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# Climate change, biodiversity and agro-biodiversity: global view and particular case of Algeria

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## ABSTRACT

Climate change is a real global threat. The main cause of the current global warming trend is human expansion of the "greenhouse effect". The biodiversity is a perfect design freely offered for well-being of all humanity; it provides benefits such as food security, resiliency, health…etc. Agrobiodiversity which is a vital sub-set of biodiversity playing a key role in food security will be increasingly threatened by climate change worldwide. Algeria is among the countries that will be most vulnerable to climate change due to its predominance of arid and semi-arid regions. Despite many efforts taken per Algeria to preserve biodiversity in general, genetic erosion of different ecosystems remains an alarming fact caused by several factors linked for climatic conditions, socio-cultural upheaval, difficulties for application of legislations, lack of consistent programs and adequate mechanisms for the effective implementation of the various strategies to safeguard biodiversity in the widest possible context. Awareness-raising campaigns on the need to preserve local resources with their diversity, *in situ* and *ex situ* conservation, the promotion of resilient crops and systems, the support of research in general and that of development in particular, participatory approach and better collaboration between the various actors in the agricultural and environmental sectors are some options for sustainable development and to lift the challenge of climate change in Algeria.

**Key words:** New challenge; Genetic erosion; Strategies of conservation; Food security

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## Introduction

Global food security threatened by climate change is one of the most important challenges in the 21st century to supply sufficient food for the increasing population while sustaining the already stressed environment (Lal, 2005). Genetic diversity in food systems provides the foundation of crop development and food security and promotes resistance and resilience to environmental stresses including pests and diseases of crops and livestock (COHAB, 2010). It provides the basis for new breeding programs, improved crops, enhanced agricultural production, and food security (IBRD, 2008). Agrobiodiversity is the outcome of the interactions between genetic resources, the environment and the management systems and practices used by farmers and herders. It has developed over millennia, as a result of both natural selection and human interventions (GIZ, 2015).

Agrobiodiversity is highly threatened mostly by the spread of modern agriculture and the globalization of food markets (Wolff, 2004).

With climate change, the biodiversity will be more and more threatened. Indeed, global warming will affect all species and exacerbate the other environmental stresses already being experienced by ecosystems (IBRD, 2008). Climatechange has already caused significant impacts on waterresources, food security, hydropower, human health especially for African countries, as well as to the whole world (Magadza, 2000). CC may thus further accelerate both the ongoing impoverishment of global biodiversity, caused by unsustainable use of natural capital, and the degradation of land, freshwater, and marine systems (IBRD, 2008).

The Mediterranean basin is one of the world's richest places in terms of animal and plant diversity (Cuttelod et al., 2008). It is home to a tremendous diversity of habitats and species and has designed by IUCN as biodiversity hotspot because of its rich biodiversity and its threatened status (Valavanidis and Vlachogianni, 2013).

Algeria is part of this Mediterranean region considered to be a center of great genetic variability. It is an important exceptional ecological entity in the biosphere possessing such a surface formed by ecosystems of the Mediterranean, steppe and Saharan types (Benderradji et al., 2006). It show from north to south a series of ecosystems, sheltering a diversity of habitats and a diversity of species, ranging from island and marine ecosystems, with fringe Coastal ecosystem, through forest and mountain ecosystems, followed by steppe ecosystems, then the Saharan ecosystem (GEF-UNDP[1]).

Algeria is predominated by arid and semi-arid lands and is threatened by desertification. By this phenomenon and according to Moulai (2008), Algeria loses a few thousand hectares each year. The socio-economic development in Algeria was not reasoned taking into account its impact on the environment. Nedjraoui and Bedrani (2008) indicate that desertification mainly concerns the steppes of the arid and semi-arid regions which have always been the privileged area of extensive sheep farming. These natural paths, which play a fundamental role in the agricultural economy of the country, are subject to recurrent droughts and increasing human pressure.

Current environmental issues in Algeria include soil erosion, rangeland destruction and land degradation caused by overgrazing, unsound farming practices, indiscriminate collection of fuel wood, uncontrolled fires, inadequate supplies of potable water and the pollution of rivers and coastal waters by the dumping of raw sewage, petroleum-refining wastes and other industrial effluents (Le Roux and Bouazid, 2009). Many studies confirmed the degradation of steppe (Nedjraoui 2011; Bouchetata et al. 2005; IUCN 2008), oases (Rahal-Bouziane et al., 2003; Rahal-Bouziane et al., 2010); forest ecosystems (Ghazi, 2009), Coastal and marine ecosystems, Mountain ecosystems in the Tell Atlas and Saharan ecosystems in general (IUCN, 2008).

