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The social driving forces of desertification in the high Algerian steppe plains

The sedentarization of shepherds at the margins of the desert and the introduction of private land ownership in the high Algerian steppe plains has led to profound lifestyle transformations and increased desertification. Based on policy analysis, field observations and oral surveys with 188 household heads, this paper underlines the social drivers of desertification where short-term economic strategies and political misunderstanding are the key elements. Agro-forestry-pastoral practices are no longer in balance with the local environment. Assembling the puzzle pieces has underlined that political leaders and administrators are only partially familiar with the local geosystem, have implemented multiple unsuccessful measures, and have been unable to sufficiently learn (from their efforts) due to political instability. The paper shows that the sedentarization occurring in this fragile environment with low soil fertility creates rural systems that are less resilient to climate fluctuations, which severely impacts both the environment and the most vulnerable inhabitants.

Key words: desertification, sedentarization, steppes, land ownership, political instability, Algeria

Sedentarizacija, odnosno stvaranje stalnih pastirskih naselja na rubovima pustinje te uvođenje privatnoga vlasništva nad zemljištem u visokim alžirskim stepskim ravninama doveli su do snažnih transformacija u načinu života i povećane dezertifikacije. Na temelju analize politika, terenskih opažanja i provedenoga anketnog upitnika s otvorenim odgovorima 188 voditelja kućanstava u radu su istraženi socijalni pokretači dezertifikacije, pri čemu se kao ključni elementi prepoznaju kratkoročne ekonomske strategije i političko nerazumijevanje. Poljoprivredne, šumarske i pastirske prakse više nisu u ravnoteži s lokalnim okolišem. Politički vođe i osobe uključene u administraciju samo su djelomično upoznati s lokalnim geosustavom, proveli su više neuspješnih mjera te zbog političke nestabilnosti, unatoč vlastitom trudu, nisu bili u stanju dovoljno naučiti o tome. Rad pokazuje da sedentarizacija koja se pojavljuje u ovom krhkom okruženju s niskom plodnošću tla stvara ruralne sustave koji su manje otporni na klimatske fluktuacije, što snažno utječe i na okoliš i na najranjivije skupine stanovnika.

Ključne riječi: dezertifikacija, sedentarizacija, stepa, vlasništvo zemljišta, politička nestabilnost, Alžir

Introduction

Desertification is a significant issue in the 21st century (World Bank, 2002; Ozer and Ozer, 2005; UNCCD, 2015; FAO, 1993). It affects about one-sixth of the world's population and one-quarter of its land surface (MEA, 2005). Both physical and anthropogenic factors amplify the phenomenon of desertification. However, while the arid and semi-arid ecosystems have been studied in their structure and function in different regions of the world (Helldén and Tottrup, 2008), the study of the process of desertification remains incomplete because of its complexity and diversity (Liang et al., 2021; Khaldi, 2014; Xu et al., 2011; Schröter et al., 2005; García-Ruiz et al., 2011; Eekhout et al., 2018; Helldén, 2008). Recurrent droughts and low amounts of rainfall combined with pastoralism practices, population increase, overgrazing and socio-economic changes have strengthened desertification (Githu et al., 2022).

The concept of 'desertification' appeared in the 1970s, even if it was effectively used 25 years earlier by Aubréville (1949) to describe the anthropogenic impacts on tropical forests, such as forest fires and logging (Delay et al., 2022). Poverty in the Sahelian regions, caused by the recurrent droughts of the 1970s, was a significant signal for the United Nations Assembly, which highlighted the phenomenon of desertification in series of conferences (1977) (Bruckmann et al., 2022).

The UNCCD (the United Nations Conference to Combat Desertification) defines desertification as: "land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities, which encompass both physical and social bio-factors" (UNCCD, 1994; Bied-Charleton and Burger, 2012). This definition is similar to the definition adopted by the NAIROBI Conference in 1977: "accentuation or extension of the characteristic conditions of deserts; it is a process that leads to a decrease in biological productivity, and consequently a reduction in plant biomass, the useful capacity of the land for livestock, agricultural yields and a deterioration of living conditions for man . . .". The criteria defined at the United Nations Conference on Desertification involve the notion of a "risk of desertification" assessed based on the measure of land vulnerability combined with current and future human and animal pressure. Such criteria lead to considering desertification phenomena as evolutionary, according to changing climatic and human factors.

Nevertheless, this 'official' definition has been widely criticised. Le Houérou (1996) found it "too vague" and defined desertification as "a set of actions that result in a more or less irreversible reduction in vegetation cover leading to the extension of new desert landscapes to areas that did not have the characteristics" (Le Houérou, 1968). Wilson and Juntti (2005) and El Zerey et al. (2009) lamented that the definition of the Earth Summit did not emphasise the political, economic, and socio-cultural dimensions of the phenomenon. However, Lavauden (1927), who studied the degradation of vegetation cover in Tunisia, insisted on its anthropogenic character. "Closely linked to human activity, land degradation is one of the consequences of poor development and a major obstacle to the sustainable development of dry areas" (Cornet, 2001). For a long time it was considered a phenomenon of natural origin, but the anthropogenic drivers of desertification are no longer in doubt.

Human practices generated by socio-environmental and legal situations influence landscape dynamics via actions related to uses, which modify the biotic and abiotic processes of agro-forestry-pastoral environments in steppe landscapes (Geist and Lambin, 2004; Reynolds et al., 2007; Weber and Horst, 2011). With the increase in population and food demands, the steppes are under increasing pressure to intensify load rates, leading to overgrazing, land clearing extension, and deforestation (Akbari et al., 2020; Kaz'min, 2016; Le Houérou, 1996; Bensouiah, 2004).

The UNCCD encourages contractors to "adopt an integrated approach to address the physical, biological and socio-economic aspects of desertification and drought processes" (Akhtar-Schuster et al., 2022). In Algeria, the desertification phenomenon is driven by drought and anthropogenic actions,

including random and food-producing grains, and poor governance of organisations managing and combating desertification (Boussaid et al., 2018; Boukerker et al., 2021). Steppe rangelands remain the most exposed to the phenomenon of degradation. Deforestation, overgrazing, and cultivation of steppes are among the agents that have contributed to this situation; in fact, yields are low, and often equivalent to or less than 4 quintals/ha on predominantly calcareous soils (Arabi et al., 2007). Nevertheless, most of the studies of desertification in Algeria have focused on the description of the phenomena based on remote sensing studies (Ahmed, 2015; Benhizia et al., 2021) or plant inventories (Henni and Mehdadi, 2012; Merdas et al., 2021), rather than exploring the socio-economic drivers. This research aims to fill this gap via policy analysis, intensive field research and interviews with local herders.

While the utilised agricultural area (UAA) represents only 7.4 million hectares or 3% of the national territory of Algeria, the UAA per capita ratio is rapidly declining due to population growth and land degradation (RGA, 2015; Bessaoud et al., 2019). In 1962, this rate was 0.82 hectares per capita; it had decreased to 0.32 in 1989, and to 0.17 in 2020; (Harrane, 2000, World Bank, 2023). Nevertheless, the alfa and mugwort steppes remain the preferred domain of sheep and pastoralists (Pouget, 2008). These immense arid and semi-arid lands cover an area of thirty-six million hectares, where more than 8 million inhabitants live. In 2001, the collective herd reached twenty million heads of sheep (Nedjraoui, 2001) and increased to twenty-eight million in 2017 (FAOStat, 2017). However, since the 1980s, the steppe has been in constant decline. (Slimani and Aidoud, 2004). In addition, further north, 12 million hectares of mountain land are subject to water erosion, causing considerable soil loss and the siltation of dams with a loss in water reserve capacity estimated at 20 million cubic meters per year. According to the General Directorate of Forests, 20 million hectares of land (more than 52% of Algerian land north of the Sahara) are threatened by accelerated desertion in arid and semi-arid bioclimates (DGF, 2007).

In 2001, Nedjraoui (2001) mentioned 600,000 hectares of desertified land in the Algerian steppe zone without the possibility of natural renewal. Compared to the beginning of the 20th century, when the areas occupied by alfa were around 5 million hectares, at the time of writing alfa covers less than 2.6 million ha and does not produce more than 10,000 tons per year (Boudy, 1950; FAO., 2010; FaoStat., 2023)

Our contribution aims to scrutinise the socio-environmental co-evolution (Kallis, 2007) of the steppes around Djelfa in Algeria to underline the diversity of factors, including their diverse spatial levels. Besides local (e.g. agro-pastoral practices, demography) and global (e.g. global warming) factors, national and regional governance should be examined and added to the list of the most influential drivers of desertification. Significantly, successive land reforms have led to the cessation of winter and summer transhumance (*Achaba* and *Azzaba*) and forced sedentary nomads to adopt a new way of life and exploitation of their environment (Boukhobza, 1982; Trautmann, 1989; Hounet, 2013; Daoudi et al., 2015).

