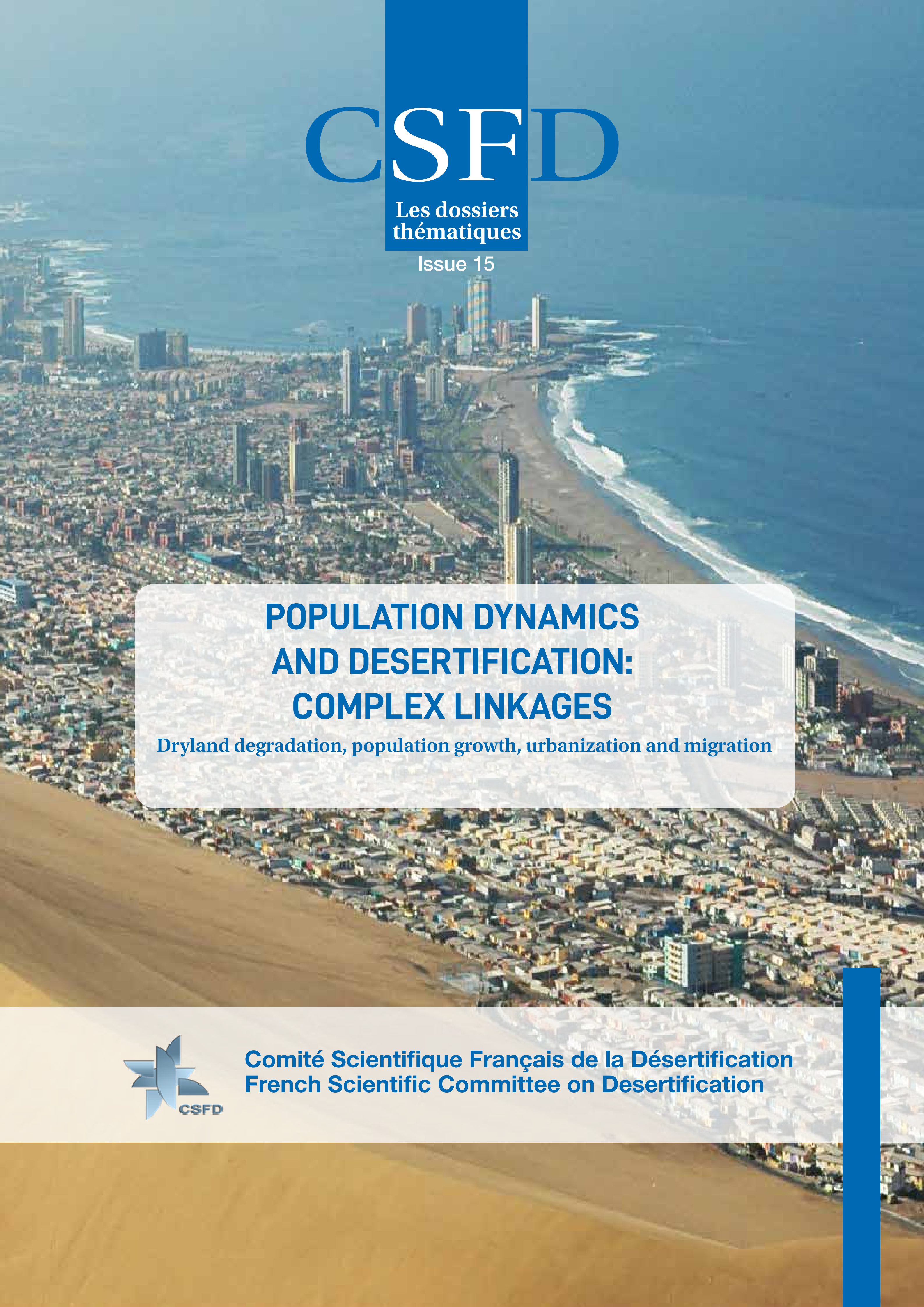

CSFD

Les dossiers thématiques

Issue 15

POPULATION DYNAMICS AND DESERTIFICATION: COMPLEX LINKAGES

Dryland degradation, population growth, urbanization and migration

Comité Scientifique Français de la Désertification
French Scientific Committee on Desertification

Les dossiers thématiques du CSFD Issue 15

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French Scientific Committee on Desertification

The creation in 1997 of the French Scientific Committee on Desertification (CSFD) has met two concerns of the Ministries in charge of the United Nations Convention to Combat Desertification. First, CSFD is striving to involve the French scientific community specialized on issues concerning desertification, land degradation, and development of arid, semiarid and subhumid areas in generating knowledge as well as guiding and advising policymakers and stakeholders associated in this combat. Its other aim is to strengthen the position of this French community worldwide. In order to meet such expectations, CSFD aims to be a driving force regarding analysis and assessment, prediction and monitoring, information and promotion. Within French delegations, CSFD also takes part in the various statutory meetings of organs of the United Nations Convention to Combat Desertification: Conference of the Parties (CoP), Committee on Science and Technology (CST) and the Committee for the Review of the Implementation of the Convention. It also participates in meetings of European and international scope. It puts forward recommendations on the development of drylands in relation with civil society and the media, while cooperating with the DesertNet International (DNI) network.

CSFD includes a score of members and a Chair, who are appointed *intuitu personae* by the French Ministry of Higher Education, Research and Space and come from various specialties of the main relevant institutions and universities.

CSFD is managed and hosted by the Agropolis International Association that represents, in the French city of Montpellier and Occitanie region, a large scientific community specialised in agriculture, food and environment of tropical and Mediterranean countries. The Committee acts as an independent advisory organ with no decisionmaking powers or legal status. Its operating budget is financed by contributions from the French Ministry for the Ecological Transition, Biodiversity and International Climate and Nature Negotiations, as well as the French Development Agency.

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More about CSFD: www.csf-desertification.eu

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Foreword

Land degradation affects about 23% of the global land area and is increasing at a rate of 5–10 million ha/year, while affecting 3.2 billion people worldwide. In dryland areas, which account for nearly 40% of the land (excluding frozen land), this process is referred to as desertification.

Poorly managed human land use is the main cause of land degradation. Climate change is worsening this trend and accelerating desertification while the key focus of the United Nations Convention to Combat Desertification is to control this process. Curbing soil degradation and restoring degraded land can help combat climate change (e.g. restoring 350 million ha would enable sequestration of 13–26 Gt of atmospheric CO_2) and biodiversity loss. Striving to achieve a land degradation-neutral world is target 3 of United Nations Sustainable Development Goal 15 'Life on Land'. Moreover, restoring land and the services it provides to the planet and to societies is pivotal to the UN Decade on Ecosystem Restoration (2021-2030).

Combating desertification and land degradation is a global challenge underpinned by firm initiatives tailored to local conditions, while requiring cooperation between all actors—civil society organizations, professional organizations, technical and financial partners, public decision makers, private sector actors, higher education and research institutions. Research has the role of supporting these territory-anchored actions, alongside public and private decision makers, driven by the most recent scientific knowledge.

The French Scientific Committee on Desertification has decided to fulfil this need by launching a series entitled *Les dossiers thématiques du CSFD* (CSFD thematic reports), with the aim of supplying valid scientific information on desertification, all of its implications and challenges. This series is geared towards policymakers and their advisors in the Global North and South, but also towards the general public, development and environmental science reporters. Moreover, it strives to provide teachers, trainers and trainees with further information on various disciplinary fields. Finally, it intends to contribute to knowledge dissemination of stakeholders in the combat against desertification, land degradation and poverty alleviation—leaders of professional organizations, nongovernmental organizations and international solidarity organizations.

These *Dossiers* are focused on diverse topics, including global public goods, remote sensing, wind erosion, agroecology, pastoralism, etc., to review current knowledge in these specific domains. The aim is also to fuel debate on ideas and new concepts, including controversial issues, to highlight commonly implemented methods and outcomes obtained in various projects, while also providing useful references, addresses and websites. The *Dossiers* are endorsed by the Committee.

JEAN-LUC CHOTTE
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Preamble

Although there is little room for doubt, this CSFD Dossier on desertification surely dispels the idea that the linkages between population and the environment cannot be assessed without taking full account of their complexity. Since Paul R. Ehrlich's claim in *The Population Bomb* (1968) that all forms of environmental degradation are simply due to the presence of "too many people" on Earth, it has often been argued that population is the prime factor responsible for the currently unfolding environmental crisis. While there is no denying that population pressure plays a role in current ecological transformations, the population variable cannot, firstly, be equated with human activities. The latter involve production and consumption patterns as well as technological progress which, as Barry Commoner pointed out, has disrupted the ecological cycle, thereby complicating recycling. Secondly, it is essential to bear in mind that seemingly straightforward dependent relationships might turn out to be interdependent when a broader time frame is taken in to account.

In this *Dossier*, Emmanuel Chauvin, Bénédicte Gastineau and Christine Raimond take a closer look at the population-environment relationship through the lens of the desertification phenomenon. How is the population factor involved and can the trends be considered as universal? The authors analyse population from diverse angles: population growth and density, urbanization and mobility (internal and external migration). They note that dryland areas are not uninhabited, which means that climatic conditions alone cannot explain the geographical distribution of populations. Very large urban agglomerations—although few in number—are even found in some dryland areas (Cairo, Istanbul, Tehran and Karachi), while population growth is rising in small- and medium-sized agglomerations. In this *Dossier*, Emmanuel Chauvin, Bénédicte Gastineau and Christine Raimond analyse responses to environmental degradation and reveal two types of response: migration and adaptation. The latter involves changes in both lifestyles and implemented techniques.

The *Dossier* authors' focus on how to measure the phenomenon is especially interesting. How can degraded areas undergoing desertification be identified? A comparison of different maps obtained via diverse methods (expert opinion, satellite observation, abandoned agricultural land surveys and biophysical models) shows that it is not easy to characterise the phenomenon as the geographical aspects of the extent of degradation may vary between maps.

The authors' have specified the relevance of interface systems in their analysis of the population-environment relationship at the local level, while recognizing that there is no clear mechanical link at this scale. They have also sought to clarify the mechanisms involved. For instance, it is put forward that population density has a knock-on effect on agricultural practices, yet it is still vital to specify how this effect unfolds. The authors stress the importance of economic, social, political and other contextual factors that shape the relationship between population and environment. It is particularly important to consider the extent of development of the target populations. The holistic approach that the authors advocate makes it possible to take interdependent and circular relationships into account, e.g. global warming promotes droughts, which in turn contribute to global warming. The holistic approach provides a way to transcend disciplinary boundaries and consider the desertification phenomenon as a whole. It also enables us to account for the complexity that arises, as the authors note, from the fact that "the processes underway in these areas are dependent on the length of time required for societies living in dryland environments to adapt, but also on the short time scales of crises such as drought or armed conflicts." This highlights the importance of spatiotemporal scales when analysing population-environment dynamics. Note that similar issues may arise in completely different settings, such as during natural disaster events like cyclones. Do people migrate or adapt in response to extreme events? The immediate reaction may be to move and then subsequently return, but this process cannot be considered as migration. The time scale considered is therefore important before categorizing a movement as migration. For example, Cyclone Idai in Mozambique (2019) forced people living in affected areas to move, but they still wanted to return to their homes despite the flood risk and government orders. The alleged mechanical link between disasters and migration highlighted in some reports and in the media is dispelled when an interdisciplinary approach is adopted, particularly one that takes people's attachment to places into account, and when the observation scale is suitable.