With climate change, desertification will increase and the arid and semi-arid regions will be most vulnerable to this change. Also, the threat of biodiversity will be accentuated. According to World Meteorological Organization, climate change may exacerbate desertification through alteration of spatial and temporal patterns in temperature, rainfall, solar radiation and winds.The coming decades are expected to see further increases in temperature, rising sea levels, more intense pest and disease pressures, water shortages,

extreme weather events and loss of biodiversity (Padgham, 2009).

From years 1980, Algeria became aware of this important strand and has implemented a policy preservation of ecological resources, including preservation of sites presenting original ecosystems or fragile protection of rare species or threatened with extinction (Benderradjiet al., 2006).

Algeria has been one the first African countries to ratify all sections of international environmental protection agreements (including the Kyoto Protocol and the Barcelona Convention). However, their application and monitoring has been inadequate (Caritas, 2011). Algerian biodiversity, which is very rich, is subject to numerous anthropogenic and climatic pressures and suffers, among other constraints: a lack of awareness of the general public, lack of intersectoral coordination, notably to share diagnostic tools and data, as well as difficulties in implementing existing legislation. The resources devoted to biodiversity are insufficient: the human resources and the necessary budgets are not yet mobilized to the extent necessary (GEF-UNDP[1])

In this work, we try to highlight biodiversity and agrobiodiversityin the face of the biggest challenge of the 21st century, which is climate change on a global scale and in particular in Algeria

**Climate change: signification and impacts**

The climate system is a complex, interactive system consisting of the atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things. The atmospheric component of the climate system most obviously characterizes climate; climate is often defined as ‘average weather’ (IPCC, 2007). Life on Earth depends on energy coming from the sun. About half the light reaching Earth’s atmosphere passes through the air and clouds to the surface, where it is absorbed and then radiated upward in the form of infrared heat. About 90 percent of this heat is then absorbed by the greenhouse gases and radiated back toward the surface, which is warmed to a life-supporting average of 59 degrees Fahrenheit (15 degrees Celsius) (NASA, 2017).

Global warming refers to the recent and ongoing rise in global average temperature near Earth’s surface. It is caused mostly by increasing concentrations of greenhouse gases in the atmosphere. Global warming is causing climate patterns to change. However, global warming itself represents only one aspect of climate change. Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among other effects, that occur over several decades or longer (EPA, 2016).

Human activities intensify the blanketing effect through the release of greenhouse gases. For instance, the amount of carbon dioxide in the atmosphere has increased by about 35% in the industrial era, and this increase is known to be due to human activities, primarily the combustion of fossil fuels and removal of forests (IPCC, 2007). To a lesser extent, the clearing of land for agriculture, industry, and other human activities has increased concentrations of greenhouse gases (NASA, 2017). According to FAO (2016), intensive crop production contributes significantly to the greenhouse gases responsible for climate change. Between 2001 and 2010, direct emissions from crop and livestock production grew from 4.7 billion to more than 5.3 billion tons of carbon dioxide equivalent, with most of the increase occurring in the developing countries (FAO, 2014). Thus, humankind has dramatically altered the chemical composition of the global atmosphere with substantial implications for climate (IPCC, 2007).

Since the industrial revolution, the mean surface temperature of Earth has increased an average of 1° Celsius per century due to the accumulation of greenhouse gases in the atmosphere (IBRD, 2008).

Scientific research shows that the climate - that is, the average temperature of the planet’s surface - has risen by 0.89 °C from 1901 to 2012 (Met Office, 2015).

Furthermore, most of this change has occurred in the past 30 to 40 years, and the rate of increase is accelerating, with significant impacts both at a global scale and at local and regional levels (IBRD, 2008). There have been observed changes in precipitation, but not all areas have data over long periods. Rainfall has increased

in the mid-latitudes of the northern hemisphere since the beginning of the 20th century. There are also changes between seasons in different regions (Met Office, 2015).

The planet's oceans and glaciers have also experienced some big changes – oceans are warming and becoming more acidic, ice caps are melting, and sea levels are rising. As these and other changes become more pronounced in the coming decades, they will likely present challenges to our society and our environment (EPA, 2016).

The synthesis study by Hare et al. (2011) looks at four areas of possible dangerous climate change-adverse declines in regional food and water security, loss of arctic sea ice with projected extinction of species, large scale sea-level rise and loss of coral reef systems. These issues affect a number of different regions including Africa, South Asia, and Small Island Developing States.

Climate change will impact the extent and productivity of both irrigated and rainfed agriculture across the globe. Reductions in river runoff and aquifer recharge are expected in the Mediterranean basin and in the semi-arid areas of the Americas, Australia and southern Africa, affecting water availability in regions that are already water-stressed (FAO[1], 2011).

A recent study of climate change impacts on agriculture found that, without adaptation by farmers, global crop yields in 2050 would be 6.9 percent below estimated yields without climate change; cereal yields would be lower by as much as 10 percent in both developed and developing regions (Wiebe et al., 2015).