This research, based on a local study, aims to understand the complexity of a steppe system affected by desertification and to articulate :(1) the ways of life, in other words, the ways of being, building, and cultivating (Heidegger, 1948; Schmitz, 2012) in these semi-arid environments located on the margins of the desert; (2) the colonial and later Algerian policies of rural development and development of the territory; and (3) land degradation. Regarding the recent nomads' sedentarization, how have agro-pastoral practices adapted? How do these practices expose new lands to desertification? Based on a survey of 188 heads of agro-pastoralist households in the Wilaya of Djelfa, the article presents the adaptations of living patterns that followed the land reforms and sedentarization of nomads. It shows that sedentarization in low-productive environments produces systems that are much less able to adapt to frequent climatic hazards and leads to disastrous situations both for the environment and the most vulnerable people in the system.

The study area

The Algerian steppe forms a vast region located south of the Tell Atlas; it is over 1,000 km long and 300 km wide in the west and centre, and narrows to less than 150 km wide in the east. The steppe ecosystem is delimited to the north by the isohyet of the 400 mm of average annual precipitation in the southern piedmont of the Tell Atlas and to the south by the isohyet of 100 mm along the Saharan Atlas (Khaldi, 2014)

The research was conducted in the OuledNaïl rangelands in the Saharan Atlas, north of Djelfa. The Wilaya of Djelfa (see Fig. 1) lies at the center of northern Algeria, south of the Tell Atlas. Its provincial capital, Djelfa, is 300 kilometres south of Algiers. This part of the territory of 32,000 km² represents

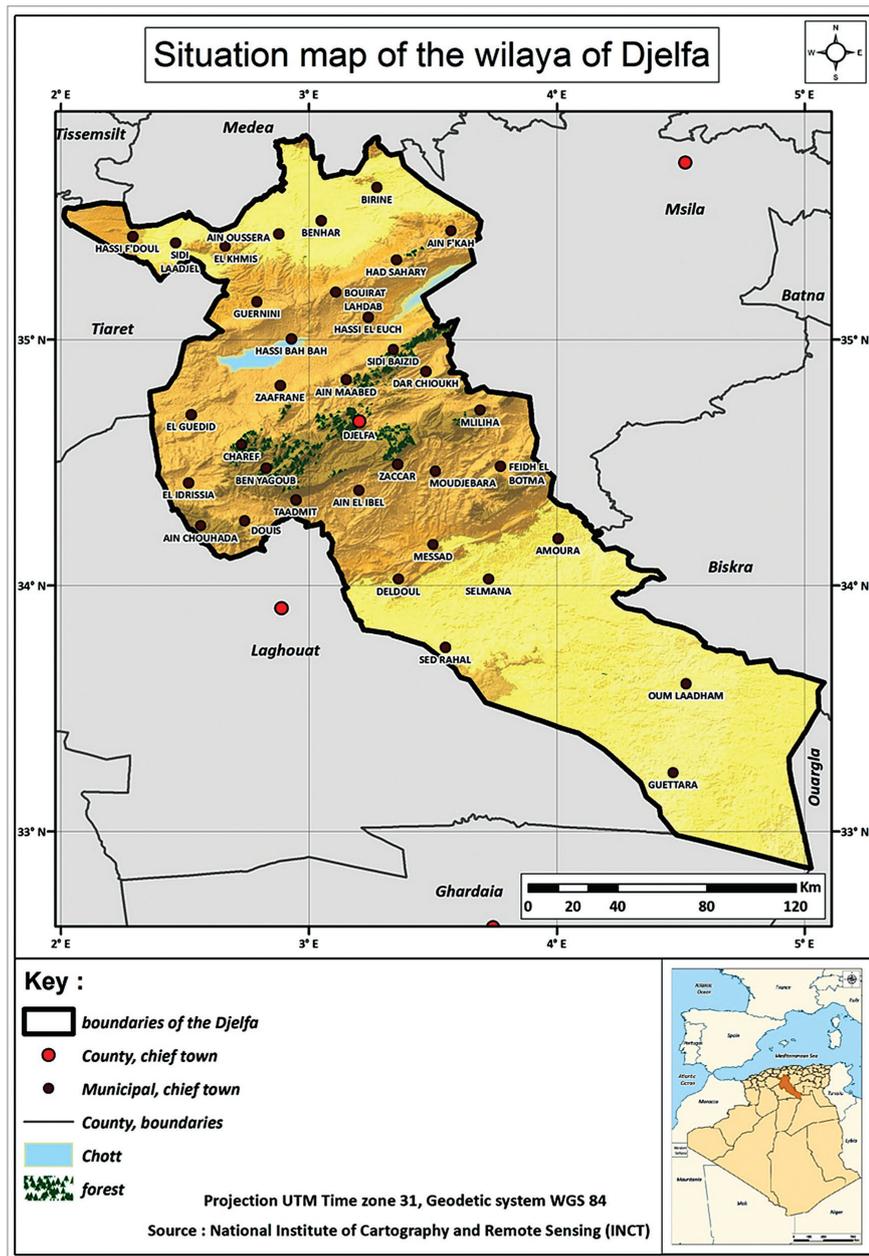


Fig. 1 Situation map of the Wilaya of Djelfa

1.36% of the country's total surface area and houses a population of 1,092,000 inhabitants (RGPH, 2008), currently spread over 36 municipalities. The steppes represent 85% of the total area of Wilaya. The entire herd has about 4 million heads of sheep (DPAT, 2009).

The Wilaya has four distinct landscapes from north to south. In the north, the plains of Aïn Oussera are a relatively flat area between 650 and 850 m altitude. South of these plains, we encounter the depression of the Chotts, Zahrez Gharbi and Zahrez Chergui, the Ouled Naïl mountain range (the backbone of the Saharan Atlas), and further south, the desert plateau which succeeds the foothills of the Saharan Atlas (Mezrag, 2018)

The climate is of the continental Mediterranean type, characterised by a cold winter and a dry period of seven months. The average rainfall is 326 mm per year (Seltzer, 1946; Hirche et al., 2007; Boussaid et al., 2012) but has decreased to an average of 275 mm per year in the last three decades (ONM, 2022); rainfall generally occurs in the form of thunderstorms and torrential rains, sometimes mixed with hail; the number of rainy days varies between 37 and 80 per year, the average (Piche) evaporation exceeds 1,800 mm/year (Bouteldjaoui et al., 2012). The average annual temperature is generally above 20°C. The minimum temperature in the coldest month is 1.9°C, while the maximum temperature in the hottest months can exceed 37°C (ONM, 2010). The prevailing winds are mainly from the west and northwest in winter and the southwest in summer. The average wind speed is 2.7 m/s; winds are sometimes violent due to the number of open spaces without physical obstacles (Merzouk, 1999).

The soils are defined by limestone agglomeration and low organic matter content. These soils are generally shallow. However, some soils located in depressions are relatively deep and rich (Kadik, 1987). The vegetation consists mainly of patches of grasses that do not entirely cover the ground, such as Alfa (*Stipatenacissima*) and White absinthe (*Artemisia herba alba*). These perennial grasses occupy a large part of the territory, especially in the south. The land cover of open forests consists mainly of Aleppo pine (*Pinus halepensis*), Holm oak (*Quercus ilex*) and Phoenicia juniper (*Juniperus phoenicea*) (Djeddaoui et al., 2017).

This area, located in the heart of the steppe with the appearance of a natural geographical entity, is representative of the steppe. However, it also corresponds to a human entity. Most of the population feels a sense of belonging to the Ouled Naïl tribe, composed mainly of formerly nomadic shepherds.

Methods

Before analysing the current agro-pastoral practices, we needed to explore the political history of Algerian steppes to consider nomad people's ancestral rights, agricultural development, and efforts to combat desertification.

We visited the area several times over the last decade to examine the evolution of the landscape and agro-pastoral practices, and analysed the desertification sensitivity map developed in 2010 by the Algerian Spatial Agency and the General Directorate of Forests, based on Thematic Mappers Landsat 5 data (ASAL, 2001; ASAL, 2010; Boulahouat and Naert, 1996; HCDS, 2012; Oussedik et al., 2003; Salamani et al., 2013).

We were able to complement the study on the social drivers thanks to a socio-economic survey conducted in the spring of 2015 on agro-forestry-pastoral practices and their impacts on desertification mitigation. We interviewed 188 household heads and sedentary agro-pastoralists in their home. The sample was constructed based on stratified random sampling that considers the diversity of the surrounding vegetation. The notion of the 'head of the household' still makes sense in the tribal societies of the Algerian steppes, where the patriarchal family persists (Addi, 2005). The head of the household is the reference person, the elder who rules the life of all family members and the agro-forestry-pastoral

activities. It would have been offensive to question another family member on issues that deal with the activity of the entire family clan. Similarly, it was not conceivable for a man to interview a woman, which makes it difficult to gain information regarding women's agroforestry practices or even to know how many wives are present within a given household. When we approached a house, we had to honk to give time for the women to withdraw.