Emmanuel Chauvin, Bénédicte Gastineau and Christine Raimond have sought to gain further insight into the relationship between the population density and land degradation, while pointing out that there is no clearcut correlation on a global scale. They note that "severe degradation is visible in dryland regions of Arizona and South America, which have fewer than five inhabitants per km^2, whereas land productivity in Central Asia, with more than 250 inhabitants per km^2, remains stable." Moreover, there are some cases of regreening in dryland areas. The authors also point out that adaptation can come through enhanced forestry, gardening and small-scale irrigation. Analyses generally cannot overlook the diversity of production systems and social organization, nor the innovation potential and family strategies. Communities can combat desertification via intensified crop cultivation. The authors mention an interesting case of small-scale intensification involving the use of livestock manure as fertilizer in an extensive farming system context in western Niger, where high population growth is under way. Another example of an intensive agricultural production system discussed concerns the Mandara Mountain region in Cameroon where, despite the high population density, rocky land has been transformed into arable farmland through terracing. Clearly, however, production is not just an agronomy issue, i.e. the insecurity that currently prevails in the far north of Cameroon has led to a labour shortage that is jeopardising all previous agricultural progress. Communities can also diversify their activities to combat desertification, while undergoing short-term migrations to more attractive areas that offer employment opportunities, such as wetland areas and cities.

The overall picture of links between population and desertification painted by the authors led them to consider the apparent competition between mining (where present) and agricultural production, particularly due to the high water consumption rates inherent in mining activities. Moreover, agricultural production may be unsustainable because of groundwater depletion or soil impoverishment due to monocropping, while sometimes also being hampered by chemical pollution.

The analysis of the relationship between population and desertification cannot be reduced to an assessment of agriculture in rural areas because urbanization is also a key factor in this and many other situations. Rapid urbanization leads to urban sprawl, at the expense of farmland. Grounding their analysis in their field experience, the authors devote a text box to the case of N'Djamena, a Chadian city located in a semiarid zone, and to the 2008 project to create a green belt. These developments on the outskirts of cities, which may include wooded plots, hedgerow systems or even market gardening areas, are designed to protect fragile areas. But in N'Djamena the green belt project is being undermined by urban growth: "local land dynamics and speculation have dealt a fatal blow to this renaturation and sustainable city symbol promoted at the global level", conclude the authors regarding the capital of Chad. Water needs are huge worldwide, and growing population pressure is obviously making things worse. Urbanization is also boosting the water demand. For example, the large Mahanadi River in central-eastern India dwindles to a few streams during the dry season. It is affected by water abstraction for irrigation and water supplies to large cities such as Cuttack. The river is also impacted by pollution arising as a result of the intensive chemical treatments used in agriculture. Similar issues prevail in other parts of the world, as illustrated in this *Dossier*.

The authors mention two cities located in arid parts of the United States—Phoenix and Tucson (Arizona), with populations of 1.7 million and 550,000, respectively—which are coping with a structural shortage in a region where aridity is increasing and domestic water consumption rates are among the highest in the country. The populations of these cities are far from being homogeneous, given the wide income inequality. The wealthy inhabitants can better cope with drought than the poor because they can afford to live in wooded areas, water their lawns and install swimming pools. This way of dealing with drought in residential areas is, however, not sustainable as it significantly increases water consumption.

One of the commendable features of this *Dossier* is that, as we have seen, it does not overlook the issue of the methods and measurements involved. The authors highlight the fact that the desertification concept is still subject to debate and, while stressing the relevance of the scales involved, they also point out that demographic and environmental data are not collected at the same scales. Another virtue of this report is that it combines different disciplinary approaches and diverse field conditions. By describing a range of contrasted situations (Madagascar, a small Sahelian village in central Mali, a semiarid region of Brazil), Emmanuel Chauvin, Bénédicte Gastineau and Christine Raimond reveal the diversity of responses to the impacts of climate change. They also note that "drought and desertification, although related, do not have the same causes or produce the same damage, and have not been addressed politically with the same commitment."

Finally, the authors invite us to ask a straightforward question: why are dryland areas, where life can be extremely harsh, not uninhabited? It is also surprising that the populations are growing in cities located in these areas. To understand the dynamics involved, it is essential to look at the history of the areas, which may explain how they were first settled. However, as the authors suggest, we must also take the "family structures, local production methods, security conditions in the surrounding areas, etc." into account. Emmanuel Chauvin, Bénédicte Gastineau and Christine Raimond conclude that "the root of the desertification issue is not population growth or even population density, but instead certain agricultural and non-agricultural production methods implemented, resource use, unequal distribution of wealth and inappropriate public policies."

This *Dossier* contains a trove of references and the authors should also be commended for tackling the desertification issue in a very methodical and extremely clear manner. More generally, readers interested in environmental demography are invited to consider the response, adaptation and sustainability concepts with regard to populations facing sudden or gradual changes that may drastically affect their livelihoods and living conditions.

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▲ Urbanization in Lima, Peru
© IRD - G. Roudaut

▲ Tehran, the new city
© IRD – P. Haeringer

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Introduction – analyzing population-desertification linkages

This *Dossier* of the French Scientific Committee on Desertification (CSFD) looks closely at the links between desertification and population trends based on published scientific findings. In dryland areas, can population growth, urbanization and migration be the cause or consequence of land degradation? The authors demonstrate here that desertification and population dynamics are usually independent processes and that the potential linkages between them are mostly indirect and vary depending on the area, production systems and lifestyles of the concerned communities.

From an anthropogenic viewpoint, land degradation can be defined as a reduction of the soil production capacity. The term 'desertification' is generally used to describe this degradation process in drylands (although such degradation also occurs in other areas). Drylands include arid, semiarid and dry subhumid regions, as commonly distinguished according to the aridity index, which is the ratio of annual precipitation to the evapotranspiration potential. Drylands prevail on all five continents, yet they are particularly widespread in Africa, Asia and Oceania (see map opposite). Drylands cover an estimated 45-50 million km^2 worldwide, representing 30-36% of the Earth's land surface (Dresch, 1982; Noin, 1998; Burrell *et al.*, 2020). Yet not all drylands are undergoing the same changes in terms of production capacity, i.e. some are turning into deserts, others are barely changing, while others are improving, for instance through greening (increased vegetation cover).

▲ **Ander-n-Bukhar (Anderamboukane), in the Niger-Mali border region**
© IRD –C. Gremont

This *Dossier* focuses on three population dynamics dimensions that are potentially linked to desertification: (1) changes in population size (population growth and decline); (2) transformations in the spatial distribution of the population (settlement), particularly through urban concentration; (3) migration, changes in people's main place of residence, internally (within a country) or internationally (across borders).

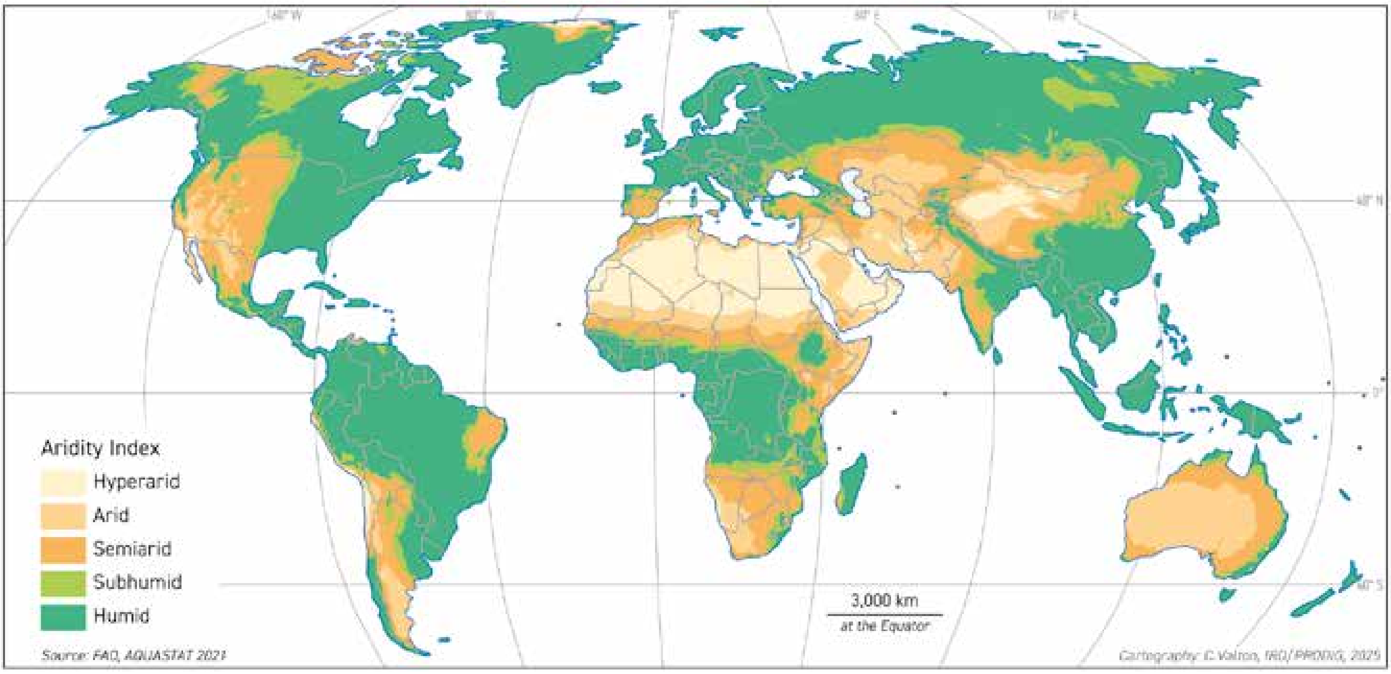
We look at whether population changes can drive desertification, especially population growth and urbanization, as well as, conversely, whether desertification can spur population changes, especially by triggering out-migration from regions that have become less productive and more unattractive due to degradation.

The first part defines and outlines the main concepts discussed in the *Dossier*: desertification, population, urbanization and migration in dryland areas. The second part highlights the difficulty of quantifying, comparing and establishing links between desertification and population dynamics. The third part looks at the links between population growth (and decline), rural densification, activity systems and desertification. The fourth part deals with the interactions between urbanization and desertification and the feedback effects between these two phenomena. Finally, the fifth part analyses the impacts of desertification on migration, as well as the effects of settlement policies on desertification.

▼ Spatial distribution of regions worldwide according to their aridity index

Source: Food and Agriculture Organization of the United Nations (FAO), AQUASTAT 2021 - (www.fao.org/aquastat/en).

Cartography: Catherine Valton, 2025



Population dynamics diversity and desertification in drylands

What are the nature and intensity of the links between population dynamics and desertification processes in drylands? These phenomena are separately assessed in this first section, while briefly reviewing their respective definitions: desertification measurement and delineation in drylands, population size and trends, urbanization and migration dynamics in these areas.

DESERTIFICATION – A COMPLEX PROCESS TO MEASURE WORLDWIDE

Desertification is not desert encroachment (as proposed by Lamprey, 1975), but rather a land degradation process occurring in dry areas. According to the United Nations Convention to Combat Desertification (1994), land degradation is: "the reduction or loss [...] of the biological or economic productivity and complexity [of various lands...] resulting from land uses or from a process or a combination of processes [...] such as: (i) soil erosion caused by wind and/or water, (ii) deterioration of the physical, chemical and biological or economic properties of soil, and (iii) long-term loss of natural vegetation" (United Nations, 1994, pp. 4-5). Desertification is: "land degradation in arid, semiarid and dry subhumid areas resulting from various factors, including climatic variations and human activities" (United Nations, 1994, p. 4).

There is no overall consensus on how to delineate and measure desertification. In terms of delineation, some authors have a very broad view of drylands, encompassing hyperarid areas and deserts, whereby drylands would account for as much as 40-45% of the Earth's land area. There are marked differences in terms of desertification measurement: according to a 2010 literature review (Safriel, 2010), 4% to 74% of drylands are affected by desertification, depending on the author. More accurate recent studies suggest that the lower estimates are more reliable (Cornet, 2024). Around 10% of drylands are thought to be undergoing desertification (Klein Goldewijk *et al.*, 2017, cited by Mirzabaev *et al.*, 2019). Positive trajectories are seldom highlighted. Yet, according to Burrel, between 1982 and 2015, 6% of drylands underwent desertification, whereas 41% underwent positive greening and 53% showed little or no change (Burrell et al., 2020).