Defining what it means for ecosystems to adapt naturally is quite difficult and may be best approached by examining the effects of climate change on key ecosystem properties, services and values. Substantial loss of, or damage to, properties such as biodiversity including conservation of species, food production and provision of livelihoods, may be relevant measures of ecosystem response to climate change (Hare et al., 2011).

Stabilization of greenhouse gas concentrations is specifically linked to levels that would "prevent dangerous interference with the climate system", and these levels are to be achieved ''within a time frame'' sufficient for criteria (ecosystems, food production and economic development) to be met (Verheyen, 2007). Various adaptation measures that deal with climate variability and build upon improved land and water management practices have the potential to create resilience to climate change and to enhance water security. They imply a good understanding of the impact of climate change on available water resources and on agricultural systems, and a set of policy choices, and investments and managerial changes to address them (FAO[1], 2011).

## Biodiversity and agrobiodiversity: meaning and history

Biodiversity is the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems (Millennium Ecosystem Assessment, 2005). About 1.75 million species of plants, animals, and microorganisms have been identified out of the 13 million total species estimated by scientists (Sustaining, 2000). Central to biodiversity is the ecological complexity of interactions between biota and abiotic environment. Biological diversity is not accidental but purposeful, seen in the Qur'an as a prime indicator of the existence and unity of God (Solihu, 2014). Habitats in the world are in a state of equilibrium when the relationships that characterize are harmonious and precise. All such organisms, including micro-organisms, plants, animals and people, together form a unified living whole, characterized by biodiversity (Charouk and Boumenjel, 2013).

Agricultural biodiversity also known as agrobiodiversity or the genetic resources for food and agriculture is a vital sub-set of biodiversity (FAO, 2005). Agrobiodiversity is the outcome of more than 10 000 years of efforts by farmers and herders in selection and breeding, and in developing appropriate production systems and methods (GIZ, 2015). It means the variety of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. It comprises the diversity of genetic resources (variet-

ies, breeds) and species used for food, fodder, fiber, fuel and pharmaceuticals (Johnston, 2016).

Many people's food and livelihood security depend on the sustained management of various biological resources that are important for food and agriculture (FAO, 2005).

Vavilov (1926) was the first geneticist to realize the essential need for a broader genetic base for crop improvement. He and his colleagues collected germplasm of crops and their wild relatives globally (Upadhyaya et al., 2007). Beginning in 1950, the strategic role of biological diversity in plant breeding extended with the development of international trade (Trommetter, 2001). According to Millennium Ecosystem Assessment (2005), genetic diversity has declined globally, particularly among domesticated species. According to Rotherham, Human impacts have increased dramatically in recent centuries and in the last few decades, and the effect on habitat destruction and species loss has led directly to concerns over loss of 'biodiversity'.

Since 1960 there has been a fundamental shift in the pattern of intra-species diversity in farmers' fields and farming systems as a result of the "Green Revolution". The Green Revolution was driven initially by the work of the American biologist Norman Borlaug and scientists at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico and the International Rice Research Institute (IRRI) in the Philippines. It gathered momentum during the 1960s, with the introduction to South Asia of high-yielding, semi-dwarf rice and wheat varieties (FAO, 2015).

Following the loss of traditional cultivars and local varieties, caused by agricultural development since the 1970s, massive efforts have been made to collect genetic material. A network of international centers was implemented from the early 1980s to improve the collection, conservation, evaluation and documentation of crop genetic resources (Plucknett et al., 1987). The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (one of the 15 CGIAR centers) has responded to this need by establishing a Genetic Resources Unit for assembly, characterization, evaluation, maintenance, conservation, documentation and distribution of germplasm of sorghum (*Sorghumbicolor*), pearl millet (*Pennisetumglaucum*), chickpea (*Cicerarietinum*), pigeonpea (*Cajanuscajan*), groundnut (*Arachishypogaea*), finger millet (*Eleusinecoracana*), foxtailmillet (*Setariaitalica*), barnyard millet (*Echinocloacrus-galli*), kodo millet (*Paspalumscrobiculatum*), little millet (*Panicumsumatrense*) and proso millet (*Panicummiliaceum*) (Upadhyaya et al., 2008).

By the 1990s, several international initiatives were focused on the more specific question of how the diversity of life forms impacts upon ecosystems. The Scientific Committee on Problems of the Environment (SCOPE) produced an influential book reviewing the state of knowledge on biodiversity and ecosystem functioning (BEF) (Cardinale et al., 2012).

According to the FAO (1996), a survey conducted during this period revealed that over 5 550 000 entries of plant genetic material were assembled and stored in a total of 1308 gene banks. This enormous volume of germplasm resources cannot be used effectively to conduct research and also requires funds for gene bank management (Upadhyaya et al., 2007).