The surveys included the following themes: type of housing, energy use, and agro-pastoralism practices, including the area sown, the nature of crops, the tools used for cultivation, the legal status of the land, the water resources, the composition of the herd and its natural feeding schedule in the diverse rangelands, and additional fodder supply.

Due to the fear of having to declare their capital to the State and to allow respondents to answer in a relaxed fashion, all the variables collected are qualitative: areas of land sown (5 classes), types of water supply (4 types), building materials (4 types), energy sources (3 types), composition of the sheep and goat livestock (2 species and three classes), and finally food supplements (3 types). We adopted the grids established by the 1968 Nomadism Survey (Chellig, 1989), which uses "a defined number of sheep animals to give an accurate picture of the distribution of livestock among owners." The critical masses of 10, 50, 100, and 500 heads of sheep and/or goats characterise the economic and social features of household heads (Chellig, 2005). Agro-pastoralists with less than 50 heads of livestock are mainly small owners or shepherds; those with up to 500 head of livestock are average owners, and those with more than 500 animals are large owners. For this study, we considered three classes: less than 20, between 20 and 50, and more than 50.

Political Backgrounds

Sedentarization and land rights

The steppes regions' current socio-economic and political changes stem from a historical dynamic that has never been adequately investigated or assessed. Sedentarization and the extension of crops to the detriment of grazing lands result from natural and political constraints. As Bourdieu (1958) stated, "This society has known a deep decline: the invading nomadism from a previous era up to 1830 has given way to a limited, regulated and weakened nomadism". For centuries, nomadic tribes exploited the Algerian steppes and lived from transhumance stock farming of small ruminant animals. However, the modern state considers nomad people problematic, for security and control reasons as well as the intent to improve general living standards.

It started with the Sénatus-Consulte (1863) and the Warnier Law (1873), which led to the sedentarization of nomads and the erosion of socio-territorial links between tribes (Bernard, 1930; Sainte-Marie, 1975; Lahmar, 1994). In 1923, summer transhumance (*Achaba*) was placed under the supervision of the municipalities before being vigorously legislated in 1927: "The tribes had to obtain administrative permission to move and to occupy stubble" (Couderc, 1975). In addition, concessions of alfa steppes to industry (mainly the paper industry) have come at the expense of livestock interests (Marion, 1958, *Entreprise coloniales*, 2017). The appropriation of herding land by settlers and the colonial administration has had a disastrous effect on the valorisation of the steppes (Boukhobza, 1982; Hadeid et al., 2015). The complementarity between north and south rangeland gradually disappeared. The herds had to stay year-round in the south, causing severe ecological degradation to an environment weakened by the recurrent droughts of 1930 and 1940. This situation dramatically affected the total Algerian herd from 1876 to 1954, which shrank from 9 million heads to 4 million (Trautmann, 1989; Chellig, 2005; Bencherif, 2013).

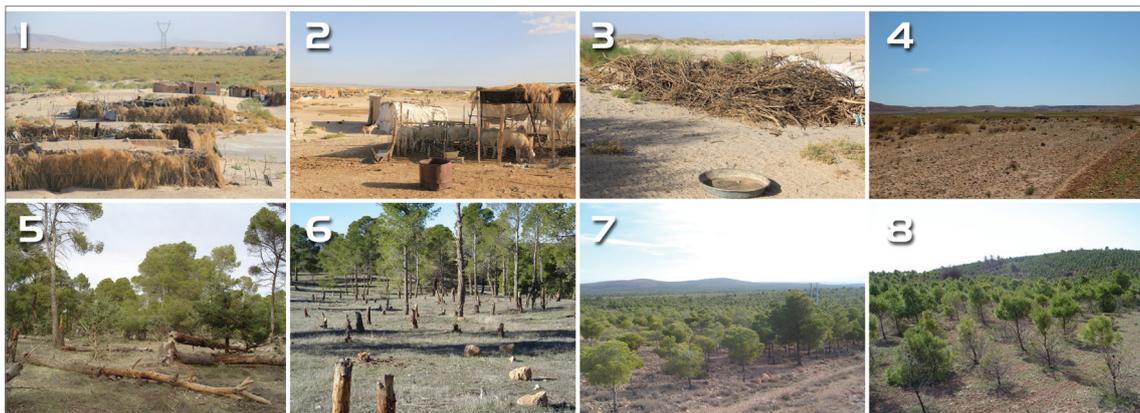


Fig. 2 Illustration of the different modes of land degradation in the Wilaya of Djelfa

1: Type of habitat in the dune belt. 2: Sheep herd of a small pastoralist. 3: Firewood from retamaretam. 4: Illicit cultivation of the soil. 5&6: Illicit logging in an Aleppo pine forest for construction. 7&8: View of the degraded green dam.

Many authors (Sari, 1975; Boukhobza, 1976; Côte, 1993), have emphasised that, at the dawn of the French colonisation, there was a delicate balance between the population, production, and social organisation, whereas during the colonial period, agriculture underwent significant political, legal, economic and social changes. The French period disrupted local nomad society by expropriating lands and creating forested reserves. From 1962 until 1986, the Algerian State implemented an agrarian reform: its objectives were social, economic, and ecological. It promoted Socialist Agricultural Cooperatives and implemented the Green Barrier to contain desertification (Adair, 1983). This reform also included the enactment of the Code Pastoral (HCDS, 1998), which limited the amount of livestock held by each family, abolished absentee livestock farming, generalised herders' cooperatives, prohibited ploughing in the steppe, and reduced the rangelands (Ordinance 75/43 of 17 June 1975) (Abaab et al., 1995; Ahmed, 2011). Nevertheless, this code was rejected by pastoralist tribes, primarily because of the transformation of the status of the Arch lands (tribal lands) into the private property of the state (Benmoussa, 2013). This ambivalence between the new pastoral code and tribal rules led to conflicts of interest between large and small breeders, overuse of steppe resources, and excessive speculation with large herds to capture maximum state subsidies and tax exemptions (Bedrani, 1992).

Later, until 1990, a liberalisation and agricultural restructuring policy aimed to break the socialist policy. Although the civil war slowed down this policy, it created collective and individual farms and ownership of agricultural land (Amichi et al., 2011). In 1983, the Law of Accession to Land Ownership (APFA) authorised full (private) ownership of public land. These reforms paved the way for the privatisation of agriculture but did not liberalise the land market. In 1997, the State changed the conditions of land allocation by entrusting the right of exploitation to the farmer for 99 years and trying to empower local populations regarding land distribution. These repetitive legislation changes concerning the allocation of the steppe broke the traditional links between the herders and the rangeland. They led to the privatisation or the afforestation of former community lands. The new legislation also encouraged ownership of an increasing share of the rangelands because this practice is construed as evidence of ownership. These policies favouring extensive cultivation of grains, including on unsuitable lands, have increased anthropogenic pressure (Houyou et al., 2014).

Viewed as progress, the sedentarization of the agro-pastoralist tribes led to land fragmentation, steppe overuse, deforestation, and soil degradation (see Fig. 2). Moreover, the population and sheep flock have tripled since 1980, going from 8 to 40 sheep/ha.

Agricultural supports

The state's impact on the steppe also includes how the state has supported farmers to be more productive, climatic crises notwithstanding. The significant droughts in the seventies and eighties were combated by a policy of massive imports of livestock feed (barley especially) and sales to livestock farmers at low prices. This state support had controversial results, as the size of the herd throughout the steppe would jump from 9 million heads in 1972 to 16 million in 1991 (Nedjraoui, 2001). As a result, the herds of the Wilayah of Djelfa have experienced significant growth. From 700,000 heads between 1929 and 1954 (Dermenghem, 1956), to 1 million heads in 1978 (transhumant and sedentary) (Smail, 1991), 2 million in 1997, and over 3 million in 2009 (DSA, 2009). Currently, this number is approaching 4 million heads, representing one-fifth of the national herd (Kanoun et al., 2016). Yet, according to the National Territorial Development Scheme (SNAT 2007, p. 55), the Algerian "steppe, in its current state, can only support 4 million head, given the possibilities of natural regeneration". As a result, the pastoral load has evolved from a sheep equivalent of 4 ha in 1968 to a sheep equivalent of 0.78 ha in 2009, causing excessive grazing; the vegetation composed of esparto and artemisia has regressed gradually, causing the widespread appearance of the calcareous crust (FAO, 2010)

In 2000, Algeria launched the National Plan for Agricultural and Rural Development (PNDAR), which supports agricultural production by encouraging farmers to invest. This support is carried out with the state's financial participation from funds and investment credits (Cherrad, 2012). The financing model does not prioritise one cultivation system. However, programs are set according to each area (Hadibi et al., 2009). Concerning the Wilaya of Djelfa, despite numerous achievements financed by the Fund to Combat Desertification, the Protection of Rangelands and Steppes, and the Rural Development fund and land development, the achievements were far from the objectives: only 3 million hectares of fencing, 300,000 ha of pastoral plantations and the multiplication of water points (Nedjraoui and Bédrani, 2008). HCSD has not yet been able to implement a comprehensive strategy for the sustainable development of steppe areas, due to the difficulties of grasping the steppe systems from a holistic point of view and the effort required to understand the complex socio-environmental co-evolution.

