiarid Mediterranean area.*In* :*Soil erosion and carbon dynamics*, É. ROOSE, R. LAL, C. FELLER, B. BARTHÈS et B.A. STEWARD édit., Édit. CRC Press, Advances in Soil Science, vol. 15, p. 289-300.
- Arabi M. et Roose E., 1991. Influence du système de production et du sol sur le ruissellement dans la station Ouzera, Algérie. Bulletin Réseau Erosion n° 9, ORSTOM : 123 – 129.
- Avenard J.M., 1990. Sensibilité des terres aux mouvements de masse. Cahiers ORSTOM, série Pédologie, vol. 25, n° 1 : 119-130.
- Benchetrit M., 1972. L'érosion actuelle et ses conséquences sur l'aménagement de l'Algérie. Pub Univ. Poitiers XI PUF Paris 1972 ; 216p.
- Bep A., Boli Z. et Roose E., 2002. Pertes de carbone par érosion hydrique et évolution des stocks de carbone sous rotation intensive coton / maïs sur des sols ferrugineux sableux du Nord Cameroun. Résumés des actes du Coll. International : gestion de la Biomasse et Erosion du Carbone, Montpellier. IRD ; 9 p.
- Berhe, A. A., Harte, J., Harden, J. W., and Torn, M. S.: The Significance of the Erosion-induced Terrestrial Carbon Sink, Bioscience, 57, 337–346, 2007.
- Billings, S. A., Buddemeier, R.W., Richter, deB., Van Oost, K., and Bohling, G.: A simple method for estimating the influence of eroding soil profiles on atmospheric CO2, Global Biogeochem. Cy., 24, 1–14, https://doi.org/10.1029/2009GB003560, 2010.
- Blanchart E., Roose E., Khamsouk B., Dorrel M., Laurent J.Y., Larre-Larroui Ch., Rangon L., Tisot JP. etLouri J., 2002. Comparaison des pertes de carbone par érosion et drainage aux variations du stock de C du sol en deux années : Cas d'une rotation bananiers-cannes-ananas-sol nu sur un nitisol argileux sur cendres volcaniques de Martinique. Actes du Coll. International : gestion de la Biomasse et Erosion du Carbone, Montpellier ; 9 p.

- Blavet D., De Noni G., Roose E., Maillo L., Laurent JY. Et Asseline J., 2004. Effets des techniques culturales sur les risques de ruissellemnt et d'érosion en nappe sous vigne en ardeches (France). Sècheresse 15 (1): 111-120.
- Boli Z., Roose E., Bep A., Ziem B., Sanon K., Waechter F., 1993. Effets des techniques culturales sur le ruissellement, l'érosion et la production de coton /maïs sur un sol ferrugineux tropical sableux : recherches de systèmes intensifs et durables en région Soudanienne du Nord Cameroun (Mbissiri, 1991-1992). Cah. ORSTOM. Pédol., 282 : 309 – 325.
- Burke, M. and Lobell, D. (2010). *Climate effects on food security: An overview. In Climate Change and Food Security: Adopting Agriculture to a Warmer World*. Lobell, D., Burke, M., Eds.; Springer: Rotterdam, The Netherlands, 2010; pp. 13–30.
- Casenave A. et Valentin C., 1989. Les états de surface de la zone sahélienne. Influence sur l'infiltration. Edit. ORSTOM Paris; 229 p.
- Casenave A., 1990. Etude du ruissellement et de l'infiltration : la technique des pluies simulées. Bull. Réseau Erosion 10, ORSTOM : 28 – 37.
- Chebbani R., Djili K., Roose E., 1999. Etude des risques d'érosion dans le bassin versant de l'isser, Algérie. Bulletin Réseau Erosion 19: 85-95.
- Cros-Cayot, S. 1996. Distribution spatiale des transferts de surface à l'échelle du versant. Contexte Armoricain, thèse de doctorat, Sciences de l'environnement, Rennes ; 223 p.
- De Noni G., Viennot M. et Trujillo G., 1991. Mesures de l'érosion dans les Andes d'Equateur, cah. ORSTOM, Sér. Pédol. 25, 1-2 : 183-196.
- De Noni G., Viennot M., Asseline J., Trujillo G., 2001. Terres d'altitude, terres de risque. La lutte contre l'érosion dans les Andes équatoriennes. IRD Editions, Paris, Collection Latitude 23 : 224 p
- Diallo D., Boli Z., E. Roose., 2008. Influence of no-tillage on soil conservation, Carbon sequestration and yield of intensive maize-cotton rotation: research on sandy Alfisols of Northern Cameroon and Mali. In "no-till farming systems"Goddard, Zoebisch, Gan, Ellis, Watson, Sombatpanit S.(eds)Special publication3 by WASWC, Bangkok : 383-392.