Frankel (1984) proposed the manageable sampling of the collection or "core collection". A nuclear collection contains a subset of accessions from the collection that captures the most diversity of species (Brown, 1989a). The core of the subassembly thus formed can be widely evaluated and the derived information can be used to guide the use of the entire collection more effectively (Brown, 1989b). The size of the reduced collection will also help to reduce the costs of managing the gene bank (Upadhyaya et al., 2007).

## Biodiversity, agrobiodiversity, conservation of genetic resources and climate change: the links

Agriculture and climate change are inextricably linked–crop yield, biodiversity, and water use, as well as soil health are directly affected by a changing climate (C-FARE). Climate change is expected to influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems. It may also change the types, frequencies, and intensities of various crop and livestock pests; the availability and timing of irrigation water supplies; and the severity of soil erosion (Adams et al., 1998).

Biodiversity is a growth industry in conservation biology; traditionally nature protection has aimed at preservation target species and landscapes (Haila and Kouki, 1994). Biodiversity plays an important role in ecosystem functions that provide supporting, provisioning, regulating, and cultural services. It goes beyond the provisioning for material welfare and livelihoods to include security, resiliency, social relations, health, and freedoms and choices. These services are essential for human well-being (Millennium Ecosystem Assessment, 2005). Biodiversity is positively correlated with ecosystem productivity by a mechanism known as functional complementarity, which states that the more species there are, the more niches occupied, and thus the greater productivity of the ecosystem (Wilby and Hector, 2008). Agrobiodiversity is a vital sub-set of biodiversity (FAO 2005).A diverse portfolio of activities bases on the contributions of agricultural biodiversity (e.g. crop cultivation, harvest on wild plant species, herding, fishing, hunting…) helps sustain rural livelihoods because it improves their long term resilience in the face of adverse trends of shocks. In general, increased diversity promotes more flexibility because it allows greater possibilities for substitution between opportunities that are in decline and those that are increasing (FAO, 1999).

The modern era has come to be defined as a period of rapid environmental change. One of the most prominent changes taking place globally is a reduction in the number of genes, species, and functional groups of organisms that comprise the biological diversity of natural and managed communities (Cadotte et al., 2008). Globally, over 4000 assessed plant and animal species are threatened by agricultural intensification, and the number is still rising. Over 1000 (87%) of a total of 1226 threatened bird species are impacted by agriculture. Overfishing and destructive fishing methods along with eutrophication caused by high nutrient run-off from agricultural areas are among the major threats to inland and marine fisheries (UNEP, 2009).

Agriculture has greatly modified interactions between plants and pathogens via the reduction of biodiversity in crop species and the selection of resistant genotypes that put high selection pressure on pathogens. Large areas under monospecific or monovarietal crops have offered pathogens suitable ecological conditions for switching hosts and for the onset of devastating epidemics (Agropolis). The Green Revolution's quantum leap in cereal production was often achieved at the cost of land degradation, salinization of irrigated areas, over-extraction of groundwater, the build-up of pest resistance, and damage to the wider environment, through increased emissions of greenhouse gases and nitrate pollution of water bodies (FAO[2], 2011).

Virtually all of Earth's ecosystems have now been dramatically transformed through human actions. More land was converted to cropland in the 30 years after 1950 than in the 150 years between 1700 and 1850. Between 1960 and 2000, reservoir storage capacity quadrupled, and as a result the amount of water stored behind large dams is estimated to be three to six times the amount of water flowing through rivers at any one time (Millennium Ecosystem Assessment, 2005). The worldwide adoption of high-yielding cereal varieties has led to the large-scale loss of plant genetic diversity and the erosion of biodiversity in general (FAO, 2016).

The conservation discourse on biodiversity originated with notion of a 'diversity crisis' (Haila and Kouki, 1994).

In 2004, Wolff mentioned that during the last three decades the understanding of agrobiodiversity has developed from the recognition of the importance of genetic diversity, particularly for crops and an emphasis on the *ex situ* conservation of genetic resources in the 1970s, to the adoption of an *in situ*/on farm approach where plants and animals are kept in natural surrounding or used within agricultural production systems in the 1990s.

*Ex situ* refers to a wide range of techniques to conserve biodiversity outside its natural places, such as the use of botanic gardens, zoos, gene banks, etc. *in situ* conservation refers to the protection of biodiversity on the spot usually necessitates protected areas and nature reserves (EOLSS).

After the UN conference on the environment and development held in Rio de Janeiro in June 1992 (United Nations Environment Programme, 1992), it was declared preservation of biodiversity as a major element in 'sustainable develop-

ment' (Haila and Kouki, 1994). Conservation is not the way we try to isolate biodiversity from human beings but means protecting biodiversity so that human beings can benefit from sustainability (EOLSS). If humans want to continue benefiting from the abundance of these natural goods and services, the biodiversity that establishes them must be preserved. The United Nations Convention on Biological Diversity notes that, "at least 40 per cent of the world's economy and 80 per cent of the needs of the poor are derived from biological resources"; saving this biodiversity is in the self-interest of the human race (Mission, 2015).