The method of financing these programs remains essentially public in the form of subsidies and is closely dependent on state oil revenue. However, this enthusiasm has gradually faded: first, because of the low average annual growth in agricultural production and the increasingly high food costs, and second, because of the oil and security crises.

Combating desertification

Nonetheless, besides the concern of land ownership and agriculture development, the State tried to stabilise the dunes with mechanical and plantation methods (Makhlouf, 1993; Akkouche et al., 2017) and planted a forest—the green dam—to contain the desert (Nedjraoui and Bédrani, 2008; Martinez-Valderrama et al., 2018). Launched in 1974, the 'green dam' aimed to reforest 3 million hectares in the band between 200 and 300 mm of annual rainfall to slow down the process of desertification and restore the ecological balance. However, the project was diverted from its primary target (the junction of the forest massifs of the Saharan Atlas) and transferred to rich alfa steppes, thus contributing to degradation from deep ploughing and inadequate plantations (Bensaïd, 1995; Halimaet al., 2006). Spread over 1,000,000 ha in the Djelfa region, only a few islets remain populated by gnarled trees among vast decertified areas. Indeed, these projects and plantations neglected agro-pastoral practices and their interaction with rangelands (Hadeid, 2008). Due to the anthropogenic impacts accompanying population and livestock increase, projected to reach two million inhabitants and five million sheep heads by 2030,

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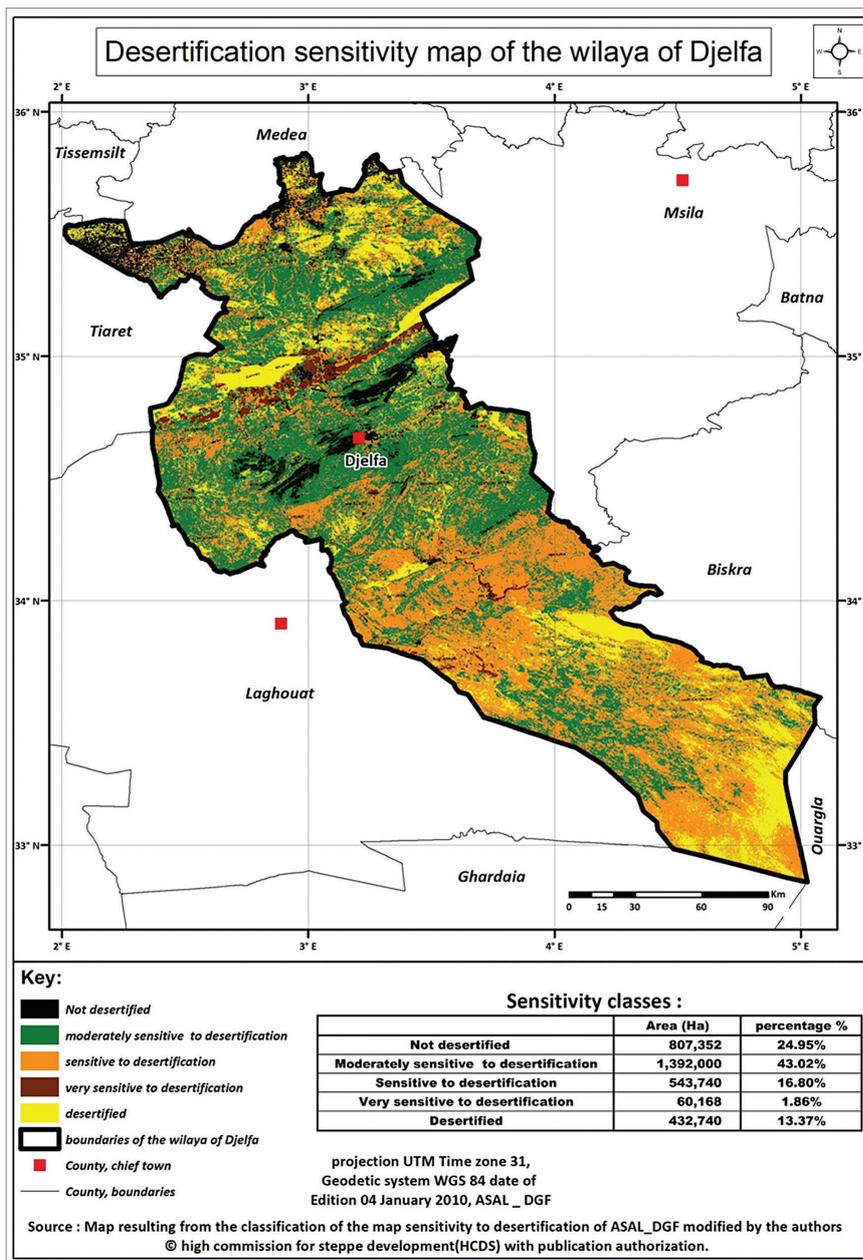


Fig. 3 Desertification Sensitivity Map of the Wilaya of Djelfay

we will likely witness the degradation of Aleppo pine plantations and the disappearance of the green dam project in the Wilaya of Djelfa (Benzhizia et al., 2021).

The desertification sensitivity map (see Fig. 3) distinguishes five sensitivity levels ranging from the forest and matorral areas in the Djebels area, to desertified areas that already concern 14% of the Wilaya of Djelfa. Roughly 19% of the land is susceptible to desertification. These areas mainly concern land occupied by degraded psammo-halophilic vegetation near the dune ridge, the depression of the Zahrez el Gharbi, or the Chott. The millions of hectares of alfa and mugwort steppes, 43% of the total area, are less sensitive to desertification but require attention and monitoring due to the increasing size of the herd and the multiplication of sown areas.

The agro-pastoral practices

The socio-economic survey conducted in the spring of 2015 on agro-forestry-pastoral practices allows us to point out how the agro-pastoralism population accommodates this changing natural and political environment.

The ancestral nomads, turned into sedentary agro-pastoralists, have established their houses near water points where the pressure on the environment is significant due, inter alia, to repeated trampling by livestock. Around 60% of the households interviewed collected surrounding firewood for cooking and heating. Many buildings used varied local materials such as mud, wood, and palm leaves to replace the mainly traditional tents, and one-quarter of the interviewed households used cement. In most cases, water and grazing are usually insufficient for the family and the herd's needs, which requires the adoption of new practices.

During field visits, we observed the multiplication of the sown areas, including on the Chott (Salt Lake). These practices considerably impact the ecosystems because the few endogenic plants have been destroyed to allow grain cropping, which, in practice, offers a meagre yield and can be sustained for only a few years.

Sedentarization has redistributed agro-forestry-pastoral practices: the semi-stabling of herds (a portion of the feed is subsidized by the state), harvest of fodder units from smaller temporary fields, and mobilisation of aquifer resources for land appropriation. Thus, new ways of living in a historically sparsely-populated area are generating new relationships between man and the natural environment that pose dangers to an environment in advanced degradation.