Discrepancies in the measurement and spatial location of desertification raise questions regarding the most suitable method to be used to assess this process. Globally, depending on the method used (expert opinion, satellite observation, biophysical models, abandoned agricultural land inventories), total degraded land area estimates range from <1 to >6 billion ha, with different spatial locations (see global land degradation map on p. 19) (Gibbs and Salmon, 2015). From a national standpoint, results may differ markedly depending on the data source, particularly due to the complexity of implementing an information system capable of measuring desertification (low data reliability, lack of benchmark situations, etc. (Requier-Desjardins *et al.*, 2009).

Does this mean it is pointless to measure and map desertification on a global scale? The World Atlas of Desertification does not provide a land degradation map on this scale (Cherlet *et al.*, 2018), but it does include a series of associated global indicators, e.g. land productivity trends based on remote sensing analyses (see map opposite).

From 1999 to 2013, a steady decline in land productivity was observed on ~20.4% of the Earth's vegetated land area, with a serious decline on ~10.5% of this area, while the rest was in an unsustainable state, with very different trends noted between regions worldwide (e.g. a serious decline in Australia and virtually none in Europe). The authors point out that this is not synonymous with land degradation and that readers should take contextual information on regional and local conditions into account, according to each user's knowledge, when interpreting their series of maps (Cherlet *et al.*, 2018). Gibbs and Salmon (2015) echo this view: assessing land degradation and desertification would require a combination of satellite data analysis and in-depth field surveys. A system would also need to be designed for collecting detailed socioeconomic and demographic data (at area, municipality and household levels).

Difficulties in desertification measurement occasionally lead to assumptions rather than proof of the existence of this phenomenon. There is often a lack of clarity regarding the initial condition of the land deemed to be degraded. Measuring desertification via remote sensing without any onsite surveys limits the data accuracy. This lack of desertification measurement clarity could be exploited for political purposes (Taïbi, 2015). For instance, the press release for the *World Atlas of Desertification* states that over 75% of the Earth's land area is already degraded and more than 90% could be degraded by 2050*, but this statement is not backed by any specific data in the Atlas!

* See: https://ec.europa.eu/commission/presscorner/detail/en/ip_18_4202

▲ Sand build-up in oases due to wind erosion, Tunisia
© IRD - IRA - C. Lamontagne

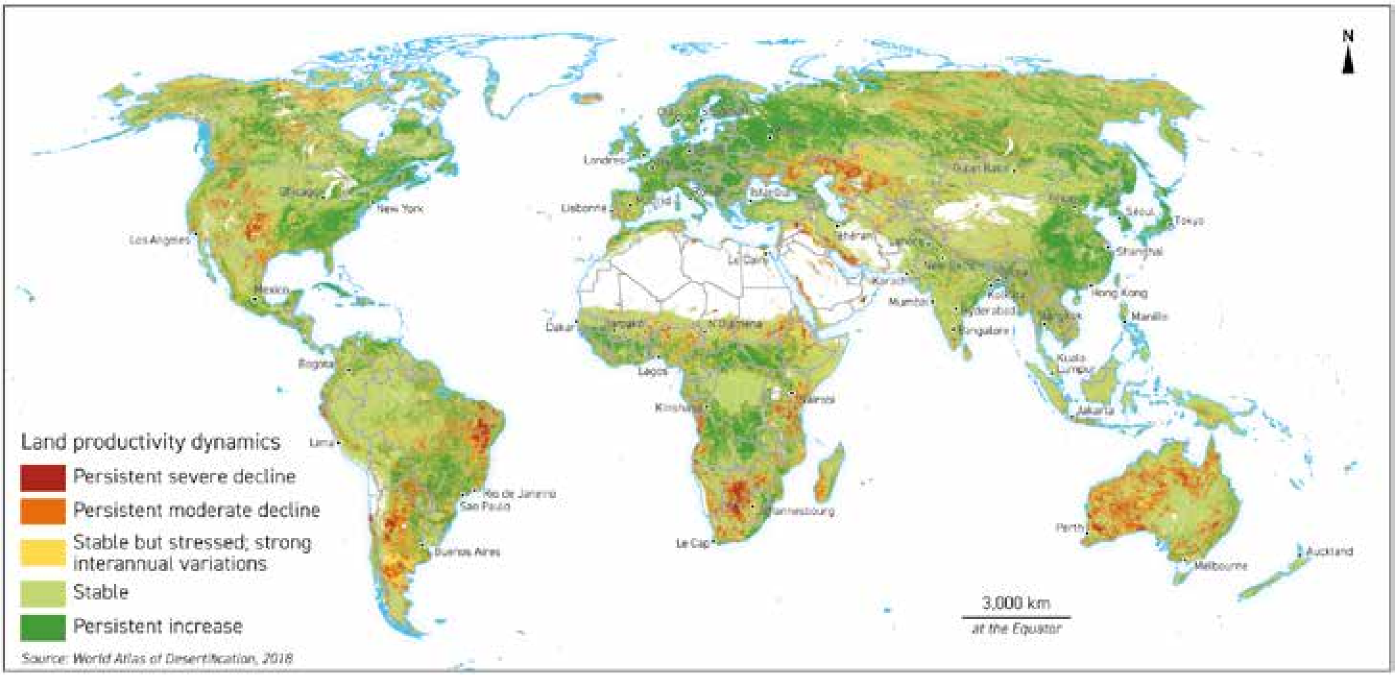
▼ View of a neighbourhood in Matam, Senegal

© Labaly Toure

▼ Worldwide land productivity trends from 1999 to 2013

Data: map based on phenological measurements derived from vegetation indices measured by remote sensing. For further information, see the source: Cherlet *et al.*, 2018.

Cartography: Catherine Valton, 2025



POPULATIONS INHABITING DRYLAND AREAS – LIMITED SIZES AND MARKED DIFFERENCES

The world population exceeded 8 billion in 2022 and has increased eightfold since 1800. The global population distribution is extremely uneven: population densities (number of inhabitants per km²) vary between and within countries. For instance, Mauritania, Canada and Australia have <4 inhabitants per km², compared to >500 in the Netherlands and South Korea (Pison *et al.*, 2022). How many people currently live in drylands and what are the population densities in these areas?

It is generally hard to estimate the number of people living in each climate zone because of the shortage of relevant data. In dryland areas, the administrative population counting scales seldom align with aridity maps. Most countries—apart from a few that are entirely situated in drylands (e.g. Egypt, Mauritania, Niger and Saudi Arabia)—have several climate types. The physical boundaries of dryland areas must first be clearly defined so as to be able to allocate inhabitants by climate zone This is a very labour-intensive task involving highly fine-tuned analysis based on census data to match administrative units (region, district, municipality, etc.) with climate units.

This task was attempted on a global scale in the late 1990s (Noin, 1998). It led to an estimate of 841 million people living in drylands, or just under 15% of the world population. Drylands are not uninhabited despite the harsh climatic conditions, but their population density is relatively low compared to that of the rest of the world. In arid regions, large cities such as Addis Ababa (3 million inhabitants) and Cairo (22 million inhabitants) have even developed. Climatic factors therefore cannot solely explain the distribution of men and women in a concerned area. In sub-Saharan Africa, for instance, the long-standing population density inequalities seem to stem from complex combinations of ecological, political and socioeconomic factors. The most arid part of central Tanzania is hence more densely populated than the supposedly more hospitable highlands (Dubresson *et al.*, 1998). Yet the most arid locations in the world continue to be among the least densely populated.

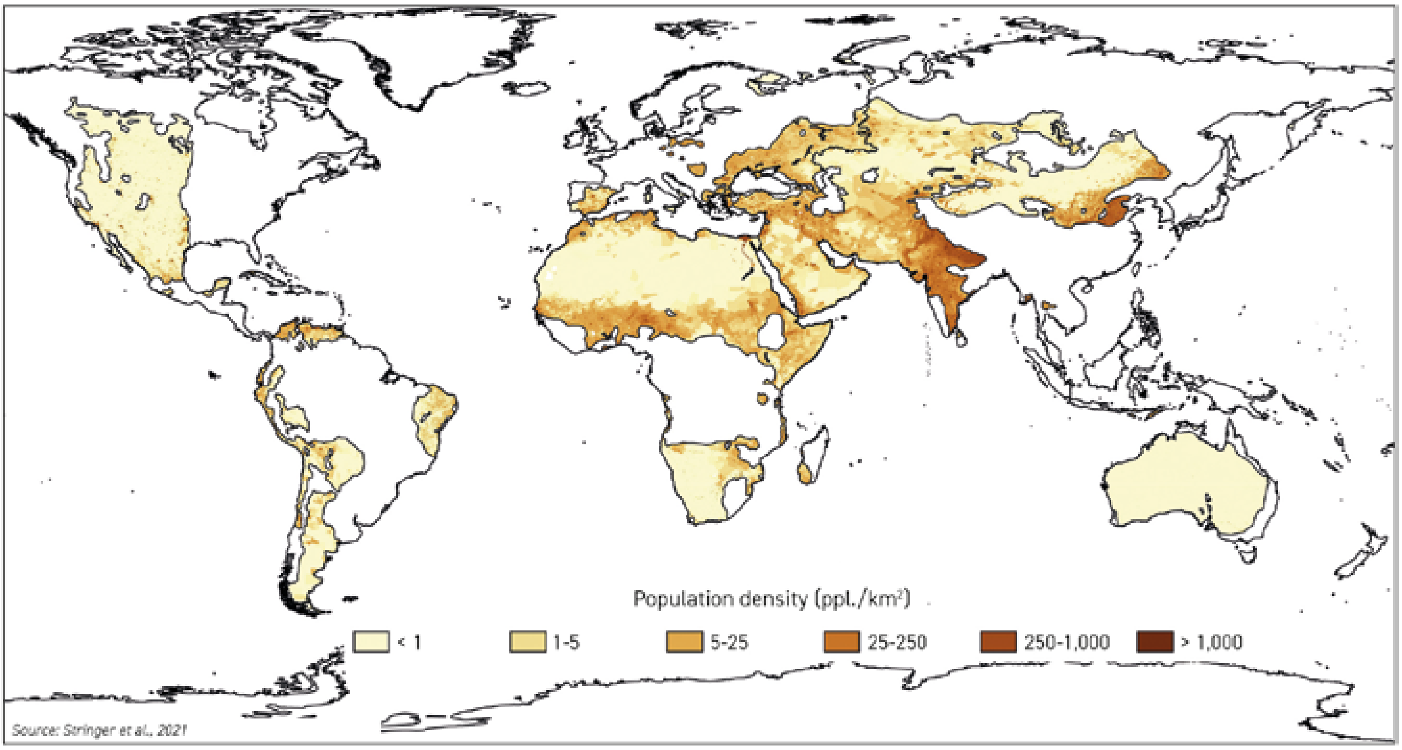
Note that the demographic conditions that prevail in countries located in arid zones often differ greatly, e.g. fertility and mortality rates in Sahelian countries (Burkina Faso, Mali, Niger, etc.) have little in common with rates in arid parts of California, Australia, and even North Africa. East, West and southern Africa (large parts of which are arid) are currently undergoing the fastest population growth in the world (see table opposite).

▲ Inhabitants of Casablanca, Morocco
© IRD – M. Donnat

The populations of these three African regions was estimated at 971 million in 2022 but could reach 1.5 billion by 2050. A country's population growth rate depends much more on its stage of socioeconomic development (school enrolment rates, healthcare access, infant mortality rates, etc.) than on its desertification index.

The map presented below represents the population densities in dryland areas. It highlights some general trends, but it does not enable detailed analysis of subtle differences on a finer scale.