The Convention on Biological Diversity (CBD) recognizes the intrinsic value of these biological diversities and expresses concern over the extent and speed of its degradation, and the need to take collective actions to prevent losses (Porceddu et al. 2005). With its three objectives, the CBD is often seen as the key international instrument for sustainable development (UNEP-CBD). According to Agropolis, it is essential to gain insight into the biodiversity of crop pathosystems and pathogen adaptation mechanisms in order to be able to assess agrosystem sustainability and to develop more reliable methods for reducing losses.

Conservation of biodiversity is essential for climate change adaptation (COHAB, 2010). ). Agro-biodiversity has been proposed as an adaptation to climate change. This proposition rests largely on principles borrowed from natural ecological systems which have been extended to agricultural systems at a global/regional scale (Johnston, 2016).

Variation in genetic materials is the basis of diversity within species. This allows populations to adapt to changes in climate and other local environmental conditions (EOLSS). Biodiversity influences climate at local, regional, and global scales, thus changes in land use and land cover that affect biodiversity can affect climate. Some components of biodiversity affect carbon sequestration and thus are important in carbon-based climate change mitigation when afforestation, reforestation, reduced deforestation, and biofuel plantations are involved (Millennium Ecosystem Assessment, 2005). Although perceived differently, climate change, biological diversity and desertification are intrinsically linked issues because at the local level measures to improve the effects of variability and climate change also contribute to the effective fight against desertification and to protect Biodiversity (AlHamndou and Requier-Desjardins, 2008).

In 2010 Parties to the Convention on Biological Diversity (CBD) adopted the Strategic Plan for Biodiversity 2011–2020, a ten-year framework for action by all countries and stakeholders to safeguard biodiversity and the benefits it provides to people. As part of the Strategic Plan 20 ambitious but realistic targets, known as the Aichi Biodiversity Targets, were adopted (UNEP-CBD).

By improving soil health, reducing pest and pathogen pressure, reducing erosion, increasing the availability of water and nutrients, and increasing soil carbon storage, conservation agriculture enhances crop resilience to higher temperatures, drought and flooding, enhances ecosystem services, and helps to mitigate climate change (FAO, 2016).

## Biodiversity, Agrobiodiversity and climate change in Algeria

### 1. Situation of biodiversity and agrobiodiversity

In the Arab region, in terms of biodiversity wealth and beside Sudan, Lebanon, Morocco, Syria, Tunisia and Somalia, Algeria is one of the richest countries in plant diversity with numbers exceeding 3000 species and animal diversity exceeds that of plant diversity with 5000 species in Algeria, Lebanon, Syria and Tunisia (UNEP, 2015). Algerian biodiversity (natural and agricultural) is immensely rich, with approximately 16 000 known species overall. Known marine biodiversity amounts to 3183 species and between 720 genera and 655 families. Marine flora is estimated to comprise 713 species and up to 4150 when littoral and island vegetation and marine and littoral ornithological fauna are considered. Mountain biodiversity is also very rich. Further, Algeria's Sahara hosts a large diversity of ecosystems, most of which are still unknown (CBD).

Agricultural biodiversity in Algeria is highly valued for the presence of numerous agricultural species and crop wild relatives (date palm, wheat/

barley, vegetable stocks, and legume pulses) representing unique traditional agricultural systems capturing high proportion of the national biological heritage (GEF-UNDP[1]).

Apart from water scarcity, another environment problem affecting Algerian agriculture is soil erosion and desertification. In the Algerian steppes 3.5 percent of the land is already subject to desertification or being irreparably damaged and more than 50 percent of the territory is either highly sensitive to desertification (MATE, 2010).

According to GEF-UNDP[1], all Algerian ecosystems are threatened. The main threatened ecosystems and falling within the safeguard priorities are: Coastal and marine ecosystems, Mountain ecosystems in the Tell Atlas, Steppe ecosystems and Saharan ecosystems (IUCN, 2008). The main threats to biodiversity are driven by human activity and include the destruction or overexploitation of biological resources, extension of cultivated areas (the surface of natural steppe vegetation has decreased by 50% since 1989), urbanization and infrastructure development, pollution, tourism and hunting (CBD).

As part of its METAP program, the World Bank has undertaken studies on the cost of environmental degradation in four countries in the region (Algeria, Egypt, Morocco and Tunisia). It emerged from these assessments that the total cost of environmental degradation for these four countries is 7.6 billion US dollars per year, corresponding to a percentage of GDP that varies between 2.1 and 4.8% per country (IUCN, 2008).