Most of household heads in our study area have modest herds; 39% of the household heads surveyed had a sheep herd of more than 50 head, while 45% of household heads had less than 20 sheep. Regarding goats, 32% of household headshad a herd of fewer than 20 heads, while only four household heads interviewed had more than 50 heads (Tab.1). Nearly 60% and 88% of the agro-pastoralists in the sample have a herd, of sheep

Tab.1 distribution of variables according to household heads

Variables	Number of households	Share %	Variables	Number of households	Share %
sheep herd			Area of land sown		
<20 heads	85	45%	[0–5] hectares	83	44%
[20–50] heads	47	25%	[5–10] hectares	23	12%
>50 heads	56	30%	[10–15] hectares	19	10%
Goat livestock class			[15–20] hectares	20	11%
<20 heads	153	82%	> 20 hectares	43	23%
[20–50] heads	31	17%	supplementary feed (barley seed)		
>50 heads	4	1%	Seasonal	17	9%
Legal nature of land			All year	127	68%
Stateprivate domain	73	39%	No supplement	44	23%
Private property	20	10%	Energy sources		
State domain	95	51%	Charcoal	19	10%
Water sources			Firewood	111	59%
Tube wellpumps	30	16%	Electricity and Coal	58	31%
Uncovereddugwells	30	16%			
Surface water	9	5%			
Truck-tank	119	63%			

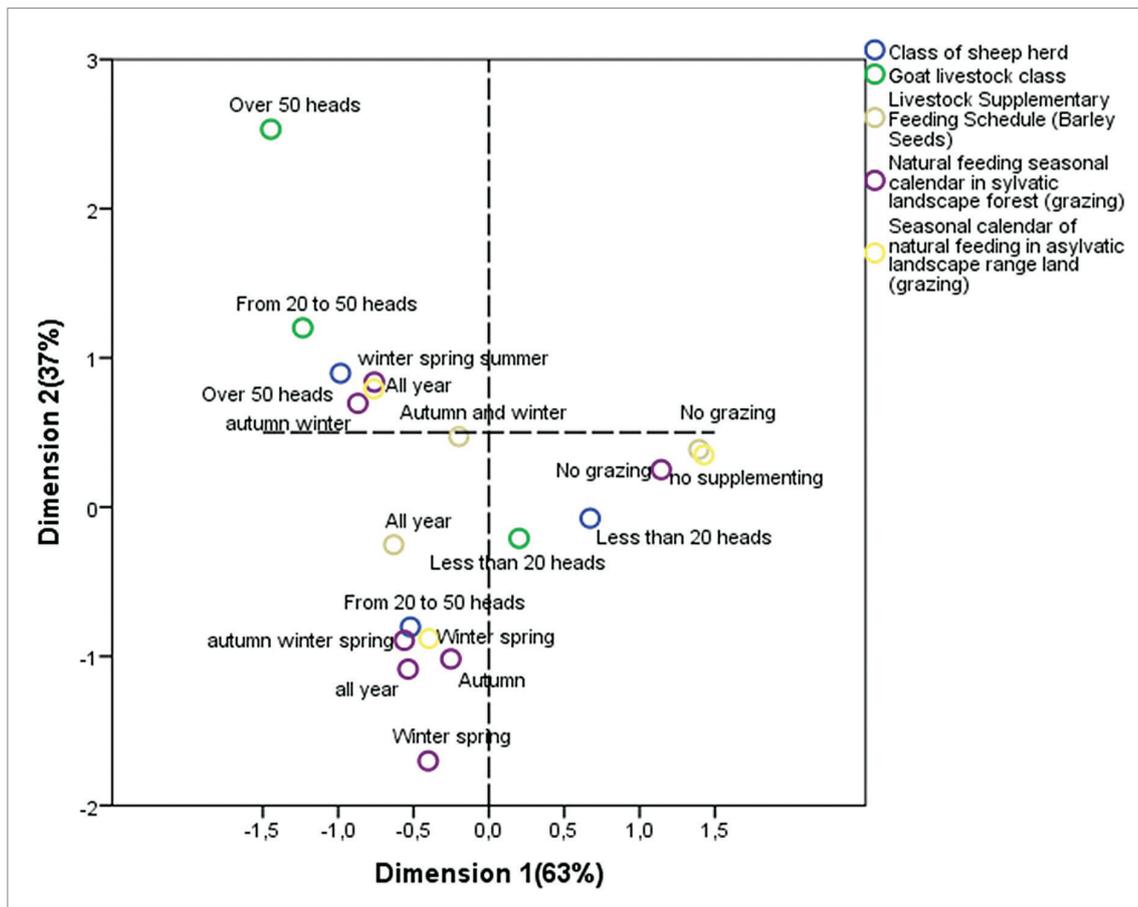


Fig. 4 Multiple correspondence analysis

or goats respectively, of less than 50 heads (Tab. 1). This means that most of the household heads in our study area are small shepherds. The ownership nature of the Ouled Nail rangelands remains primarily of the public domain status, with 51% of households of the sample. In the second category, the private domain status, i.e. formerly land arch (Tribal), predominates with 39% of households. If we include the 10% of household heads who own private lands, half of the households valorize privatized lands. These lands represent 75,000 ha of the studied territory.

The interviews showed herds belonging to people living in town who maintain their rights to the rangelands and contribute to the overuse of resources. These absent herders pay other people to take care of their herds which are usually bigger than those belonging to herders still living in the steppes.

Most households use ploughs with mechanical traction, and household heads practice a combination of grain farming (wheat and barley). Moreover, 44% of the household heads interviewed have tiny sown areas, less than five hectares. These small areas are located mainly in the forest environment, the dune ridge, and the Chott. In contrast, 23% of heads of households cultivate the most prominent areas (those greater than 20 ha), usually in steppe environments. These practices' evolution has led to a marginalization of the smaller herders who do not own lands personally and need to occupy forest or the less valuable steppes near the Chott and the dunes. Nonetheless, both categories of household head have an increasing impact on land degradation: the wealthier people increase their livestock thanks to water and fodder exportation, and the poor households overuse marginalized areas that should be grazed sparingly.

Multiple correspondence analysis (see Fig. 4) of feeding systems and livestock size identified two dimensions that represent the sample's variability very well. The first dimension is related to the size of the herd, while the second differentiates herds of sheep and goats. In the fourth quadrant (lower right), we find the smallest farmers who do not have the need or the means to diversify their fodder sources. The third quadrant (lower left) shows medium-sized sheep herds that graze in steppes at the end of winter, frequent the forest in other seasons, and receive supplementation all year round. The fourth quadrant (upper left) isolates the larger sheep farmers. They benefit from grazing in steppes all year round while also using forest areas and buying additional fodder for autumn and winter. On the other hand, the large herds of goats graze indifferently in steppe and forest areas and do not require the purchase of fodder.

Most heads of households (68%) practice annual supplementation with barley seed (Tab. 1). This practice further taxes the sustainability of the rural systems because herders increasingly import water. If the herd does not travel to water and fodder, modern means of transport bring them in, upsetting the steppe system more. The sample's primary water source for 63% of households is a tanker truck or towed tank. The second mode of water supply concerns pumped tubular wells and uncovered dug wells, used by 32% of households (Tab. 1).

Discussion and Conclusion

The historical background indicates that, although the steppe is a limited resource, various policies paid little attention to the fragile ecosystems and how they should be managed for and with the agro-pastoralist inhabitants. On the one hand, the priorities were an increase of agricultural productivity, in a very short-term perspective, and stopping the 'progression' of the desert. Since the start of sedentarization, the result has been an ongoing tragedy leading to the destruction of the steppes, herds, and inhabitants. Unsuitable strategies, such as using water trucks, purchasing fodder, and crop cultivation, have also increased land degradation and social inequalities.

The amplification of these practices in an arid landscape contributes to the intensification of desertification (Nedjraoui, 2001; Hadeid, 2008). Due to its bioclimatic characteristics, the steppe does not allow dense settlement. Modes of coexistence that ensure the lifestyle of the different family clans while maintaining a certain ecological balance are required (Hadeid et al., 2015). The current overuse of the Algerian steppe is ecologically unsustainable (Khaldi, 2014) and leads to major socio-economic concerns (Nedjraoui and Bédrani, 2008; Bisaro et al., 2014; Akbari et al., 2020).

Numerous studies have stressed the importance of good governance in the fight against desertification and the risks associated with establishing a unified standardisation system in the approach to the phenomenon (Ferreira et al., 2021). In addition, the survey pointed out that current ways of life are, on the one hand, strongly influenced by the centuries-old practices of nomadic tribes, while the conditions of use and nutritional qualities of steppe environments have fundamentally changed, and are not in step with agricultural and social policies intended to meet critical challenges at the national level (e.g. food sovereignty, rural exodus, unemployment) that are not adapted to the socio-economic, cultural, and environmental situation of the studied semi-arid area (Boussaid et al., 2018). Assembling the puzzle pieces of desertification in the high Algerian steppes requires underlining that political leaders and administrations with little experience with the local geosystem have enacted a series of unsuccessful measures and never got the time to learn from their policies' shortcomings due to political instability.

State policies dedicated to steppe areas and the fight against desertification have resulted in resounding failures and results contrary to those sought. Whether technical, financial or regulatory, the state's interventions have neglected the human element's importance and eradicated traditional ways of life under the pretext of modernisation and efficiency. Despite some relative successes (prohibitions, pastoral

plantations, a program of significant works, etc.), the degradation of the environment has only increased, condemning the impoverished indigenous populations to urban exile or sedentarization, which are detrimental to the surrounding natural environments.

It is the opinion of the authors that political and administrative officials should examine some practical ideas with the inclusion of local people, to better assess their potential and difficulties regarding implementation. Of course, it is not easy to reinstate nomadism, but more transversal and bottom-up governance of the steppes can help better use and share the resources. This would require a certain level of political stability. Such local governance should, for instance, decide if absent shepherds should be banned or regulated, where and when cultivations are suitable, how to manage the issue of water importation, and how to diversify the rural economy considering the weight of tradition.