- Dufaure J.J., 1984.La mobilité des paysages méditerranéens. Hommage à Pierre Birot, Toulouse ; 387 p.
- European Environment Agency. (EEA). 2015.*Sol et changement climatique Le sol est un élément important — et souvent négligé — du système climatique.* Agence européenne pour l'environnement Kongens Nytorv 6 1050 Copenhagen K Danemark
- FAO ROME. 2008. *CLIMATE CHANGE AND FOOD SECURITY: A FRAMEWORK DOCUMENT*. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS ROME, 2008
- FAO. (2009a). Déclaration du Sommet mondial sur la sécurité alimentaire. Rome. http://www.fao.org/fileadmin/templates/wsfs/Summit/Docs/Final_Declaration/K6050F_Rev10_WSFS_OEWG_FINAL_17_11.pdf
- FAO. 1996. *Rome Declaration and World Food Summit Plan of Action*. Rome. Available at: www.fao.org/docrep/003/X8346E/x8346e02.htm#P1_10.
- FAO. 2001. The State of Food Insecurity in theWorld 2001. Available online: http://www.fao.org/docrep/003/y1500e/y1500e00.htm (accessed on 26 September 2015).
- FAO. 2015. The State of Food Insecurity in theWorld 2001. Available online: http://www.fao.org/docrep/003/y1500e/y1500e00.htm (accessed on 26 September 2015).
- FAO. 2015. The State of Food Insecurity in theWorld 2015. Available online: http://www.fao.org/hunger/keymessages/en/ (accessed on 26 September 2015).
- FAO. 2016. *Climate change and food security: risks and responses*. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS 2016
- FAO.2000c. Guidelines for national FIVIMS: Background and principles. Available at: www.fivims.net/static.jspx?lang=en&page=overview.
- FAO.2003b. *World agriculture: Toward 2015/2030*, Chapter 13. Rome, Earthscan.
- FAO.2007f. National Programmes for Food Security: FAO's vision of a world without hunger. Rome.
- FAO.2013b. *Climate-smart agriculture sourcebook* (available at http://www.fao.org/3/i3325e.pdf).

- Farmar-Bowers, Q. (2013). *Framing the Research Needs for Food Security in Australia. In Food Security in Australia: Challenges and Prospects for the Future*. Farmar-Bowers, Q., Higgins, V., Millar, J., Eds.; Springer: New York, NY, USA, 2013; pp. 219–234.
- Fournier F., 1960.*Climat et érosion*. Édit. Presses Universitaires de France, Paris ; 201 p.
- Fournier F., 1967. La recherche en érosion et conservation des sols sur le continent africain. Sols Africains 12 (1) : 5-53.
- Gschwendtner, S.; Tejedor, J.; Mueller, C.; Dannenmann, M.; Knabner, I.K.; Schloter, M 2014. Climate Change Induces Shifts in Abundance and Activity Pattern of Bacteria and Archaea Catalyzing Major Transformation Steps in Nitrogen Turnover in a Soil from a Mid-European Beech Forest. PLoS ONE 2014, 9, e114278.
- Habi M. et Morsli B., 2011a.Impact of water and soil conservation (WSC) strategies in improving water balance and soil production in Algeria: options to alleviate the negative impacts of climate change, Arabian Journal of Geosciences. Saudi Society for Geo Sciences.Publisher Springer, Vol. 2, n° 2.
- Hammoudi A., Monjengue BS. Et Roose E., 1989. Enquête sur l'efficacité des aménagements de DRS en Algérie. Bull Réseau Erosion ; 9 : 14-8.
- Hammoudi A., Monjengue BS. etRoose E., 1989. Enquête sur l'efficacité des aménagements de DRS en Algérie. Bull Réseau Erosion ; 9 : 14-8.
- Heddadj D., 1997 – La lutte contre l'érosion en Algérie. Bull. réseau-érosion n° 17, Edit. IRD, Montpellier, : 168-175.
- Heusch B., 1970. L'érosion du Pré rif occidental : une étude quantitative de l'érosion hydrique. Ann. dela Recherche Forestière du Maroc ; 12 : 9 -176.
- Heusch B., 1986. Cinquante ans de banquettes de DRS. –C.E.S. en Afrique du Nord : un bilan cah. ORSTOM, sér. Pédol.,vol XXII, n° 2 : 153-162.
- Heush B., 1971. Estimation et contrôle de l'érosion hydrique. C.R.Soc.Sc.Nat et Phy du Maroc T37 : 43-48.
- Hjulström F., 1935.Studies on the morphological activity of rivers as illustrated by the river Fyries. Bull. Geo. Inst. Univ. Uppsala 25: 293-305 et 442-452.