◄ Population, India
© IRD – D. Rechner



▲ Human population density in drylands (2018)
Source: Stringer *et al.*, 2021, p. 852.
Cartography: Catherine Valton, 2025

Country	Annual population growth rate (%)	Composite fertility index (n° children per woman)	Life expectancy (years)
Tunisia	0.8	2.1	74
United Arab Emirates	0.8	1.4	79
India	0.8	2.0	68
Mongolia	1.4	4.5	73
Egypt	1.5	2.9	71
Pakistan	2.0	3.4	67
Australia	2.4	1.6	84
Mauritania	2.6	4.3	64
Somalia	3.1	6.2	56
Niger	3.3	6.7	62

▲ Demographic indicators in 10 countries located entirely or partially in dryland areas (most recently available data)
Sources: Pison *et al.*, 2022 and World Bank (https://data.worldbank.org/indicator/SP.POP.GROW), queried in April 2025.

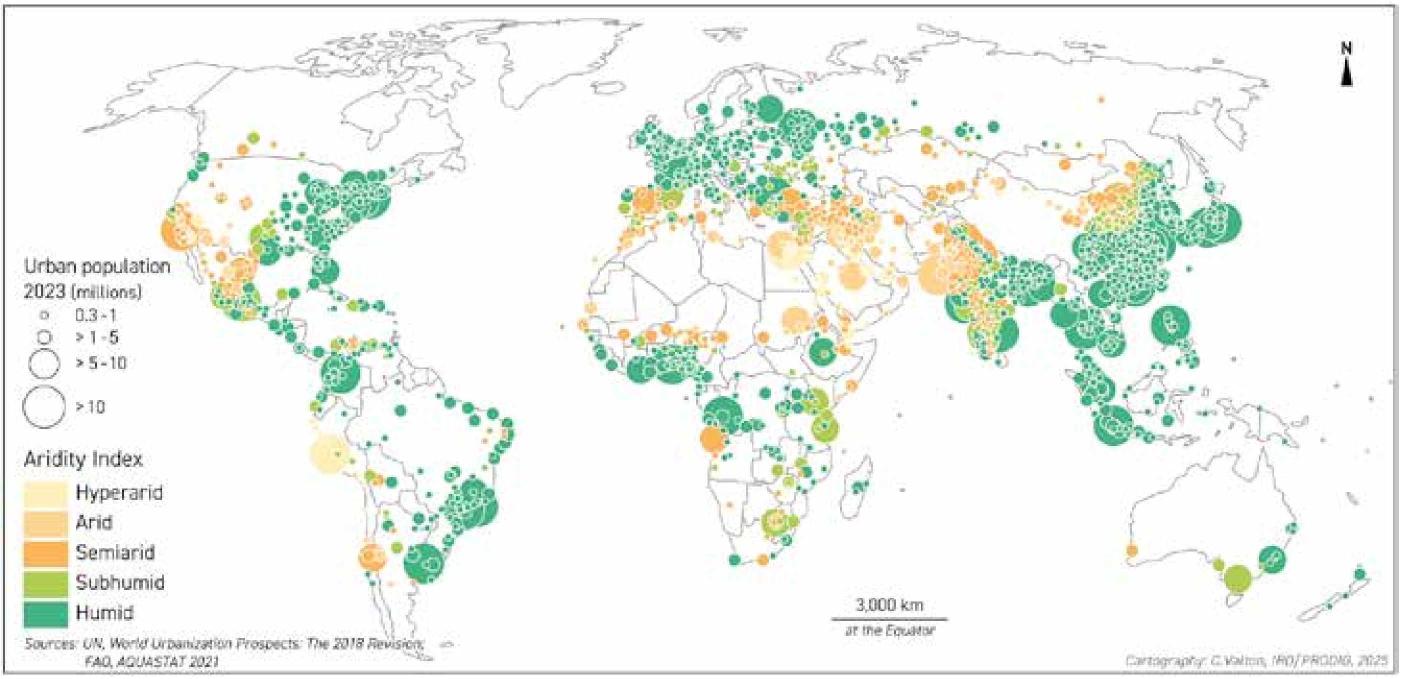
▲ Cairo, Egypt
© IRD – T. Ruf

URBANIZATION IN DRYLANDS – FEW CITIES BUT HIGH URBAN GROWTH

Urbanization is defined as a process involving urban population growth and expansion, accompanied by changes in lifestyles, production systems and sociopolitical organization. It leads to a disconnect between city dwellers, primary activities and subsistence systems. This process has been under way since the 19th century Industrial Revolution in Europe and the Americas, particularly in the wake of large-scale rural-urban migration movements. The trend also emerged in South America, Asia and Africa in the mid-20th century and will likely continue throughout the 21st century (as already noted in some countries of the Global South). Over half of the world population currently resides in cities, and this figure is expected to rise to nearly two-thirds by 2050 (Chaouad and Verzeroli, 2018; *Géoconfluences*, 2022).

Most cities are located remote from drylands—the world population, as well as the majority of cities, are concentrated along coastlines. 80% of this population lives within 100 km of a coast (see map below). In 2010, of the 32 most densely populated conurbations in the world, only Cairo, Istanbul, Tehran and Karachi were located in drylands along coastlines (Chatel and Moriconi-Ebrard, 2018). Otherwise, ancient cities of various sizes are often found inland, along major transport routes (trans-Saharan trade routes, the Silk Road in Asia, etc.), but these cities are now mostly nested on the outskirts of fast-growing regions.

▼ Major cities worldwide with their degrees of aridity
Sources: United Nations, 2018; FAO, AQUASAT 2021 (www.fao.org/aquastat/en).
Cartography: Catherine Valton, 2025

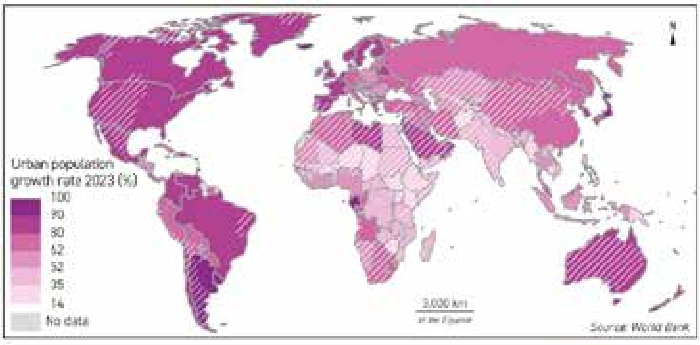


Urban growth in drylands is particularly intense in the poorest developing and emerging countries, which are also often the countries with the lowest urban population share (see map below and table opposite). The rural-urban transition—which signals a shift from a predominantly rural society to a predominantly urban society—was already underway in the early 2000s in North Africa, the Middle East, Mongolia and Australia. In contrast, urbanization has lagged in Sahelian countries and some Central Asian and South Asian countries (India), but the urban growth rates are currently high and rising. In these countries, spontaneous urban population growth is ongoing, particularly in small- and medium-sized conurbations, and also as a result of outmigration from rural areas to cities. These migratory flows to cities can be intensified in countries undergoing armed conflicts, when insecurity is high in rural areas, prompting people to move to cities (internally displaced persons), as is the case in Mali and Burkina Faso.

▼ A contrasted urbanization process among countries located mainly in drylands (in %)

Source: World Bank, 2024 (https://wdi.worldbank.org/table/3.12).

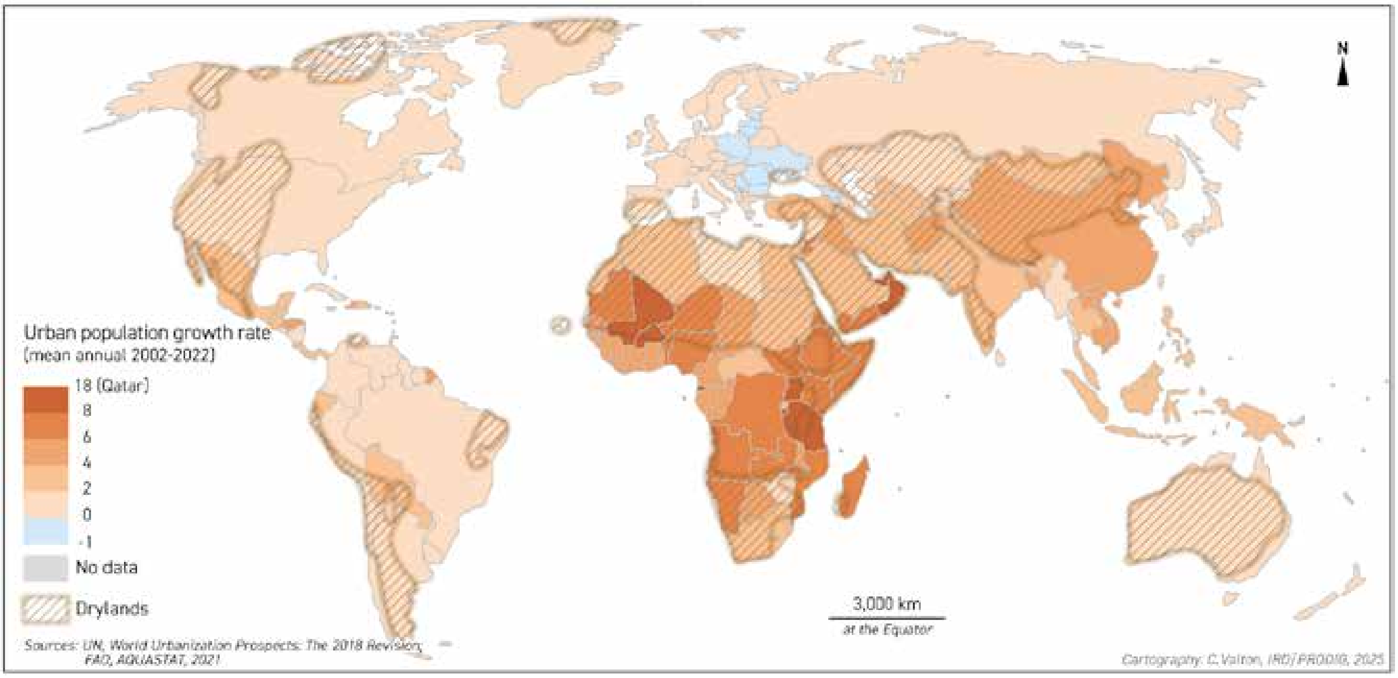
Country	% of the urban population		Annual urban growth rate	
	2002	2022	2002	2022
Mali	30.2	54.7	5,6	4.8
Niger	16.3	16.9	3,4	4.6
Chad	21.7	24.1	3,6	4.3
Afghanistan	22.3	26.6	6,9	3.7
Mongolia	59.3	68.9	2,7	1.7
Tunisia	64.2	70.2	1,6	1.2
Oman	71.5	87.8	1,2	2.0
Libya	76.6	81.3	2,6	1.5
Australia	84.2	86.5	1,3	1.3



◀ ▼ Urbanization and urban growth rates worldwide and in drylands between 2002 and 2022

Sources: United Nations, 2018; FAO, AQUASTAT 2021 (www.fao.org/aquastat/en).

Cartography: Catherine Valton, 2025



HUMAN MIGRATION FROM/TO/IN DRYLANDS – HIGH MIGRATION INTENSITY NOT SYSTEMATICALLY LINKED WITH THE ENVIRONMENT

Drylands are not immune to general migration trends: the globalization of flows as a result of their intensification (improved transport, population growth, etc.) and the diversification of flow origins and destinations; the predominance of rural-urban migration in less urbanized countries (with a more balanced pattern elsewhere); a greater tendency towards local migration than long-distance migration between departure and arrival points (see figure below); and the importance of political and economic factors as migration drivers (see Focus opposite).