In the fishery sector, the number of fishing vessels increased from 2400 in 1999 to 4000 in 2005. Increased pressure on biodiversity is compounded by the effects of climate change, notably through desertification, and the narrowness of the areas exploited, which is very likely to affect the development of commercial species such as sardines, anchovies and pikes (CBD). The review of knowledge on marine biodiversity in Algeria, based on the synthesis of the various academic research studies initiated since the early 2000s and numerous impact studies on information on specific diversity, shows a significant improvement in knowledge Ecosystem diversity and the distribution of “sensitive” or heritage habitats. The results also show a better understanding of the general structure of the marine biodiversity of Algeria as well as the importance of the various marine zoological and botanical groups (GEF-UNDP[1]).

An important initiative is the National Program on Agricultural Development (Programme National de Développement de l’Agriculture) which aims to ensure food security, increase incomes and living standards in the rural regions, and manage scarce natural resources (Burger et al., 2014). This program called PNDA has been set up in 2000 by Algerian Government. In 2002, the PNDA included a rural dimension and became the technical, organizational and institutional problems responsible for weakening the basics of national food security, degrading natural resources and reducing cohesion and social peace in rural areas (PNDAR) (MADR 2007). Since the application of the PNDA, Algeria’s agricultural sector has recorded significant growth of 6.5% on average, whereas the growth rate between 1990 and 2000 was only 4% (Laoubi and Yamao, 2012). However, households living in remote areas as well as populations that are most economically and socially vulnerable have not or have little benefited from this economic recovery (Moulai, 2008).

## 2. Actions taken by Algeria to protect its biodiversity in general

The Strategy and National Action Plan for the Sustainable Use of Biological Diversity (NBSAP) were defined in 1997 (CBD). This first strategy and a national plan of action for the preservation of the biodiversity in Algeria had been drawn up in 2000 (GEF-UNDP[1]). They were strengthened in 2002 through the development and implementation of the National Action Plan for Environment and Sustainable Development (NAPE-SD), which incorporates global and national objectives on the promotion of the conservation of the biological diversity of ecosystems, habitats and biomes (CBD). The National Strategy and Action Plan for Sustainable Use of Biodiversity in Algeria (NBSAP) aim to serve the social, economic and environmental ambitions of Algeria. Implementation of the NBSAP must therefore be an engine for sustainable job creation and income and must contribute to increasing Algeria’s resilience to climate change (GEP-UNDP[1]).

The conservation of natural biota and ecosys-

tems in Algeria has been assigned the top national priority by the NBSAP. A total of 11 national parks/nature reserves covering approximately an overall area of 600 000 km$^2$ have been designated/proposed for protection by the government. Many of these areas are fragile ecosystems subjected to various social, economic and ecological pressures especially in the arid and semiarid zones in the southern regions (GEF-UNDP[2]). Next to national parks, 05 nature reserves; 50 wetlands of international importance (RAMSAR sites) are part of protected areas (GEF-UNDP[1]).

The protection of flora in Algeria is governed by an executive Decree of 23 November 1993 made under the Environment Protection Law of 5 February 1983. This Decree contains a list of 220 protected species including many desert species, particularly from the Hoggar Region which has endemic species (Klemm, 1997). According to European Commission (2011), the most important law related to MSP (Maritime Spatial Planning) is the coastal law (Loi N° 2002-02 du 22 Dhou El Kaâda 1422 correspondant au 05 février 2002) on the protection and valorization of the coastal zone. The definition of the coastal zone comprises the natural shoreline, islands and islets, internal waters and the soil and subsoil of the territorial sea.

Protected species in Algeria include 125 bird species, 56 mammal species, 46 reptile species, 144 insect species and 550 plant species. National action plans and programs have been elaborated for certain species, such as the Mediterranean monk seal and the red coral, and national legislation related to CITES is in progress to regulate the trade of vulnerable species. The Ministry of Land Planning, Environment and City (MATEV) developed a national integrated coastal management strategy in 2005 defining management directives for the sustainable use of marine and coastal resources (CBD).

Algeria, beside other Arabic countries like this Egypt, Lebanon, Morocco, Syria and Tunisia have ratified the CBD (Convention on Biological Diversity), the UNFCCC (United Nations Framework Convention for Climate Change), and the Kyoto protocol (UNEP-MAP RAC/SPA 2009). Algeria ratified the Kyoto Protocol in 2005 as non-Annex I party country (Burger et al., 2014). The revision of the strategy, some ten years later, necessarily involves updating the knowledge of the natural heritage in its diversity and its spontaneous or cultivated status. This strategy will therefore present a summary of the results of the first stage of its development, the program of which was to achieve: an inventory of biodiversity at the ecosystemic scale, wetlands, special habitats and protected areas; a taxonomic assessment of the systematic groups of the flora and a taxonomic assessment of systematic faunal groups (GEF-UNDP[1]).