- Abaab, A., Bédrani, S., Bourbouze, A., Chiche, J., 1995: Les politiques agricoles et la *dynamique* des systèmes agropastoraux au Maghreb, *Options Méditerranéennes* 14, 139-165.
- Adair, P. 1983: Rétrospective de la réforme agraire en Algérie (1972-1982), *Revue Tiers Monde* 93, 153-168, DOI: 10.3406/tiers.1983.4265
- Addi, L., 2005: Femme, famille et lien social en Algérie; Famille et mutations socio-politiques, in: Kian-Thiebaut, A., Lader-Fouladi, M. (eds): *L'approche culturaliste à l'épreuve*, Editions de la Maison des sciences de l'homme, Paris, 71-87.
- Ahmed Ali, A., 2011: La législation foncière agricole en Algérie et les formes d'accès à la terre, in: Elloumi, M., Jouve, A.-M., Napoléone C., Paoli, J. C., (eds.): *Régulation foncière et protection des terres agricoles en Méditerranée*, CI-HEAM, Montpellier, 35-51.
- Ahmed, Z., 2015: Determination and analysis of desertification process with satellite data Alsat-1 and Landsat in the Algerian Steppe, *Engineering Geology for Society and Territory Landslide*, Springer International Publishing, 1847-1852, DOI:10.1007/978-3-319-09057-3_327.
- Akbari, M., Modarres, R., Noughani, M. A., 2020: Assessing early warning for desertification hazard based on E-SMART indicators in arid regions of northeastern Iran, *Journal of Arid Environments* 174, 104086, DOI: 10.1016/j.jaridenv.2019.104086.
- Akkouche, S., Kadik, L., Guerrache, N., Bouderbala, R., 2017. Characterizing the fixation of dunes in the region of Djelfa in Algeria, *International Journal of Ecology & Development* 32, 1-11.
- Akhtar-Schuster, M, Stringer, L. C., Metternicht, G., Barger, N. N., Chotte, J-L., Kust, G., 2022: Assessing the Impact of Science in the Implementation of the United Nations Convention to Combat Desertification., *Land* 11 (4), 568, DOI: 10.3390/land11040568.
- Amichi, H., Bazin, G., Chehat, F., Ducourtieux, O., Fusillier, J. L., Hartani, T., Kuper, M., 2011: Enjeux de la recomposition des exploitations agricoles collectives des grands périmètres irrigués en Algérie: le cas du Bas-Chelif, *Cahier Agriculture* 20 (1), 150-156, DOI: 10.1684/agr.2010.0459.
- Arabi, M., Bourougaa, L., Kedaïd, O., 2007: Intensification de l'agriculture et réduction des risques érosifs en milieu semi-aride algérien, *Actes des JSIRAUF*, Hanoi, 1-8.
- ASAL - Agence spatiale algérienne, 2001: Conservation des forêts de la Wilaya de Djelfa, Rapport de synthèse sur la carte de sensibilité à la désertification à l'aide de deux images satellitaire MSS 1972 et ETM + 2001, ASAL, Alger.
- ASAL - Agence spatiale algérienne, 2010: Finalisation de la carte nationale de sensibilité à la désertification par l'outil spatial, ASAL, Alger.
- Aubréville, A.A., 1949: *Climats: forêts et désertification de l'Afrique tropicale*, Société d'éditions géographiques, maritimes et coloniales, Paris.
- Bedrani, S., 1992: Les aspects socio-économiques et juridiques de la gestion des terres arides dans les pays méditerranéens, *Cahiers du CREAD* 31-32, 9-26.
- Bencherif, S., 2013: L'élevage agropastoral de la steppe algérienne dans la tourmente: enquêtes et perspectives de développement, *Mondes en développement* 161, 93-106, DOI: 10.3917/med.161.0093.
- Benmoussa, B., 2013: An effect of globalization? The individual appropriation of 'arch lands in Algeria, *The Journal of North African Studies* 18, 668-677, DOI: 10.1080/13629387.2013.849889.
- Bensaïd, S., 1995: Bilan critique du barrage vert en Algérie, *Sécheresse* 6, 247-255.
- Bensouiaïh, R., 2004: Pasteurs et agropasteurs de la steppe algérienne, Enquête sur la région de Djebel Amour, *Strates* 11, 478, DOI: 10.4000/strates.478.
- Benhizia, R., Kouba, Y., Szabó, G., Négyesi, G., Ata, B., 2021: Monitoring the Spatiotemporal Evolution of the Green Dam in Djelfa Province, Algeria, *Sustainability* 13, 7953, DOI: 10.3390/su13147953.
- Bernard, A., 1930: *Histoire des colonies française et de l'expansion de la France dans le Monde, T.2 L'Algérie*, Société de l'Histoire dans le Monde, Librairie Plon, Paris.
- Bessaoud, O., Pellissier, J. P., Rolland, J. P., Khechimi, W., 2019 : *Rapport de synthèse sur l'agriculture en Algérie*, CI-HEAM, Montpellier.
- Bied-Charreton, M., Burger, P., 2012: Convention des Nations Unies sur la lutte contre la désertification, difficultés et perspectives, *Sécheresse* 23, 153-157. <https://www.jle.com/10.1684/sec.2012.0358>.
- Bisaro, A., Kirk, M., Zdruli, P., Zimmermann, W., 2014: Global drivers setting desertification research priorities: insights from a stakeholder consultation forum, *Land Degradation & Development* 25, 5-16, DOI: 10.1002/ldr.2220.