- HLPE Rome, 2012 .*Sécurité alimentaire et changement climatique Un rapport du Groupe d'experts de haut niveau sur la sécurité alimentaire et la nutrition.* Comité de la sécurité alimentaire mondiale Groupe d'experts de haut niveau sur la sécurité alimentaire et la nutrition Rome, 2012
- IPCC. 2016. Food Security and Vulnerability. IPCC Fourth Assessment Report: Climate Change 2007.Available online: https://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch5s5-6-5.html (accessed on 12 June 2016).
- IPCC.2014a. *Climate change 2014: synthesis report*. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, R.K. Pachauri & L.A. Meyer, eds. Geneva, Switzerland, IPCC. 151 p.
- Josef, S. and Francesco N. T. (2007). *Global food security under climate chang.* Pennsylvania State University, University Park, PA
- Kang, Y.; Khan, S.; Ma, X.2009. Climate Change Impacts on crop Yield, Crop Water Productivity and Food Security—A Review. Prog. Nat. Sci. 2009, 19, 1665–1674.
- Kouidri R., Arabi M. et Roose E., 1993. Premiers résultats de quantification du ruissellement et de l'érosion en nappe sur Jachères en Algérie (Région de Médéa). – Annales de la Recherche Forestière en Algérie, 1er sem. 1993 : 43-52.
- Lafforgue A. et Naah E., 1976 . Exemple d'analyse expérimentale des facteurs de ruissellement sous pluies simulées. *Cah. ORSTOM, Hydrol.* 13 (3) : 195-237.
- Lafforgue A., 1977. Inventaire et examen des processus élémentaires de ruissellement et d'infiltration sur parcelles. *Cah. ORSTOM, sér. Hydrol.,* 14 (4) : 299-344.
- Lal R. Soil erosion impact on agronomic productivity and environment quality. Crit Rev Plant Sci 1998;17:319–464.
- Lal R. World cropland soils as source or sink for atmospheric carbon. Adv Agron 2001;71:145–91.
- Lal, R. et al. (2004). Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. American Association for the Advancement of Science, 1200 New York Avenue NW, Washington, DC 20005

- Lowdermilk WC. Conquest of the land through seven thousand years. SCS Agric Inform Bull, vol. 99, 1953. Washington, DC, 30 pp.
- Maden Le Crom, Olivier, B. and Jérôme, M. (2013). *Changement climatique et sécurité alimentaire Impacts et vulnérabilité des populations rurales et urbaines.*
- Mahi, T. A. (2008). *Impact s du changement cl i mat i que sur l es agri cul t ures et l es ressources hydri ques au M aghreb.*Les notes d'alerte du CIHEAM N°4 8
- Mazour M., Roose E., 2002. Influence de la couverture végétale sur le ruissellement et l'érosion des sols sur parcelles d'érosion dans des bassins versants du Nord – Ouest de l'Algérie. Bullettin Réseau Erosion 21, IRD, Montpellier (France) : 320-330.
- Misra, A.K.2014. Climate change and challenge of water and food security. Int. J. Sustain. Built Environ. **2014**, 3,153–165. [CrossRef]
- Moeyersons J., 1989. La nature de l'érosion des versants au Rwanda. Annales, Kon. Mus. Mid. Afr., Tervuren, Série des Sciences economiques, 19 ; 396 p.
- Morsli B., Mazour M., Medejel N., Arabi M. et Roose E., 2005**.** Influences of land uses, soils and cultural practices on carbon eroded and carbon stocks in soils of Mediterranean mountains of northern Algeria. In: Soil erosion & carbon dynamics, Roose, Lal, Feller, Barthès and Stewart edit. Boca Raton, New YorkFl, USA). Edit. CRC Press. Advances in Soil Science, vol. 15: 103–124.
- Morsli B., Mazour M., Medejel N., Hamoudi A. et Roose E., 2004. Influence de l'utilisation des terres sur les risques de ruissellement et d'érosion sur les versants semi-arides du nord-ouest de l'Algérie. Sécheresse, 15 (1) : 96-104.
- MORSLI Boutkhil. 2015.PhD Theses. ruissellement et erosion en zone de montagne : analyse des facteurs conditionnels
- Nyamulinda V., 1991. Erosion sous cultures de versants et transports solides dans les bassins de drainage des hautes terres de Ruhengeri au Rwanda. Bull. Réseau Erosion, IRD, N° 11: 38-63.
- Porter, J.R.; Xie, L.; Challinor, A.J.; Cochrane, K.; Howden, S.M.; Iqbal, M.M.; Travasso, M.I. 2014. Part A: Global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmentalpanel on climate change. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Food