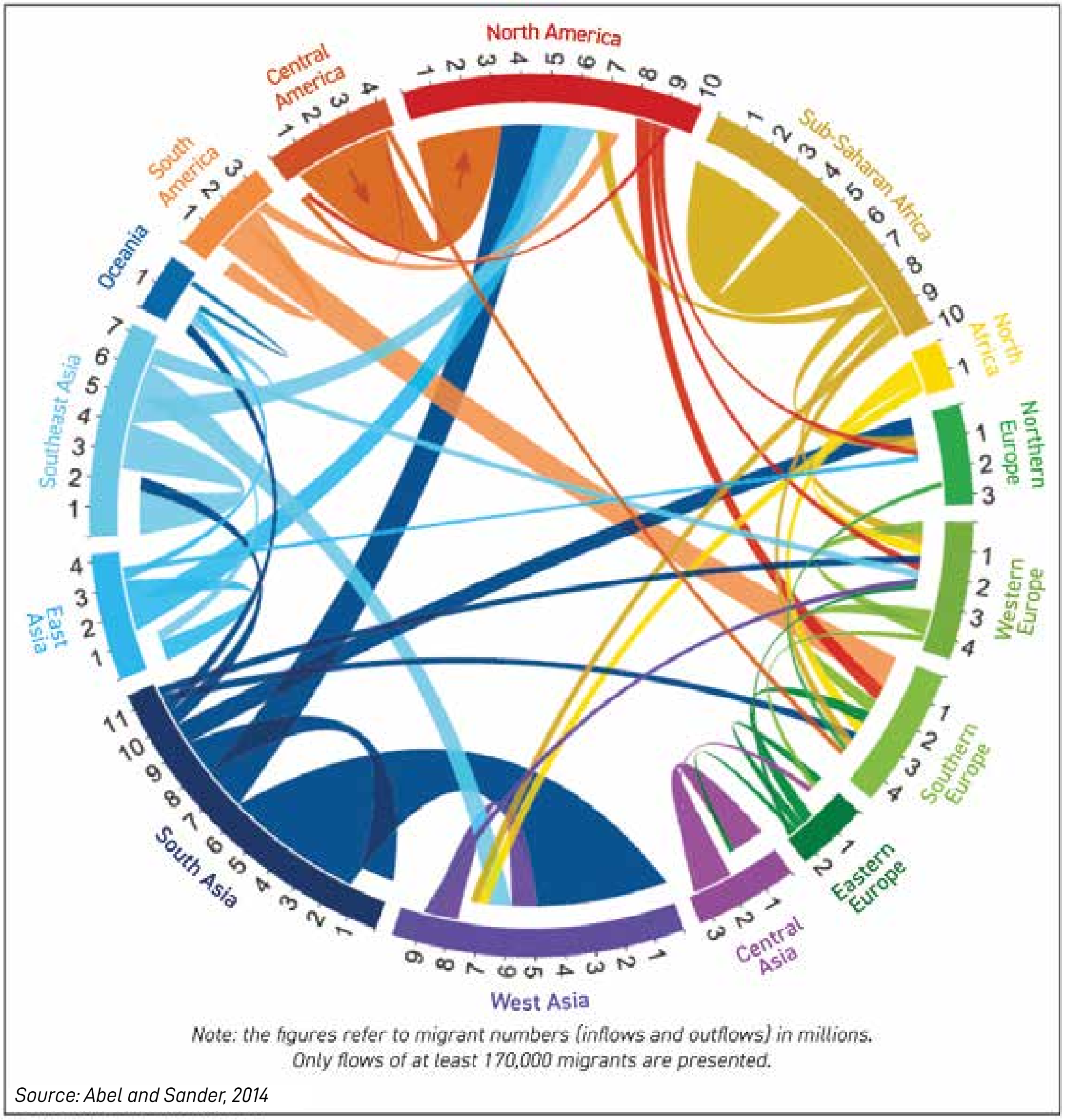
Do dryland regions have specific migration patterns? The results of an analysis of correlations between aridity, drought and migration, based on census data from 72 countries, suggest that aridity and drought tend to boost the migration intensity. This correlation is not linear due to contextual effects (socioeconomic, political and cultural conditions specific to each situation) and differing responses to environmental stress between and within countries (Hoffmann *et al.*, 2023). It might be assumed that dry regions are more prone to emigration, i.e. considered unattractive due to the harsh production conditions and their remoteness from economic and political centres, but the societies living there have actually developed techniques and lifestyles that enable them to stay put. One distinctive feature of dry regions could be the high migration intensity of primary commodity producers in settings where resources are limited and rainfall is sparse and variable, with herders moving their livestock in search of water and pasture and crop farmers moving temporarily between areas.

▼ Graph of international human migration flows between and within regions worldwide between 2005 and 2010 (in millions)

Data: Tick marks on the circle segments show the number of migrants (inflows and outflows) in millions. Only flows involving at least 170,000 migrants are shown.

Source: Abel and Sander, 2014, p. 1522.

Cartography: Catherine Valton, 2025

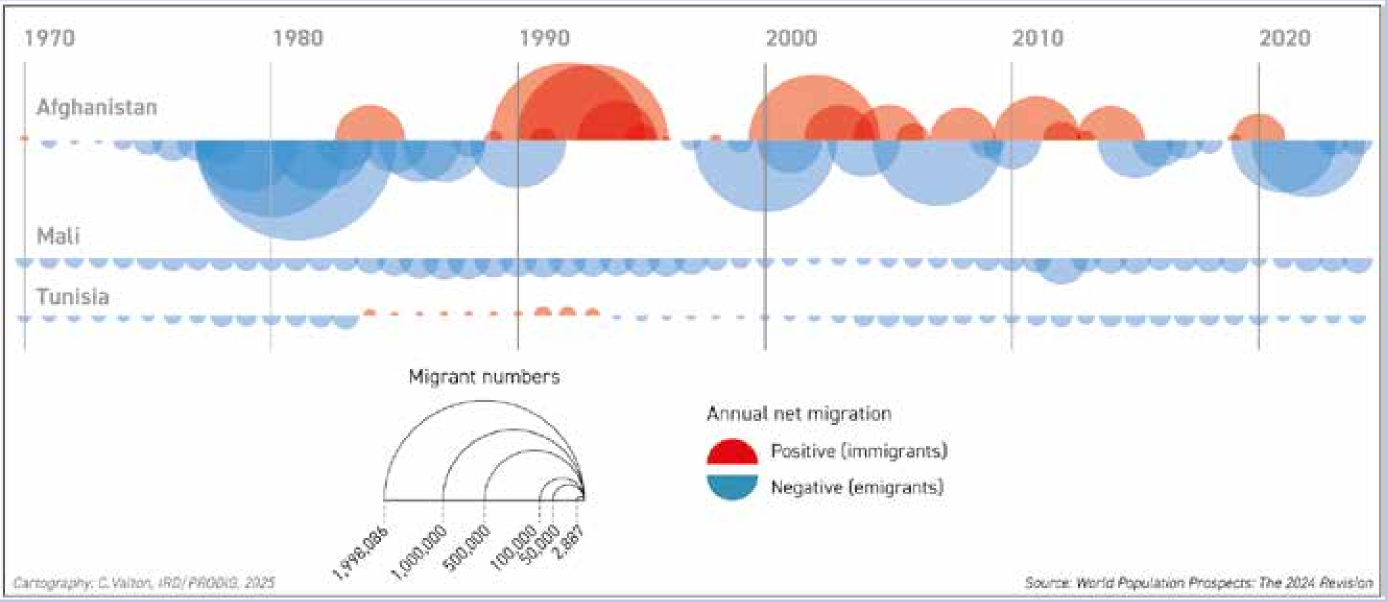


FOCUS Political and economic conditions – two key human migration drivers

Examples in Afghanistan, Mali and Tunisia

In the three target countries (Afghanistan, Mali and Tunisia), land degradation is not the main migration trigger. In Afghanistan, the series of armed conflicts that have taken place since 1978 account for most of the net migration variations (Monsutti, 2015).
In Mali—against a backdrop of poverty—economic emigration has shaped the two main migration patterns, i.e. one to coastal West African countries and the other to France (Gonin and Mary, 2015).

In Tunisia, in addition to the political factors that led to independence (Jewish exodus, 1956), the quest for employment and development inequalities accounted for the emigration trends towards France, oil-rich Libya and Italy, and also for the settlement of immigrants from sub-Saharan Africa and elsewhere in North Africa in Tunisia (Boubakri and Simon, 2015).



▲ Net migration trends of three dryland countries (Afghanistan, Mali, Tunisia) from 1970 to 2024 for non-environmental reasons.
Data: UN, 2024.
Cartography: Catherine Valton, 2025

To conclude this first section, there is no global consensus on how to measure desertification or delineate drylands. These aspects depend closely on the methods used to measure and monitor them. This considerably complicates the task of generating dryland population figures and densities. However, more detailed analyses (at regional or national scales) reveal that countries located in drylands have very diverse demographic situations in terms of both population and urban growth patterns. The extent of development that prevails—more than just the fact of being located in a dry or humid zone—seems to be a crucial factor in population, urban and even migratory dynamics. There is no straightforward linear relationship between population mobility and environmental constraints.

◀ Travellers returning from Libya in the Ténéré Desert
© IRD – J. Brachet

Methodological challenges in linking population dynamics with desertification

The lack of clarity regarding the desertification concept and measurement strategies complicate the identification of variables that shape the phenomenon. Quantifying desertification at national and global levels is challenging, thus impeding efforts to draw parallels between desertification and human population trends. Changes in the analysis scale are hence needed to overcome the difficulties encountered in quantifying population dynamics specifically in drylands.