References

- Boudy, P., 1950: *Economie forestière Nord-africaine-Tome 2: monographies et traitements des essences forestières*, E. Larose, Paris.
- Boukerker, H., Boumedjene, M., Doughbege, A., Belhouadjeb, F., Kherifi, W., Bekiri, F., 2021: State of pastoral resources in the Algerian steppe regions: main factors of degradation and definition of preservation and rehabilitation actions, *Livestock Research for Rural Development* 33 (12), 140.
- Boukhobza, M., 1976: *Nomadisme et colonisation, Analyse des mécanismes de déstructuration et de disparition de la société pastorale traditionnelle en Algérie*, Thèse de doctorat de 3e cycle, EHESS, Paris.
- Boukhobza, M. H., 1982: *L'agro-pastoralisme traditionnel en Algérie: de l'ordre tribal au désordre colonial*, Office des publications universitaires, Alger.
- Boulahouat, N., Naert, B., 1996: Télédétection des ressources en sols des zones arides. Une méthode d'inventaire adaptée au travail sur le terrain, expérimentée dans la région de Djelfa (Algérie), *Etude et Gestion des Sols* 3 (1), 7-26.
- Bourdieu, P., 1958: *Sociologie de l'Algérie*, Presses Universitaires de France, Paris.
- Boussaid, A., Nouari, S., Djaballah, F., 2012: Contribution a une étude climatique comparative entre deux trentaines d'années (1913-138) et (1975-2009), cas de la région de Djelfa, *The Egyptian Journal of Environmental Change* 4, 23-44.
- Boussaid, A., Souiher, N., Dubois, C., Schmitz, S., 2018: L'amplification de la désertification par les pratiques agro-sylvo-pastorales dans les hautes plaines steppiques algériennes: les modes d'habiter de la Wilaya de Djelfa, *Cybergeo: European Journal of Geography* 862, DOI: 10.4000/cybergeo.29257.
- Bouteldjaoui, F., Bessenasse, M., Guendouz, A., 2012: Etude comparative des différentes méthodes d'estimation de l'évapotranspiration en zone semi-aride (cas de la région de Djelfa), *Nature & Technology* 7, 109-116.
- Brückmann, L., Chotte, J. L., Duponnois, R., Loireau, M., Sultan, B., 2022: Accelerate the Mobilization of African and International Scientific Expertise to Boost Interdisciplinary Research for the Success of the Sahelian Great Green Wall by 2030; *Land* 11 (10), 1744, DOI: 10.3390/land11101744.
- Chellig, N., 1989: *Pouvoirs et société agro-pastorale dans les Hautes Plaines steppiques en Algérie: les communes pastorales de l'Algérie centrale*, Thèse de doctorat, Université de Provence, Faculté des lettres et sciences humaines, Aix-en-Provence.
- Chellig, N., 2005: *Du nomadisme: essai d'anthropologie historique sur les relations entre les pouvoirs dans la société algérienne, centre nationale préhistorique anthropologiques et historiques*, CNRPAH, Alger.
- Cherrad, S., 2012: *Mutations de l'Algérie rurale, 1987-2010, Les évolutions dans le Constantinois*, Éditions Dar El Houda, Ain M'lila.
- CNUED, 1992: Rapport sur la conférence des Nations-Unies sur l'environnement et le développement, Agenda 21, CNUED, Rio.
- Cornet, A., 2001: La désertification à la croisée de l'environnement et du développement, *Comité Scientifique français de la désertification*.
- Côte, M., 1993: *L'Algérie ou l'espace retourné*, Paris, Media Plus.
- Couderc, R., 1975: De la tribu à la coopérative, aperçu de l'évolution des Hautes Plaines oranaises, le développement des zones arides, *Options méditerranéennes* 28, 65-74.
- Daoudi, A., Colin, J.-P., Derderi, A., Ouendeno, M. L., 2015: Mise en valeur agricole et accès à la propriété foncière en steppe et au Sahara (Algérie), *Les Cahiers du Pôle Foncier* 13, 3-31.
- Delay, E., Ka, A., Niang, K., Touré, I., Goffner, D., 2022: Coming back to a Commons approach to construct the Great Green Wall in Senegal, *Land Use Policy* 115, 106000, DOI: 10.1016/j.landusepol.2022.106000
- Dermenghem, E., 1956: Le pays des Ouled Nail, *Documents algériens* 20, 1-12.
- DESA, United Nations, 2016: Transforming our world: The 2030 agenda for sustainable development, <https://wedocs.unep.org/20.500.11822/11125> (18.03.2023.).
- Djeddaoui, F., Chadli, M., Gloaguen, R., 2017: Desertification Susceptibility Mapping Using Logistic Regression Analysis in the Djelfa Area, Algeria, *Remote Sensing* 9 (10), 1031, DOI: 10.3390/rs9101031.
- DGF - Direction générale des forêts, 2007: *Politique forestière nationale et stratégie d'aménagement et de développement durable des ressources forestières et alfatières*, document provisoire, DGF, Algérie, <https://www.fao.org/forestry/16079-0c9b3b0935dcd8c7727d-952491c3eb681.pdf> (18.03.2023.).
- DPAT - Direction de la Planification et de l'Aménagement du territoire, 2009: *Monographie et statistique sur la wilaya de Djelfa*, Ministère des finances (Algérie).
- DSA - Direction des Services Agricoles, 2009: *Statistiques agricoles de la Wilaya de Djelfa*, DSA, Algérie.
- Eekhout, J. P., Hunink, J. E., Terink, W., De Vente, J., 2018: Why increased extreme precipitation under climate change negatively affects water security, *Hydrology and Earth System Sciences* 22, 5935-5946, DOI: 10.5194/hess-22-5935-2018-supplement.
- El Zerey, W., Bachir Bouiadjra, S., Benslimane, M., Mederbal, K., 2009: L'écosystème steppique face à la désertification: cas de la région d'El Bayadh, Algérie, *VertigO* 9, <https://id.erudit.org/iderudit/044098ar>.
- Entreprises coloniales, 2017: l'alfa le pontet société pour la fabrication des pâtes de cellulose (1922-1961), <http://www.entreprises-coloniales.fr/> (18.03.2023.).
- FAO, 1993: Développement durable des terres arides et lutte contre la désertification, Département des forêts, FAO, <http://www.fao.org/docrep/v0265f/v0265f04.htm> (18.03.2023.).
- FAO, 2010: Évaluation des ressources forestières mondiales, rapport national Algérie, FAO, <https://www.fao.org/forestry/20264-0d4bbec80ea29fbf19fc-082c6ed138087.pdf> (18.03.2023.).
- FAO, 2019; 2023 : FAOStat, <https://www.fao.org/faostat/fr/#data> (19.03.2023.).
- Ferreira, C. S., Seifollahi-Aghmiuni, S., Destouni, G., Ghajarnia, N., Kalantari, Z., 2021: Soil degradation in the European Mediterranean region: Processes, status and consequences. *Science of The Total Environment* 805, 150106, DOI: 10.1016/j.scitotenv.2021.150106.

- García-Ruiz, J. M., López-Moreno, J. I., Vicente-Serrano, S. M., Lasanta-Martínez, T., Beguería, S., 2011: Mediterranean water resources in a global change scenario, *Earth-Science Reviews* 105, 121-139, DOI: 10.1016/j.earscirev.2011.01.006.
- Geist, H. J., Lambin, E. F., 2004. Dynamic causal patterns of desertification, *Bioscience* 54, 817-829, DOI: 10.1016/j.earscirev.2011.01.006.
- Githu, D. W., Fehmi, J. S., Josephson, A., 2022: Pastoralist herd size maintenance during drought with the use of reseeded fields near Lake Baringo, Kenya, *Pastoralism* 12, 21, DOI: 10.1186/s13570-022-00238-4.
- Hadeid, M., 2008: Approche anthropique du phénomène de désertification dans un espace steppique: le cas des hautes plaines occidentales algériennes, *VertigO* 8 (1), DOI: 10.4000/vertigo.5368
- Hadeid, M., Bendjelid, A., Fontaine, J., Ormaux, S., 2015: Dynamique spatiale d'un espace à caractère steppique: le cas des Hautes Plaines sud-oranaises (Algérie), *Cahiers de géographie du Québec* 59, 469-496, DOI: 10.7202/1037259ar
- Hadibi A., Chekired-Bouras F. Z., Mouhouche B., 2009: Analyse de la mise en œuvre du plan national de développement agricole dans la première tranche du périmètre de la Mitidja Ouest, in Économie d'eau en systèmes irrigués au Maghreb, Actes du quatrième atelier régional, 26-28 mai 2008, Mostaganem (Algérie).
- Halima, M., Abderrahmane, L., Khéloufi, B., 2006: Essai sur le rôle d'une espèce végétale rustique pour un développement durable de la steppe algérienne, *Développement durable et territoires* 2925, DOI: 10.4000/dveloppement-durable.2925.
- Harrane, K., 2000: *Gestion des écosystèmes fragile: lutte contre la désertification (les sites ensablés)*, Rapport de synthèse, Direction Générale des Forêts, Algérie.
- HCDS – Haut-Commissariat au développement de la steppe, 1998: Problématique des zones steppiques et perspectives de développement, Rapport de synthèse, Djelfa.
- HCDS - Haut-Commissariat au développement de la steppe, 2012: Mise au point de la méthodologie de cartographie de la sensibilité à la désertification application sur la Wilaya de Djelfa, HCDS, Djelfa.
- Heidegger, M., 1958: Bâtir habiter penser, in *Essais et conférences*, 170-193, Gallimard, Paris.
- Helldén, U., 2008. A coupled human-environment model for desertification simulation and impact studies. *Global and Planetary Change*, 64, 158-168, DOI: 10.1016/j.gloplacha.2008.09.004.
- Helldén, U., Tottrup, C., 2008. Regional desertification: A global synthesis, *Global and Planetary Change* 64, 169-176, DOI: 10.1016/j.gloplacha.2008.10.006.
- Henni, M., Mehdadi, Z., 2012: Évaluation préliminaire des caractéristiques édaphiques et floristiques des steppes à armoise blanche dégradées réhabilitées par la plantation d'Atriplex dans la région de Saïda (Algérie occidentale), *Acta botanica gallica* 159 (1), 43-52, DOI: 10.1080/12538078.2012.671640.
- Hirche, A., Boughani, A., Salamani, M., 2007: Évolution de la pluviosité annuelle dans quelques stations arides algériennes, *Sécheresse* 18, 314-320.
- Hounet, Y. B., 2013: Propriété, appropriation foncière et pratiques du droit en milieu steppique (Algérie), *Études Rurales* 192, 61-77, DOI: 10.4000/etudes-rurales.9898.
- Houyou, Z., Bielders, C. L., Benhorma, H. A., Dellal, A., Boutemdjet, A., 2014: Evidence of strong land degradation by wind erosion as a result of rainfed cropping in the Algerian steppe: a case study at Laghouat, *Land Degradation & Development* 27 (8), 1788-1796, DOI: 10.1002/ldr.2295.
- Kadik, B., 1987: Contribution à l'étude de *Pin d'Alep (Pinus halepensis Mill.) en Algérie: écologie, dendrométrie, morphologie*, Office des Publications Universitaires, Alger.
- Kallis, G., 2007: Socio-environmental coevolution, Towards an analytical approach, *International journal of sustainable development and world ecology* 14 (1), 4-13, DOI: 10.1080/13504500709469703.
- Kanoun, M., Huguenin, J., Kanoun Meguellati, A., 2016: Savoir-faire des agropasteurs ovins de Djelfa (Algérie) en milieux steppiques en matière d'engraissement des produits d'élevages ovins, in: Napoléone, M., Ben Salem, H., Boutonnet, J.P., Lopez-Francos, A., Gabina, D. (eds.): *The value chains of Mediterranean sheep and goat products. Organisation of the industry, marketing strategies, feeding and production systems*, CIHEAM, Montpellier, 223-230.
- Kaz'min, M., 2016: Transformation of agricultural land use in Russian regions in the course of modern socio-economic reforms, *Regional Research of Russia* 6, 87-94, DOI: 10.1134/S2079970516010056.
- Khaldi, A., 2014: La gestion non-durable de la steppe algérienne, *VertigO* 15152, DOI: 10.4000/vertigo.15152.
- Lahmar, M., 1994: *Du mouton à l'olivier, Essai sur les mutations de la vie rurale maghrébine*, Cérès Éditions, Tunis.
- Lavauden, L., 1927: *Les forêts du Sahara, Revue Eaux et Forêts*, Berger-Levrault, Nancy.
- Le Houérou, H. N., 1968: La sédentarisation du Sahara Septentrional et des steppes limitrophes (Libye, Tunisie, Algérie), *Annales Algériennes de Géographie* 6.
- Le Houérou, H. N., 1996: Climate change, drought and desertification, *Journal of Arid Environments*, 34, 133-185, DOI: 10.1006/jare.1996.0099.
- Liang, X., Li, P., Wang, J., Shun Chan, F. K., Togtokh, C., Ochir, A., Davaasuren, D., 2021: Research Progress of Desertification and Its Prevention in Mongolia, *Sustainability*, 13, 6861, DOI: 10.3390/su13126861.
- Makhlouf, L., 1993: *Etude sédimentologie des sables du cordon dunaire dans le bassin du Zabrez Gharbi (Djelfa)*, Thèse de doctorat, Université Pierre et Marie Curie, Paris.
- Marion, J., 1958: L'alfa, matière première pour l'industrie papetière, *Revue Forestière Française*, 345-347.
- Martínez-Valderrama, J., Ibáñez, J., Del Barrio, G., Alcalá, F. J., Sanjuán, M. E., Ruiz, A., Hirche, A., Puigdefàbregas, J., 2018: Doomed to collapse: Why Algerian steppe rangelands are overgrazed and some lessons to help land-use transitions, *Science of the Total Environment* 613, 1489-1497, DOI: 10.1016/j.scitotenv.2017.07.058.
- MEA - Millennium Ecosystem Assessment, 2005: *Ecosystems and human well-being: Desertification Synthesis*, World Resources Institute, Washington DC.