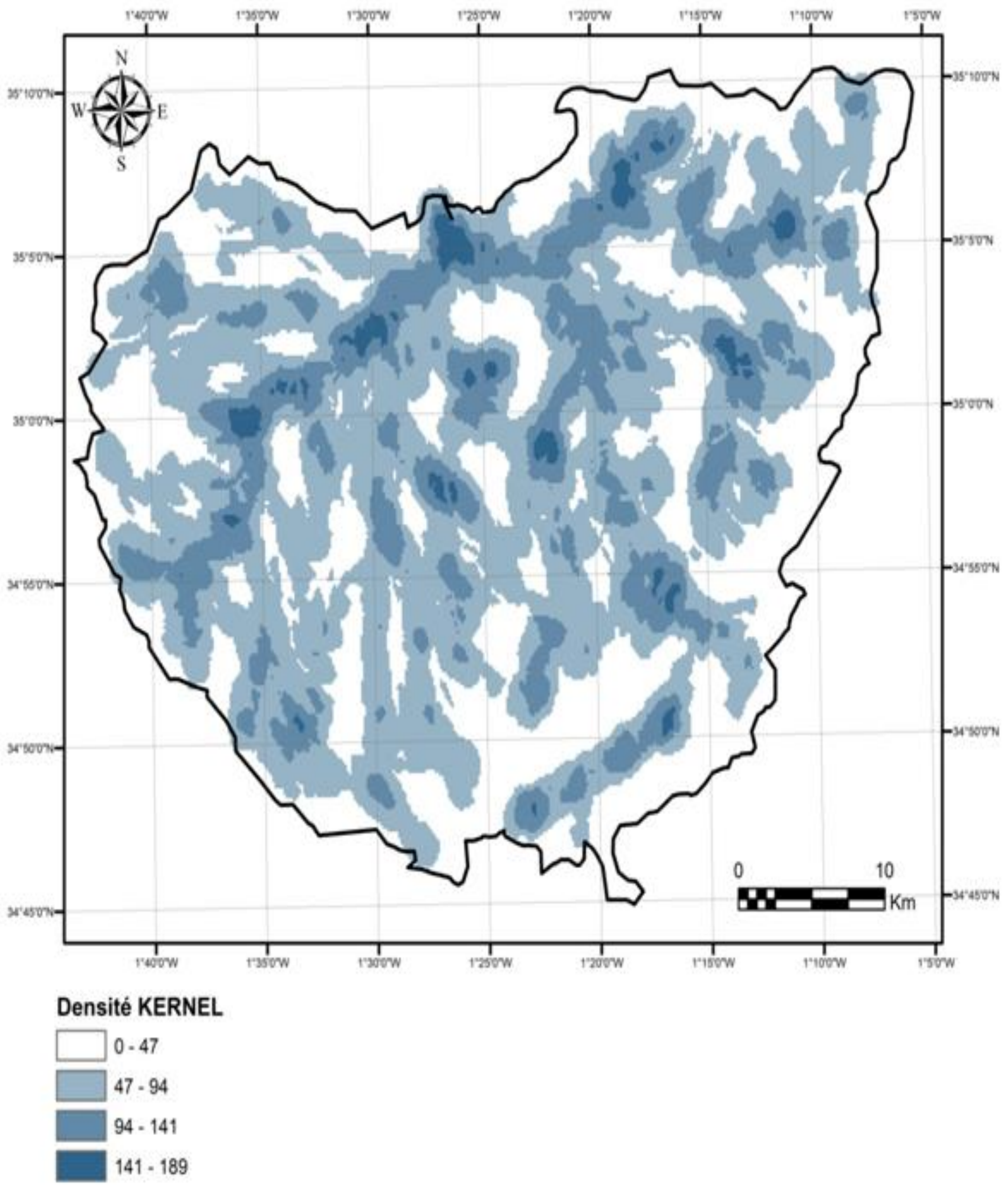
security and foodproduction systems; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2014; pp. 485–533.
- Qafoku, N.P. (2015). *Climate-change Effects on Soils: AcceleratedWeathering, Soil Carbon and Elemental Cycling*. Adv. Agron. 2015, 131, 111–172.
- Recensement général de l'agriculture en Algérie, Ministère de l'agriculture et de développement rural en Algérie, Alger, 2003.
- Rémy JC., Le Bissonnais Y., 1998. Comparaison des phénomènes d'érosion entre le Nord et le Sud de l'Europe : ampleur des problèmes et nature des mécanismes. *Bull Réseau Érosion* 1998 ; 18 : 15-32.
- Roose E., 1972. Comparaison des causes de l'érosion et des principes de lutte antiérosive en région tropicale humide, tropicale sèche et méditerranéenne. In « Les Actes des Journées d'étude du CIGR », Firenze, 12-16 Septembre 1972 : 417-441.
- Roose E., 1994. Introduction à la gestion conservatoire de l'eau et de la fertilité des sols (GCES). Bull. Sols FAO, Rome, 70 ; 420 p.
- Roose E., 1996. Méthodes de mesure des états de surface du sol, de la rugosité et des autres caractéristiques qui aide au diagnostique de terrain sur les risque de ruissellement et d'érosion, en particulier sur les versants cultivés des montagnes . Bull. Réseau Erosion 16 : 87-97.
- Saidul, I. and Andrea 201, T. W. (2017). *Climate Change and Food In/Security: A Critical Nexus. Division of Sociology.* Nanyang Technological University Singapore, 14 Nanyang Drive, Singapore 637332, Singapore
- Sari D., 1977. L'homme et l'érosion dans l'Ouarsenis (Algérie). Thèse doctorat. Alger : éditions SNED, 1977 ; 621 p.
- Shahid, S.A. 2014; Ahmed, M. Environmental Cost and Face of Agriculture in the Gulf Cooperation Council Countries: Fostering Agriculture in the Context of Climate Change; Springer: Berlin, Germany, 2014; pp. 1–179.
- Singh, D.P.2014. GlobalWarming impact on rice crop productivity. In Climate Change Effect on Crop Productivity;Sengar, R.S., Sengar, K., Eds.; CRC Press: Boca Raton, FL, USA, 2014; pp. 187–196.