The Algerian Government recently completed a report on progress achieved towards the Strategic Plan (2002-2010) and, in particular, towards its objective to reduce the rate of biodiversity loss at the national level. This assessment report will be catalytic in pushing forward a proposal for developing a new national biodiversity strategy and action plan to 2020, in accordance with the provisions of the Strategic Plan for Biodiversity (2011-2020). In February 2011, Algeria also became a signatory to the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization, adopted by the tenth meeting of the Convention. Algeria has also established a legal framework that sets the conditions for access to, circulation, transfer and valuation of biological resources (CBD).

In terms of projects, one traditional area of focus has been to implement a ‘green barrier (barrage vert) to reduce desertification and erosion through reforestation in the Saharan Atlas (Burger et al., 2014). The implementation of this vast project started in early 70’s and extends from the western to the eastern borders of Algeria; the scope of action of the Green Dam consists of the pre-Saharan area between isohyets 300 millimeters in the North and 200 millimeters to the South (Bensaid, 2005).

In 2013, the Algerian government has begun preparations the ALG / DELP project as an integral part of the Program for the Improvement of Ecosystems and Means of Life in the Deserts (MENA-DELP) of GEF, which is a Program covering the entire Middle East and North Africa region (MENA).The overall objective of Improved Desert Ecosystems and Climate Resilient Oases Project is to increase adoption of climate resilient approaches to ecosystem management and to

improve access to alternative livelihoods in selected pilot oases. Conservation of biodiversity and agrobiodiversity and adaptation to climate change were among the specific objectives of this project (World Bank, 2013).

Although progress has been made towards integration of environmental issues in sectorial policy-making, difficulties are still encountered in practice. They include an inadequate legal and institutional framework, lack support for environmental institutions, limited resources for monitoring and enforcement, lack of intersectoral coordination, marginal role of civil society and low awareness and engagement of the general public in decision-making. Algeria has made dramatic progress in the last years towards stronger policy and legal frameworks for environmental protection generally and coastal management in particular. However, implementing regulations have often lagged behind and progress is still urgently needed on the ground (AGRECO, 2009).

## 3. Climate change and strategies taken to lift its challenges in Algeria

The issue of climate change is in Algeria an important and new challenge (Sahnoune, 2013). Algeria, a country severely affected by desertification is-like other countries in Africa and in the south of the Mediterranean-particularly vulnerable to the multiform effects of climate change that threaten to undermine its economic and social development (INDC, 2015).

As one expert stated, in North Africa (Morocco, Algeria, Tunisia, Libya, and Egypt), there are two major and immediate consequences due to climate change: First, rising sea levels will affect coastlines and marine life severely and could impact on desalination plants that are the source of water for the region. Second, rising temperatures mean increasing water demand and with falling freshwater levels and increasing salinity in sea water (which affects the efficiency of desalination plants), water scarcity is a fearsome prospect (Radhouane, 2013).

In Algeria, the spatial and temporal distribution of precipitation would change, which directly affect agriculture and water resources (Sahnoune et al., 2013).Since 1975, precipitations has gradually decreased with currently only 600 cubic meters of fresh water per habitant and year, a level below the U.N. defined scarcity threshold of 1000 cubic meters (MATE, 2010). Regional models with the IPCC scenarios applied to Algeria for the period 1990-2020 forecast growth of the average temperature of 0.8°C to 1.1°C, and reduced precipitation 10% with an increase in the sea level of 5 to 10 cm. Increased evaporation and decreased precipitation will accentuate the decrease of water mobilized in dams and groundwater (Sahnoune et al., 2013).

As a developing country, Algeria has no historic al responsibility in terms of accumulation of greenhouse gases. Being a low GHG-emitting country, its current responsibility is very limited (INDC, 2015).

A large part of Algeria belongs to the Mediterranean basin which is a “hot spot” of climate change and should therefore be protected (Sahnoune et al., 2013).

By activity, the energy sector (production and consumption) which is the source of highest emissions, about ¾ of the total and this sector has the most important potential for mitigation measures (MATE, 2010). Algeria has conducted two national emission inventories of greenhouse gas (GHG) emissions for the years 1994 and 2000. The inventory covered the direct six greenhouse gases (CO2, CH4, N2O, SF6 and CFCs) and indirect greenhouse gas precursors (NOx, CO, NMVOC and SO2) (Sahnoune et al., 2013). There are also several specialist agencies and centers that were created to specifically address the challenges associated with climate change, particularly in the context of sustainable development. These include: the National Observatory for Environment and Sustainable Development (ONEDD), the National Waste Management Agency (AND), National Centre for the Development of Biological Resources (CNRB), the National Centre for Cleaner Production Technologies (CNTPP), the National Agency for Climate Change (ANCC), the Inter-sectoral Council of Energy Management (ICEM), and the National Agency for the Promotion and Rational Use of Energy (APRUE) (Nachmany et al., 2015).