- Merdas, S., Kouba, Y., Mostephaoui, T., Farhi, Y., Chenchouni, H., 2021: Live-stock grazing-induced large-scale biotic homogenization in arid Mediterranean steppe rangelands. *Land Degradation & Development* 32 (17), 5099–5107, DOI: 10.1002/ldr.4095.
- Merzouk, N. K., 1999: *Carte des Vents de l'Algérie (Résultats Préliminaires)*, *Revue des Energies Renouvelables* 2, 209–214.
- Mezrag, M., 2018: *Dynamique environnementale des zones steppiques à Djelfa (Algérie): Caractérisation par télédétection des changements du couvert végétal et des processus d'ensablement*, Thèse de doctorat, Université de Lyon.
- Nedjraoui, D., 2001: Profil fourrager, *Université des Sciences et de la Technologie H. Boumediène*, Alger, <http://www.fao.org/ag/agp/agpc/doc/counprof/algeria/algerie.htm>.
- Nedjraoui, D., Bédrani, S., 2008: La désertification dans les steppes algériennes: causes, impacts et actions de lutte. *Vertigo* 8, 1-15, DOI: 10.4000/vertigo.5375.
- ONM - Office National de la Météorologie, 2010: *Données Mensuelles de Relevés des Paramètres Climatologiques (1975–2009)*, Station Djelfa, Algérie.
- ONM - Office National de la Météorologie, 2022: *Données Mensuelles de Relevés des Paramètres Climatologiques*, Station Djelfa, Algérie.
- Oussedik, A., Iftène, T., Zegrar, A., 2003: Development of the desertification sensitivity map of Algeria using remote sensing, *Sécheresse* 14 (2), 195-201.
- Oussedik, A., Iftène, T., Zegrar, A., 2003. Réalisation par télédétection de la carte d'Algérie de sensibilité à la désertification, *Sécheresse* 14 (2), 121-127.
- Ozer, A., Ozer, P., 2005: Désertification au Sahel: Crise climatique ou anthropique? *Bulletin des Séances de l'Académie royale des Sciences d'Outre-Mer* 51, 395-423, <http://hdl.handle.net/2268/16053>.
- PNUE - Programme des Nations Unies pour l'Environnement, 1991: Status of Desertification and Implementation of the United Nations Plan of action to combat Desertification, United Nations Convention to Combat Desertification, Nairobi.
- Pouget, M., 2008: *Archives environnementales sur l'Algérie steppique (1968-1975)*, IRD, Paris.
- Reynolds, W., Drury, C., Yang, X., Fox, C., Tan, C., Zhang, T., 2007: Land management effects on the near-surface physical quality of a clay loam soil, *Soil and Tillage Research* 96, 316-330, DOI: 10.1016/j.still.2007.07.003.
- RGA - Recensement général de l'agriculture, 2015: Rapport général, MINA-GRI, Alger.
- RGPH - Recensement général de la population et de l'habitat, 2008: *Recensement général de la population et de l'habitat*, Office national des statistiques, Alger.
- Sainte-Marie, A., 1975: Législation foncière et société rurale: L'application de la loi du 26 juillet 1873 dans les douars de l'Algérois, *Etudes rurales* 57, 61-87.
- Salamani, M., Hanifi, H. K., Hirche, A., Nedjraoui, D., 2013: Évaluation de la sensibilité à la désertification en Algérie, *Revue d'Ecologie, Terre et Vie* 68, 71-84.
- Sari, D., 1975: *La dépossession des fellahs*, Société nationale d'édition et de diffusion, Alger.
- SNAT - Schéma national d'aménagement du territoire, 2007: *Schéma national d'aménagement du territoire SNAT (2025) - du diagnostic aux scénarios*, Ministère de l'aménagement du territoire et de l'environnement, Alger.
- Schmitz, S., 2012: Le «mode d'habiter»: analyse de l'usage d'une notion émergente en géographie, in Frelat-Kahn, B., Lazzarotti, O (eds.): *Habiter: Vers un nouveau concept?*, Armand Colin, Paris, 37-49.
- Schröter, D., Cramer, W., Leemans, R., Prentice, I. C., Aratújo, M. B., Arnell, N. W., Bondeau, A., Bugmann, H., Carter, T. R., Gracia, C. A., 2005: Ecosystem service supply and vulnerability to global change in Europe, *Science* 310 (5752), 1333-1337, DOI: 10.1126/science.1115233.
- Seltzer, P., 1946: *Le climat de l'Algérie*, Institut de Météorologie et de Physique du Globe 219, Alger.
- Slimani, H., Aidoud, A., 2004: Desertification in the Maghreb: a case study of an Algerian high-plain steppe, in: Marquina, A. (ed.): *Environmental Challenges in the Mediterranean 2000–2050*, NATO Science Series 37, Springer, Dordrecht, 93-108, DOI: 10.1007/978-94-007-0973-7_6.
- Smail, M., 1991: *Aspects de l'aménagement de la steppe algérienne, Cas de la Wilaya de Djelfa*, Thèse Doctorat, Université Paul Valéry, Montpellier.
- Trautmann, W., 1989: The nomads of Algeria under French rule: a study of social and economic change, *Journal of Historical Geography*, 15, 126-138.
- UNCCD, 1994: *United Nations Convention to Combat Desertification, Elaboration of an International Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa* (U.N. Doc. A/AC.241/27, 33 I.L.M. 1328, United Nations).
- UNCCD - United Nations Convention to Combat Desertification, 2015: *Land matters for Climate, Reducing the Gap and Approaching the Target*, UNCCD, Bonn.
- UNCED, 1992: *Managing fragile ecosystems: combating desertification and drought*, Agenda 21 – Chapter 12, United Nations Conference on Environment & Development Rio de Janeiro, Brazil, 3 to 14 June, <https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf> (18.03.2023.).
- Weber, K. T., Horst, S., 2011: Desertification and livestock grazing: The roles of sedentarization, mobility and rest, *Pastoralism: Research, Policy and Practice* 1, 19, DOI: 10.1186/2041-7136-1-19.
- Wilson G. A., Juntti M. (eds.) 2005: *Unravelling desertification, policies and actor networks in Southern Europe*, Wageningen University Press, Wageningen.
- World Bank, 2002: *World development report 2003, Sustainable development in a dynamic world: transforming institutions, growth, and quality of life*, World Bank, Washington D.C.
- World Bank, 2023: World Bank Open Data, <https://data.worldbank.org/> (18.03.2023.).
- Xu, D., Li, C., Zhuang, D., Pan, J., 2011: Assessment of the relative role of climate change and human activities in desertification: A review, *Journal of Geographical Sciences* 21, 926-936, DOI: 10.1007/s11442-011-0890-1.

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