- St. Clair, S.B.; Lynch, J.P.2010. The Opening of Pandora's Box: Climate change impacts on soil fertility and crop nutrition in developing countries. Plant Soil 2010, 335, 101–115. [CrossRef]
- Stengel P., 1988. Etude expérimentale de la fissuration au cours du desséchement et de l'humectation. In Séminaire du département de Science du sol (ed INRA.) : 161 – 183
- Taabni M., 1998 . Aménagement, lutte contre l'érosion des terres et pratiques paysannes dans les montagnes telliennes du nord ouest algérien. BRE 18. : 348 - 363.
- Úbeda, B.; Di Giacomo, A.S.; Neiff, J.J.; Loiselle, S.A.; Poi, A.S.G.; Gálvez, J.A.; Casco, S.; Cózar, A.2013. Potential Effects of Climate Change on the Water Level, Flora and Macro-fauna of a Large Neotropical Wetland.PLoS ONE 2013, 8, e67787.
- UK Met Office Online.*Climate averages*. Available at: www.metoffice.gov.uk/climate/uk/averages/index.html.
- UNDESA. 2015. World Population Projected to Reach 9.7 Billion by 2050. Available online: https://www.un.org/development/desa/en/news/population/2015-report.html (accessed on 11 December 2015).
- UNFCCC. Kyoto Protocol to the United Nations Framework Convention on Climate Change. Bonn, Germany: UNFCC; 1997.
- UNFCCC. United Nations framework convention on climate change. Bonn, Germany: UNFCC; 1992
- UNFCD. United Nations framework convention to combat desertification. Bonn, Germany; 1996.
- Van Oost, K., Quine, T. A., Govers, G., De Gryze, S., Six, J., Harden, J. W., Ritchie, J. C., McCarty, G. W., Heckrath, G., Kosmas, C., Giraldez, J. V, da Silva, J. R. M., and Merckx, R.: The impact of agricultural soil erosion on the global carbon cycle, Science, 318, 626–629, https://doi.org/10.1126/science.1145724, 2007.
- Victoria Naipal, 20 July 2018. Global soil organic carbon removal by water erosion under climate change and land use change during AD 1850–2005
- Wang, Z., Hoffmann, T., Six, J., Kaplan, J. O., Govers, G., Doetterl, S., and Van Oost, K.: Human-induced erosion has offset onethird of carbon emissions from land cover change, Nat. Clim. Change, 7, 345–349, https://doi.org/10.1038/nclimate3263,