In terms of the policy framework, Algeria has been party to the United Nations Framework Convention on Climate Change (UNFCC) since 1993 and it ratified the kyoto protocol in 2005 (Burger et al., 2014). By adhering to the Kyoto

Protocol, Algeria has shown its determination to participate in the international effort against climate change and its potential impacts on water resources, natural ecosystems and the sustainability of economic development (Sahnoune et al., 2013). Respecting its contractual engagements, Algeria renews its commitments to work together with the Contracting Parties to achieve the objectives of the United Nations Framework Convention on Climate Change (INDC, 2015). Algeria has committed to reduce its greenhouse gas emissions 7% from business-as-usual by 2030. This could increase to 22% with international support, the oil-producing state said in its contribution to a UN climate deal (Darby, 2015).

The climate strategy of Algeria is defined in the National Climate Plan. It aims, notably, at reinforcing water resources mobilization, controlling flood, protecting the coastline, combating drought and desertification and increasing the ecosystems and agriculture resilience and facing climate change (INDC, 2015). For both climate change adaptation and mitigation measures, strategies largely focus on 3 areas: (i) implementing plans for sustainable socio-economic development, (ii) building new and strengthening and integrating existing institutions and human capacity, and (iii) mitigating GHG emissions via energy diversification and reforestation efforts (Nachmany et al., 2015).

Strategy of Algeria (including the CC) for the agricultural sector are: development of vulnerability mapping in agriculture; mainstreaming CC into Agriculture national program; adaptation of the Agriculture Calendar for CC; selection of seed varieties suitable to CC threats; early warning and advisory climate services for Agriculture and forestry, as main priorities (AGRICONSULTING, 2013).

While climate change mitigation and adaptation measures frequently require inter-ministerial collaboration, most legislation pertaining to climate change mitigation and adaptation falls under the broad authority of four ministries: Land Management and the Environment (MATE), Energy and Mines, Water Resources and Agriculture and Rural Development (Nachmany et al., 2015).

## Conclusion

Life on earth and the well-being of human are closely linked with biodiversity. As confirmed by several scientists, biodiversity in general and agrobiodiversity for food agriculture are among the issues to face and adapt better to climate change and its adverse impacts.

In Algeria, several factors have been behind the degradation of ecosystems and the accentuation of genetic erosion threatening the country's biodiversity; these factors are related to climate, human pressures, socio-economic and cultural upheavals…etc. Global climate change is beginning to be seen at several levels in Algeria and endanger, among other things, the agro-biodiversity of the country and thus its food sovereignty.

In addition to all the steps taken to adapt to the CC, Algeria needs to strengthen its strategies for the safeguarding of its genetic resources in general and, in particular, those related to agriculture. Agricultural practices must be adapted to climate change and its impact by the support of basic research and in particular that of development including the promotion of crop varieties resistant to drought, and improved pest, disease and weed management.

The restoration of natural ecosystems is a crucial issue for the sustainability of biodiversity in Algeria. Degraded areas need to be analyzed and measured with developing appropriate restoration methods (GEF-UNDP[1]).

Rustic species such as barley and pearl millet and resilient systems such as family farming deserve special attention (Rahal-Bouziane, 2016). Pending the gene bank, urgent measures are to strengthen the establishment of cold storage rooms for the medium- and long-term conservation of genetic resources. State support for *in situ* conservation is paramount (Rahal-Bouziane, 2015). Establish an adequate plan of action with a permanent monitoring system to ensure effective coordination and involvement of relevant actors and ministries through the optimal exploitation of national experiences in technical and research institutes, universities and others. The training of cadres for a better understanding and application of legislation is also one of the needs to be done with the establishment of adequate mechanisms for the effective implementation of the various strategies drawn up.

## List of acronyms

**CC**: Climate Change

**CGIAR**: Consultative Group on International Agricultural Research

**CIMMYT** : Centro International de Mejoramiento de Maiz Y Trogo

**FAO**: Food and Agriculture Organization of the United Nations

**GEF:**Global Environment Facility

**GHG**: Greenhouse gas

**GIZ:** German Agency for International Cooperation

**ICRISAT**: International Crops Research Institute for Semi-Arid Tropics

**IPCC:** Intergovernmental Panel on Climate Change

**IUCN**: International Union for Conservation of Nature

**MENA**: Middle East and North Africa

**NASA**: National Aeronautics and Space Administration

**RAC/SPA**: Regional Activity Centre for Specially Protected Areas

**RAMSAR**: Convention Convention on Wetlands of International Importance Especially as Waterfowl Habitat

**UNEP**: United Nations Environment Programme

**UNDP**: United Nations Development Programme

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