▼ Deforestation and agriculture, Brazil
© IRD – P. Léna

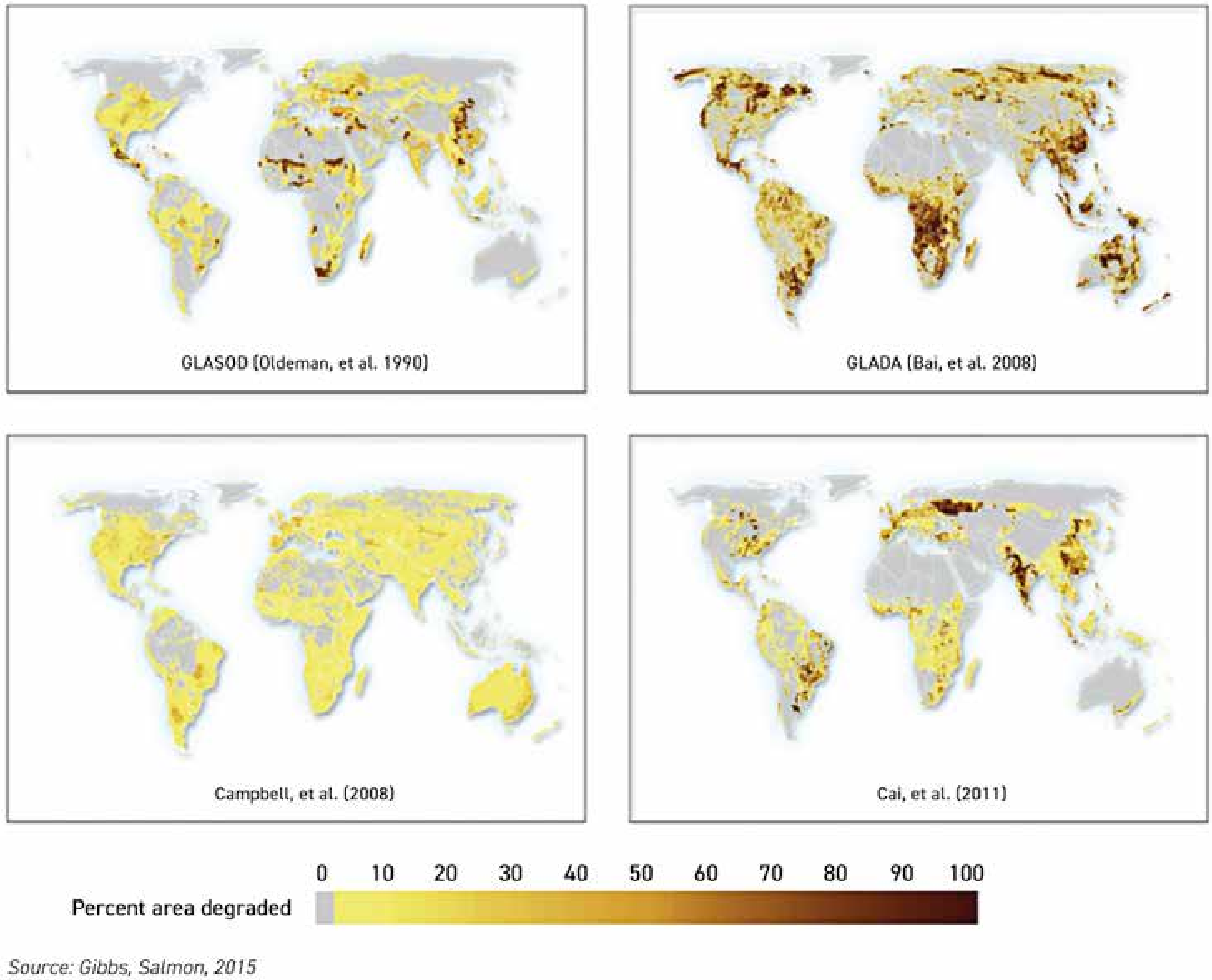
DESERTIFICATION MEASUREMENT AND POPULATION SURVEYS

Desertification measurement

Identifying, locating and measuring degraded land, while documenting the concomitant degradation dynamics, is complicated. Desertification is generally portrayed as: land degradation in arid, semiarid and dry subhumid areas resulting from various factors, including climatic variations and human activities, while being characterised by a reduction or loss of biological or economic productivity (rainfed or irrigated cropland, pastureland, forests, etc.) (United Nations, 1994).

Land degradation dynamics need, however, to be clarified according to the issues addressed (soil quality and fertility, deforestation, etc.), indicators used and scales considered. Moreover, the specific features of these dynamics in drylands compared to other conditions elsewhere in the world should also be studied from the often overlooked reversibility standpoint.

Each map below was generated on the basis of a specific desertification measurement method: expert opinion (Oldeman *et al.*, 1990), satellite observation (Bai *et al.*, 2008), abandoned agricultural land inventories (Campbell *et al.*, 2008) and biophysical models (Cai *et al.*, 2011). These cartographic depictions highlight how the choice of method has a marked impact on the definition of what is referred to as 'degraded area undergoing desertification'.



▲ Cartographic representations of land degradation according to different measurement methods

Note: Global Assessment of Soil Degradation (GLASOD), Global Assessment of Land Degradation and Improvement (GLADA).
Source: Gibbs and Salmon, 2015, p. 17.

▲ Population survey at Gadiack, Senegal
© IRD – J.-J. Lemasson

Population dynamics measurement

Population censuses are the main source of human population data. They offer an accurate view of populations down to the smallest administrative levels. Census data provide a wealth of indicators and benchmarks for comparison, thereby facilitating assessment of long-term trends. Some countries also conduct agricultural censuses on rural population samples. Overall population trends (fertility and mortality rates) are relatively well documented (via civil registries and population and health surveys, in addition to censuses), yet other social and demographic factors such as population mobility, income levels and pluriactivity are much harder to document through large-scale national surveys. One-off or repeated surveys are hence often carried out to generate data at more specific levels (district, municipality, household, etc.).

Measurement of interactions between desertification and human populations

Note, firstly, that human population dynamics and desertification have different timelines. It is essential to take long-term sociodemographic trends into account when, for instance, seeking to gain insight into the effects of desertification on population mobility. Data derived from observatories such as those linked with the Population, Health and Environment Observatory (OPSE) in Senegal, which have been generating data for over 50 years, are therefore vital for analysing the interrelationships between demographic and environmental change.

Spatial scales are also important. It is hard to gauge the impacts of desertification on rural societies, for instance, without taking specific local (social, political, economic, cultural, etc.) and national features into account. Migratory movements within a region may have completely different environmental impacts depending on the ecological and socioeconomic setting. Overall, however, very little precise information is available on emigrant and immigrant trends in dryland areas. In addition to the fact that demographic and environmental phenomena are hard to quantify, the overall lack of data stems from the intrinsic difficulties of quantifying migration events (e.g. nonrecorded migration) and the discrepancy between State-produced migration data and transborder environmental data.

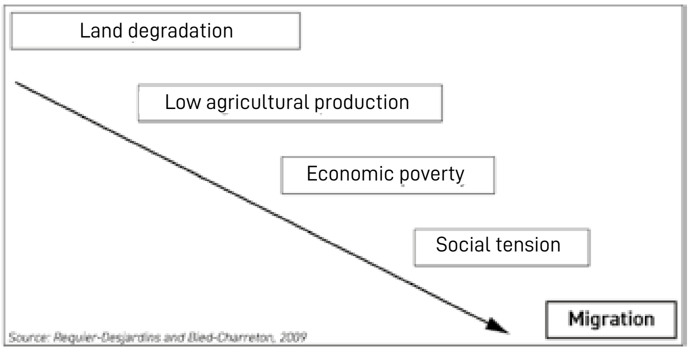
Finally, to establish the links between human population dynamics and the environment on a local level, it is essential to strive to reveal the prevailing interface systems rather than potential mechanical links. Based on the assumption that high population numbers are synonymous with land degradation, it is thus essential to identify the underlying mechanisms. How does an increase in population density affect agricultural practices, for instance? Does an increase in household size influence the income distribution, intergenerational relationships and mobility? How does this impact agricultural practices and other activities, and hence the environment?

Interdisciplinary research teams and projects are needed to develop methods and tools, and in turn produce data to assess the social and ecological dynamics and their interactions at different spatiotemporal scales.

INDIRECT CAUSAL LINKS BETWEEN DESERTIFICATION AND HUMAN POPULATION DYNAMICS

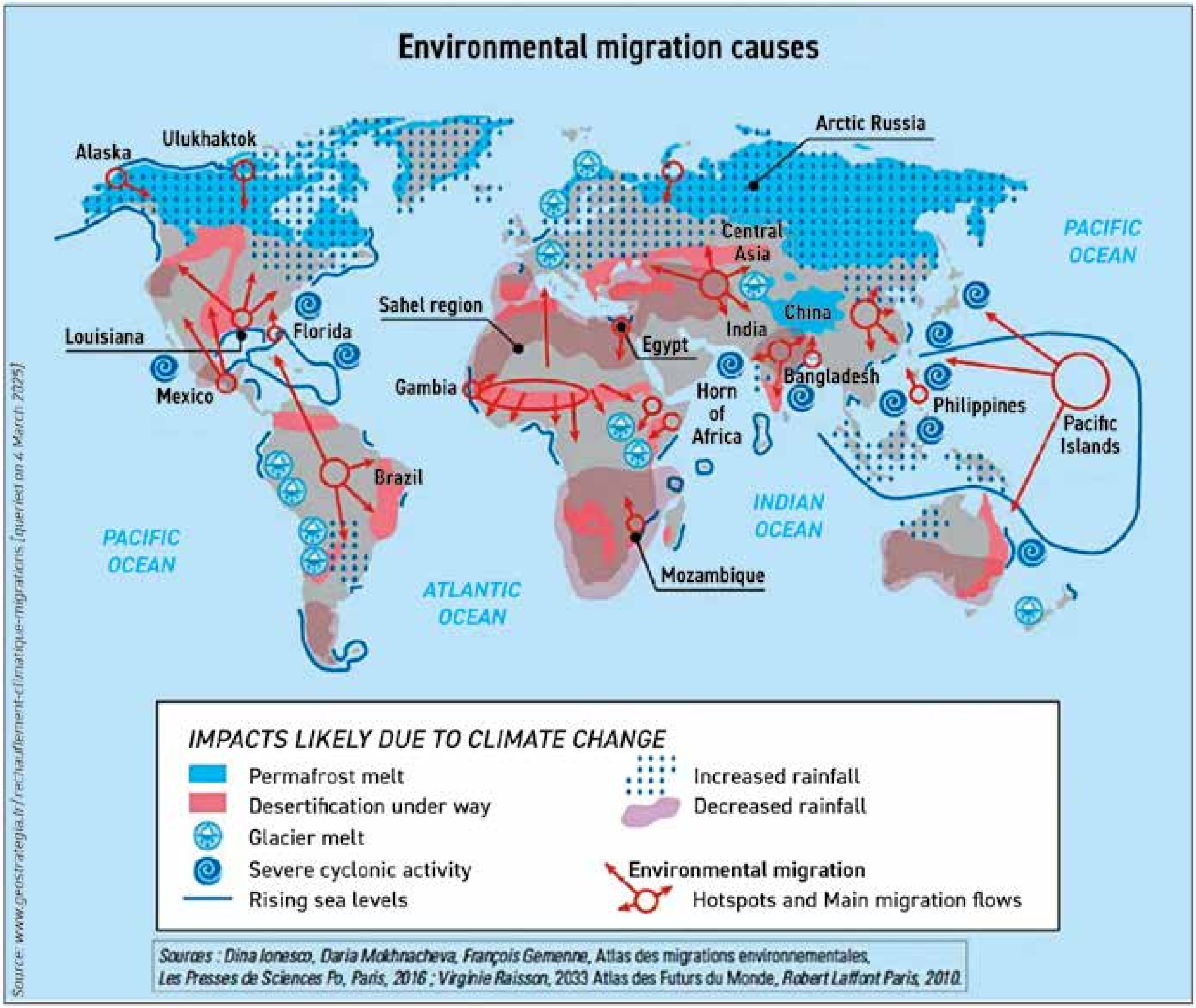
Graphic elements (images, maps, diagrams) and written documents (often in non-scientific publications) highlight a clear causal link between desertification and population trends. Global maps commonly show the copresence of 'environmental migration' and 'climate refugees' in vast regions that are 'subject to desertification', 'undergoing desertification' or 'threatened by desertification' (see map below). However, mapping desertification on a global scale is complex and unreliable, and correlating desertification with migration is even less so. Demographic phenomena are seldom solely related to the state of natural resources and local climate patterns, they are multifactorial and driven by various contextual factors (economic, political, environmental). Moreover, forms of social behaviour may differ in response to the same environmental process, and the links between desertification and population trends are often indirect. This is illustrated in the figure opposite, which highlights the impacts of desertification on agricultural production, poverty and social tension that could trigger migration phenomena once certain thresholds are crossed.

Yet there is no linear, mechanical or even teleological vision in this regard. For instance, poverty does not systematically lead to social tension, and a decline in agricultural production does not always lead to poverty. Furthermore, feedback loops and the reversibility of these processes should not be overlooked as demographic changes may also have an environmental impact.



▲ Correlating desertification and human migration patterns
Source: Requier-Desjardins, Bied-Charreton, 2009.

▼ Map illustrating the direct relations between desertification and human migration
Source: Withol de Wenden, 2021.
Cartography: Catherine Valton, 2025



OVERLAPPING SPATIOTEMPORAL SCALES

The overlapping of spatiotemporal scales must be taken into account when analysing desertification processes and human population dynamics. Phenomena observed over a short period of time at the local level (e.g. gullies in a field or emigration of families to cities) depend on factors that could be explained at other analytical levels (e.g. watershed, employment area, climate) and time scales (e.g. from one season to several decades for these examples). If long term and national scales are adopted to monitor population dynamics, while assessing land degradation processes on a local scale, other analytical and temporal scales must be considered to shed light on the two processes involved and their interactions (regional, global). This underlines the difficulty of applying local processes to larger regional areas and of documenting globally quantified phenomena in local settings.