- Wischmeier W.H. & Smith D.D., 1978.Predicting rainfall erosion losses.A guide to conservation planning.USDA Handbook n° 537 ; 58 p.
- Wischmeier W.H., 1959.A rainfall erosivity index for a universal soil loss equation. Soil Sci. Soc. Amer. Proc. 23 : 246-249.
- Wischmeier W.H., 1966.Surface runoff in relation to physical and management factors. Proc. Ist Pan Am. Soil Cons. Congress Sao Paolo, Brazil. : 237-244.
- Wischmeier W.H., Johnson C.B. & Cross B.U., 1971.A soil erodibilitynomograph for farmland and construction sites. J. of Soil and Water Conservation 26 (5) : 189-192.
- WMO, 1992. World meteorological organization, updated on 12 June 2006.

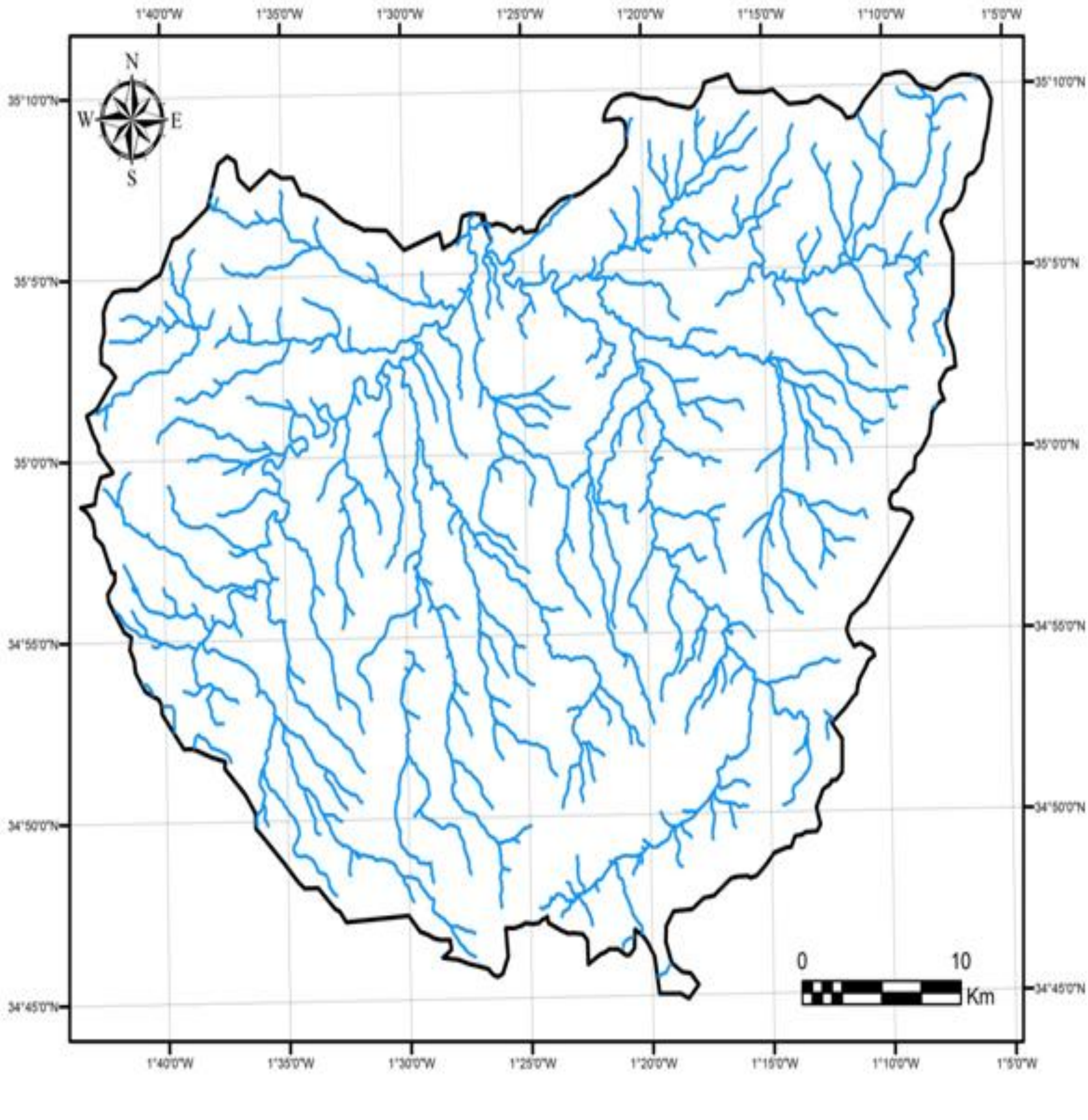
AppendixA

Carte de densité des reseaux hydrographique
SBV 07 05

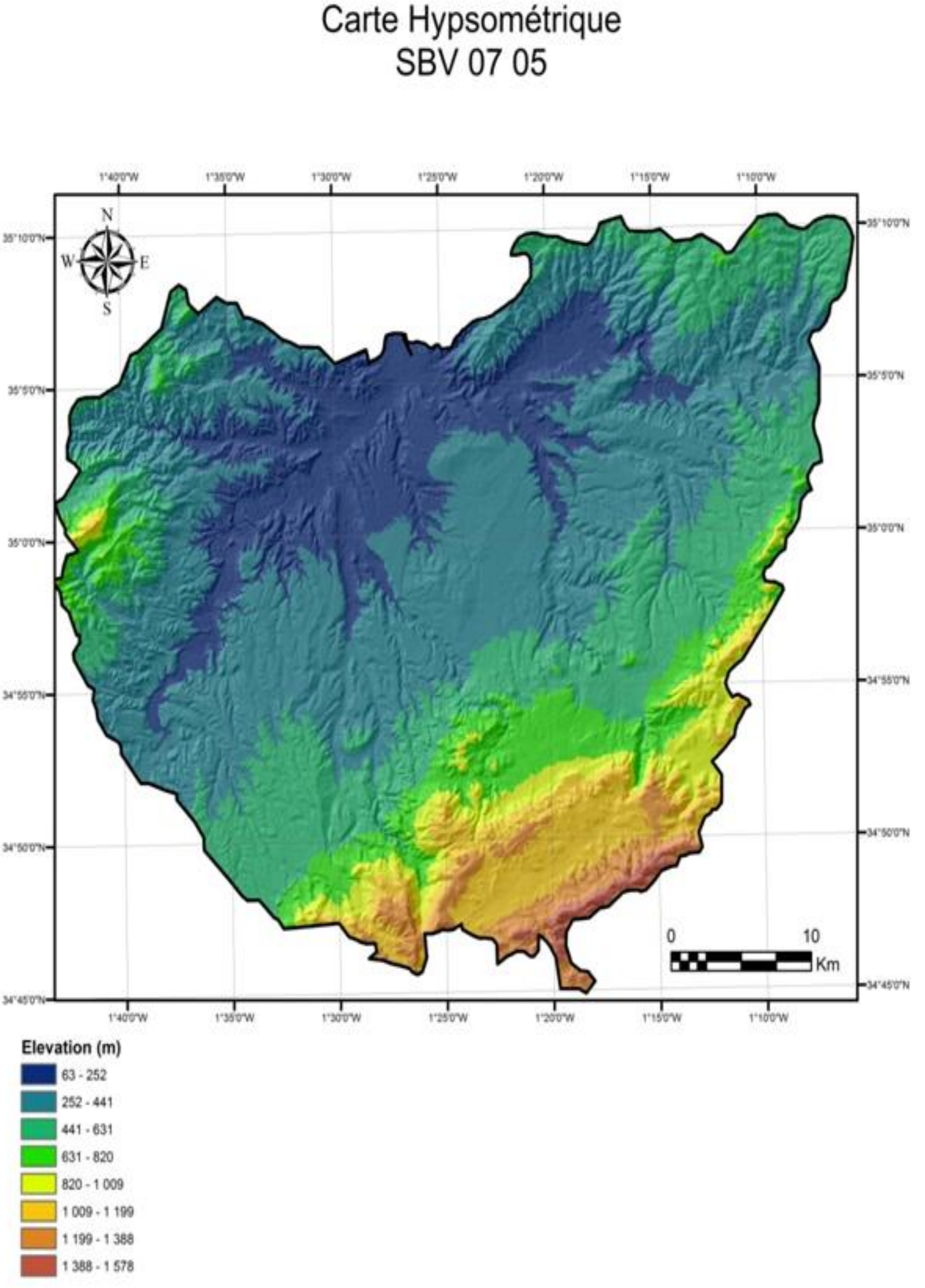


AppendixB

Carte des reseaux hydrographique
SBV 07 05

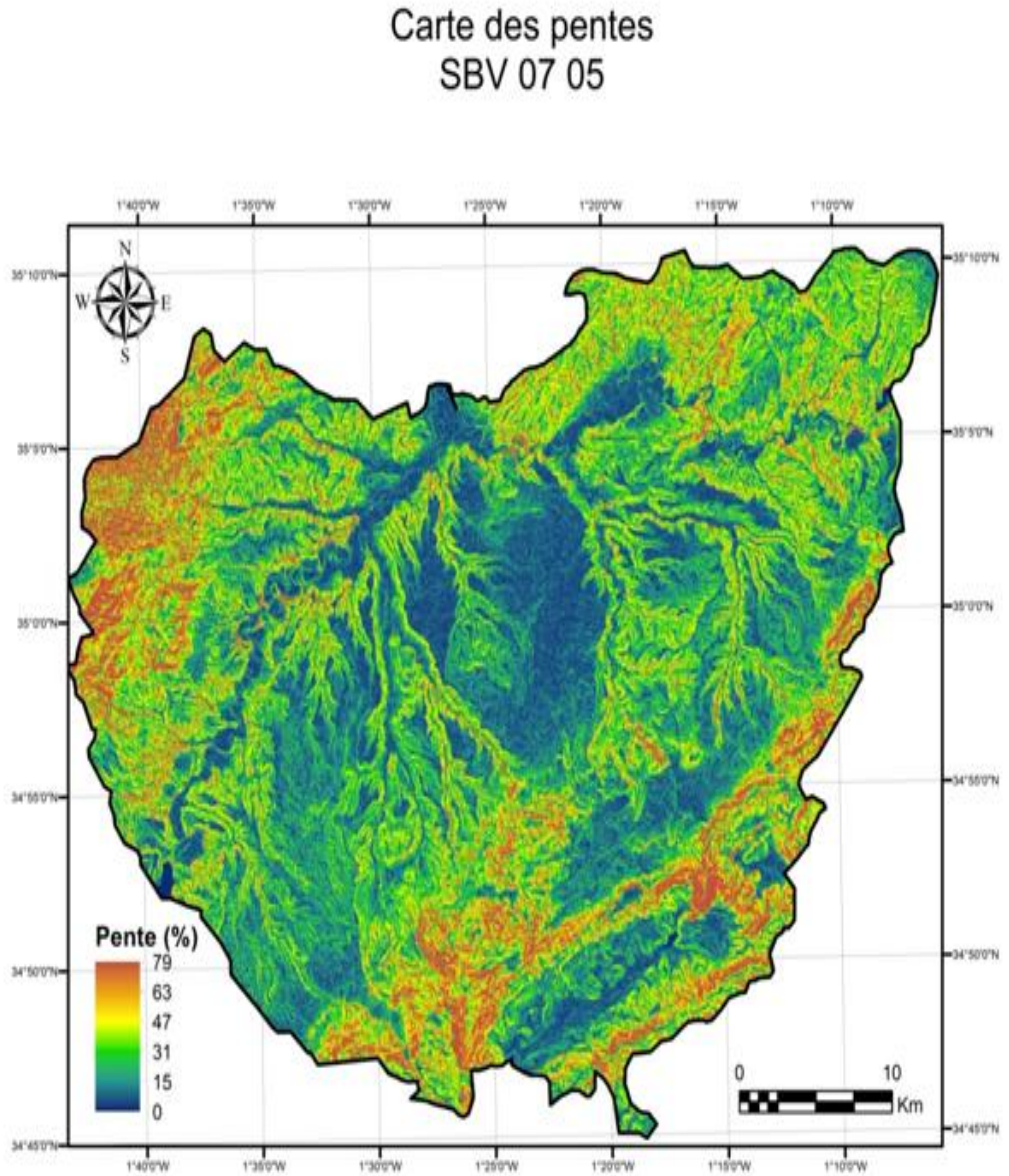


AppendixC



Carte Hypsométrique
SBV 07 05
N
W
E
S
1°40'0"W
1°35'0"W
1°30'0"W
1°25'0"W
1°20'0"W
1°15'0"W
1°10'0"W
35°10'0"N
35°5'0"N
35°0'0"N
34°55'0"N
34°50'0"N
34°45'0"N
0
10
Km
Elevation (m)
63 - 252
252 - 441
441 - 631
631 - 820
820 - 1 009
1 009 - 1 199
1 199 - 1 388
1 388 - 1 578

AppendixD


Carte des pentes
SBV 07 05
1°40'0"W
1°35'0"W
1°30'0"W
1°25'0"W
1°20'0"W
1°15'0"W
1°10'0"W
35°10'0"N
35°5'0"N
35°0'0"N
34°55'0"N
34°50'0"N
34°45'0"N
N
S
E
W
Pente (%)
79
63
47
31
15
0
0
10
Km