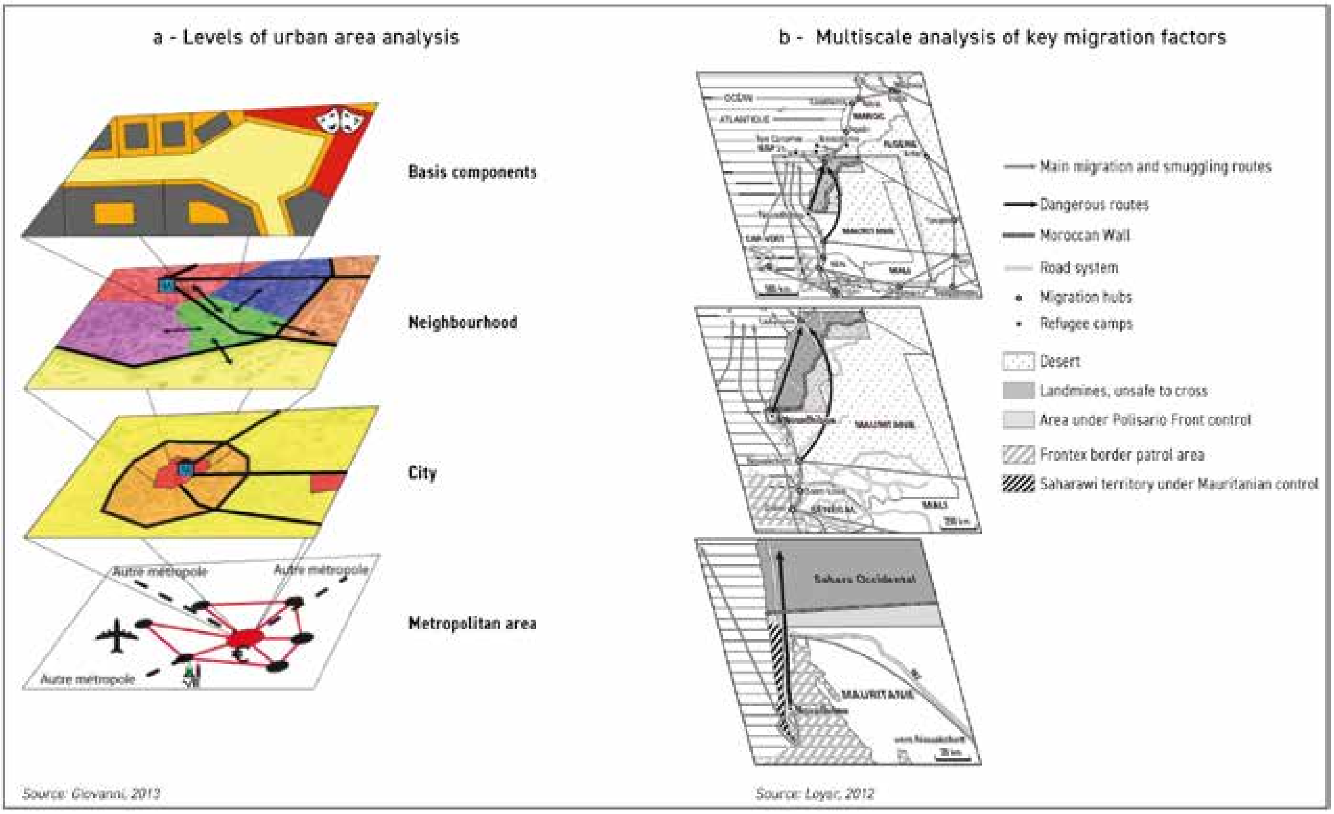
Spatial scales

To fully grasp urban dynamics, it is essential to understand how a city is incorporated within a metropolitan area relative to other cities and the rural hinterland, what its specific features are (urban boundaries, density, topography, history, functions), as well as how the neighbourhoods are composed and inhabited by city dwellers (Figure a below).

Analyses are much more detailed and thematically oriented at this scale. Analyses at the microscale (buildings, equipment, public spaces) may also be necessary to assess climate change adaptation (e.g. building designs), waste management and food procurement systems. All of the scales are interdependent: neighbourhood sanitation, power grid expansion or massive influxes of migrants will have impacts at the neighbourhood level, but also throughout the city or metropolitan area (Giovanni, 2013).

Multiscale analysis is also essential to gain a clear understanding of land degradation phenomena. This may be exemplified by wind erosion processes that take place in the Sahara, where the local impacts of wind on arid drylands with little or no vegetation cause soil degradation at the local level, with high-altitude winds also transporting sediments over varying distances, thereby contributing to soil fertilization at the continental or even global levels. Land use dynamics at the local scale should be analysed to gain insight into land degradation intensification and possibly take action, but also into large-scale air circulation patterns at the global level, alongside national agricultural policies (Loireau and Ickowicz, 2024).

The living standards that prevail in local settings are also vital population dynamics factors. Figure b below shows this overlapping of scales with regard to Europe-bound migration routes from sub-Saharan Africa via the Canary Islands (Loyer, 2012). In the vicinity of the Mauritanian city of Nouadhibou—located near the Western Sahara border and the impassable Moroccan Western Sahara wall that the Moroccan army has reinforced with



▲ Different scales for the analysis of urban and migration dynamics
Sources: a – Giovanni, 2013 ; b - Loyer, 2012
Cartography: Catherine Valton, 2025

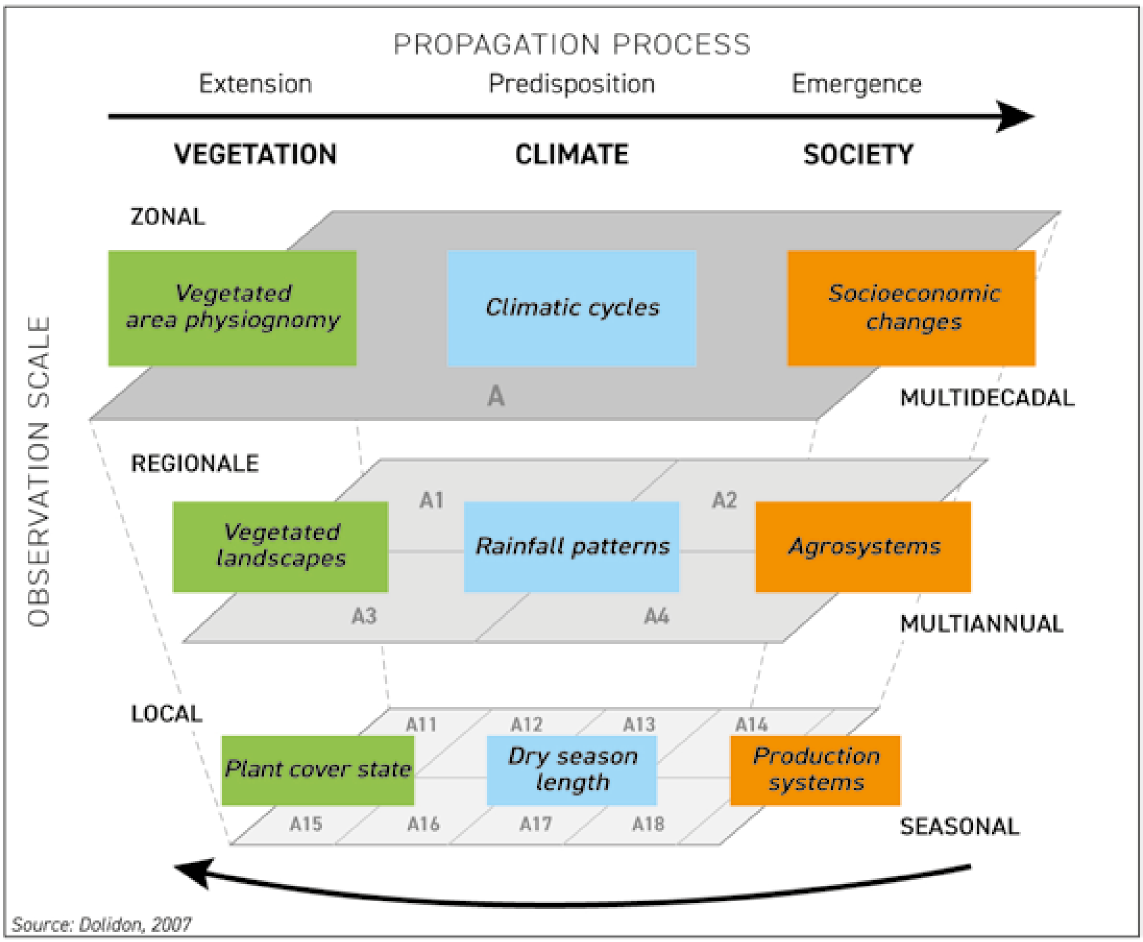
landmines (Figure b, top map)—migrants generally opt to cross to the Canary Islands along safer migration and smuggling routes (Figure b, centre map). The large scale map (Figure b, bottom) highlights the new Mauritanian national road that facilitates access to Nouadhibou from the city of Nouakchott, as well as the activity of smugglers on the Nouadhibou peninsula, where the Mauritania/Morocco/Western Sahara border passes. These three scales must therefore be taken into account to understand the conditions under which the European Border and Coast Guard Agency (Frontex) maritime patrols were implemented, and their role in the region.

Temporal scales

The processes underway in these areas are dependent on long-term adaptations of societies in dryland areas, but also on short-term crises such as drought or armed conflicts. The example reported by Dolidon (2007) regarding bush fires—which have long been recognized as a major land degradation factor—is instructive (see figure below). The author highlighted the links between short- and long-term processes and local and continental scales, as well as the diverse range of processes involved and the complexity of their interrelationships. Moreover, each of these processes is subject to contrasting temporal dynamics, such as those involved in climate (see Focus page 24) and urbanization processes.

▲ Bush fire, Australia

▼ Overlapping geographical and temporal scales in the analysis of bush fire propagation dynamics
Source: Dolidon, 2007.
Cartography: Catherine Valton, 2025



FOCUS

Three climate temporal dimensions – drought, aridity and climate change

Benjamin Sultan

Drought is a temporary water deficit period that may occur under diverse climatic conditions. Meteorological drought means that there is zero or below average precipitation, agricultural drought implies that soil moisture is insufficient to support plant growth, while hydrological drought means that the river flows or groundwater levels are very low.

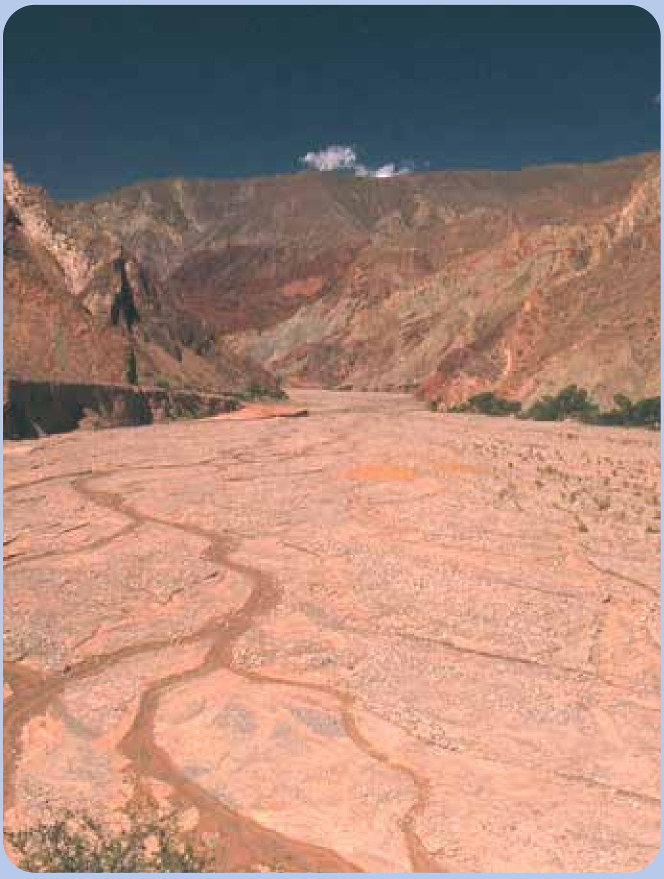
Aridity—unlike drought—is a long-term structural phenomenon occurring in a region where there is a chronic water deficit, with rainfall levels below the evaporative demand as, for instance, is the case in the Sahara Desert.

In recent decades, there has been an increase in arid areas, and climate forecasts indicate that this aridity will spread as greenhouse gas emissions rise and global warming intensifies. Some regions, e.g. South Africa, are also showing signs of longer and more intense droughts, with their duration and frequency likely to worsen with the warming trend. Yet this is not the case everywhere in the world as some areas may be impacted by other ongoing processes, such as El Niño and La Niña, whose alternating cycles may also cause droughts or floods in intertropical regions.

The short-term impacts of this increased aridification and worsening droughts are far-reaching: a higher risk of wildfires, increased difficulties in obtaining drinking water, alongside crop yield and biodiversity losses. Sustained droughts will alter vegetation in the long term and on a global scale, thereby reducing its ability to take up CO_2 and increasing greenhouse gas emissions, with global warming accelerating aridification—it's a domino effect.

▲ Drought in Burkina Faso
© IRD – P. Gazin

▼ Drought in Niger
© IRD

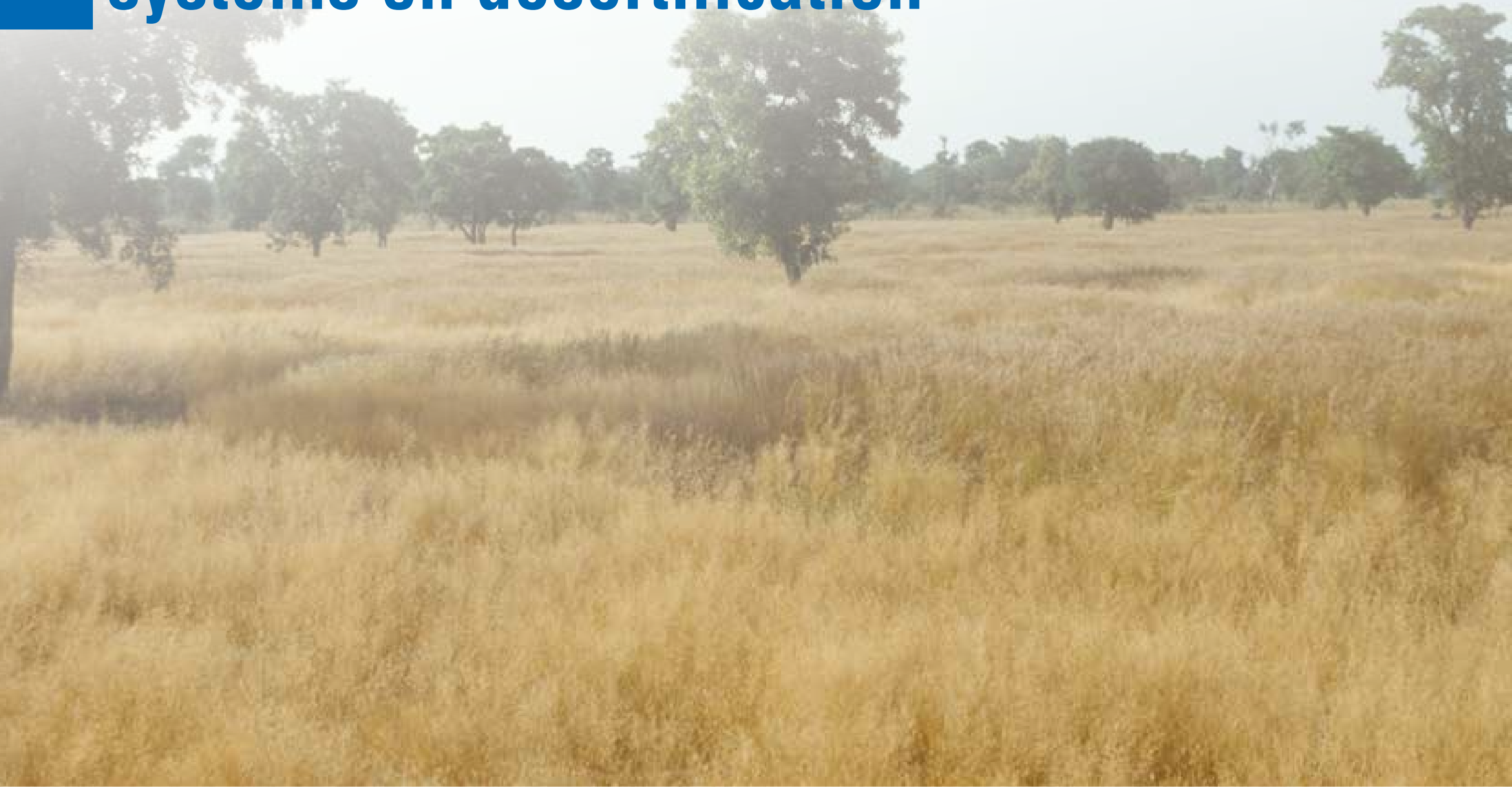


◀ Arid landscapes in Bolivia
© IRD - Marc Pouilly

▲ A new town built in a steppeland area, Inner Mongolia, China
© IRD – T. Vergoz

In conclusion to this second part, it is vital to analyse the links between population dynamics, urbanization and desertification processes through a holistic approach that incorporates a diverse range of factors, while also taking processes underway at other scales into account to analyse local and contextualized situations and enable comparisons. The research examples presented here also demonstrate the relevance of viewing the links between population trends, urbanization and desertification at different time scales.

Impacts of population growth and activity systems on desertification



▲ A fallowed dryland savanna area in Burkina Faso
© IRD – A. Fournier

Are very densely populated areas the most at risk of degradation? What is the role of agricultural production systems in land degradation? When the population size increases—and in turn the food demand—how do production systems change and how does this impact the desertification dynamics? We have addressed these questions and present several local research findings to highlight various links between population growth, density, activity systems and desertification.

POPULATION GROWTH AND ENVIRONMENTAL TRAJECTORIES

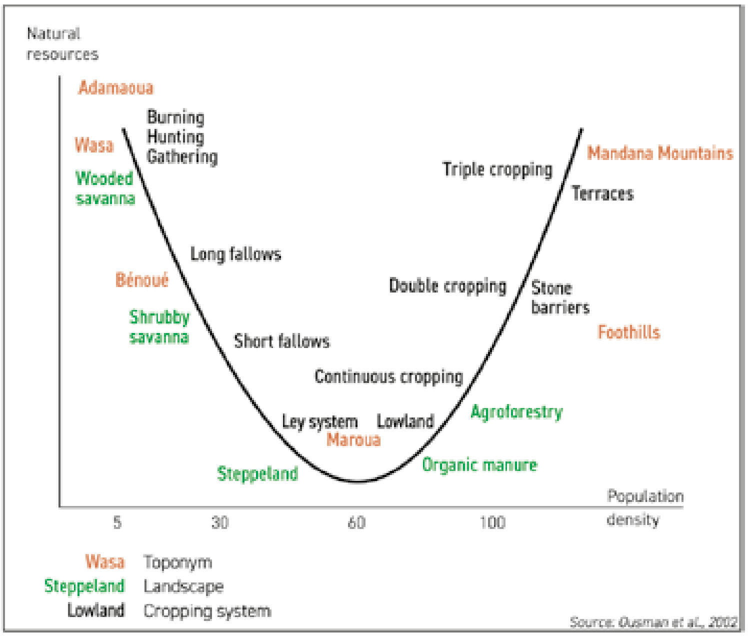
Population growth and density are often put forward as environmental degradation factors (climate change, desertification, deforestation, etc.). Curbing population growth is therefore regarded as essential and unavoidable. In 2017, 15,000 scientists penned a warning to humanity: "We are jeopardizing our future by not reining in our intense but geographically and demographically uneven material consumption and by not perceiving continued rapid population growth as a primary driver behind many ecological and even societal threats" (Ripple *et al.*, 2017).

On a global scale, the correlation between human population density and land degradation is, however, not clearcut. For instance, severe land degradation is underway in dryland areas of Arizona and South America, where there are <5 inhabitants/km^2, while Central Asia, with >250 inhabitants/km^2, is stable from the land productivity standpoint. In the Sahel, with population densities ranging from 5 to 25 inhabitants/km^2 and high population growth, landscape 'regreening' is progressing (Descroix *et al.*, 2021) as a result of the better climatic conditions and the resilience of agrosystems, which have enhanced forestry, gardening and small-scale irrigation initiatives.

This linkage between population density and land degradation is regularly being clarified in debates (see Focus opposite) urging consideration of the diversity of production systems and social organizations and their innovation potential, including agricultural intensification, activity diversification, as well as strategies fostering transitory migration to more attractive areas offering employment opportunities, e.g. wetlands and cities (see, for example: Tiffen *et al.*, 1994; Mortimore and Adams, 2001). Interactions between population dynamics and environmental degradation are complex and not mechanical.

A study undertaken in Cameroon has linked land productivity levels and population density according to the different agrosystems that are found in this Sudano-Sahelian region. Ousman *et al.* (2002) noted a decrease in the length of fallow periods as human population sizes increased, leading to major landscape changes (reduced tree cover, lower crop yields), hence prompting the need—in areas with >60 inhabitants/km²—for the introduction of agroforestry practices (organic fertiliser input, intercropping of legumes, including *Acacia albida*), the development of floodplain cropping, and even intensive terraced cropping systems in mountain regions where population sizes are historically >200 inhabitants/km² (see figure opposite).

These different agrosystems have emerged as an outcome of the turbulent political history, which accounts for the uneven population distribution patterns, the long-term adaptation of societies to contrasting ecosystems and, more recently, their inclusion in the market economy to meet the growing regional food demand. Soils deemed nonarable have thus, since the 1990s, been cropped with sorghum, which is transplanted and marketed in the off-season (Collectif, 1993).



▲ Population pressure and land productivity (natural resources) in northern Cameroon

Source: Ousman *et al.* 2002, p. 26.
Production: Catherine Valton, 2025

FOCUS Malthus and Boserup – two authors in the debate on the links between population growth and resources

Thomas Malthus (*An Essay on the Principle of Population*, 1798) and Ester Boserup (1965) are among the most prominent authors who have influenced debates on the linkages between demographic and environmental change (for a much more comprehensive overview, see Véron, 2013).

In the late 18th century, the English pastor T. Malthus published an essay in which he argued that, in the absence of controls, any population will grow exponentially, while resources increase arithmetically. The population would constantly expand beyond the subsistence threshold. This imbalance would lead to conflicts, famines and epidemics until the population declines to a sustainable level relative to available food resources. In the second version of his essay, T. Malthus advocated moral restraint to avoid this overpopulation issue, i.e. individuals should remain celibate until they have the means to provide for their offspring. This Malthusian paradigm has inspired many thinkers and politicians to this day.

So-called 'Neo-Malthusians' advocate limiting births through (more or less coercive) population policies and widespread contraception. Overpopulation was, for instance, a key theme in René Dumont's resolutely Neo-Malthusian views on famine and African agriculture (Dumont, 1997).

Ester Boserup challenged these neo-Malthusian interpretations by arguing that population growth and pressure foster innovation and agricultural development (Boserup, 1965). She claimed that increases in the population density will reduce per-capita social and economic infrastructure costs while boosting productivity (market and transport development, etc.). This virtuous demographic circle will work if public policies are designed to create a conducive environment (with investment in agricultural and rural infrastructure) and if non-polluting energy-efficient technologies are given priority. Boserup thereby explained that the imbalance between population growth and food production in Africa is due to the poor state of the prevailing communication and transport networks.

AGRICULTURAL PRODUCTION SYSTEMS AND LAND DEGRADATION

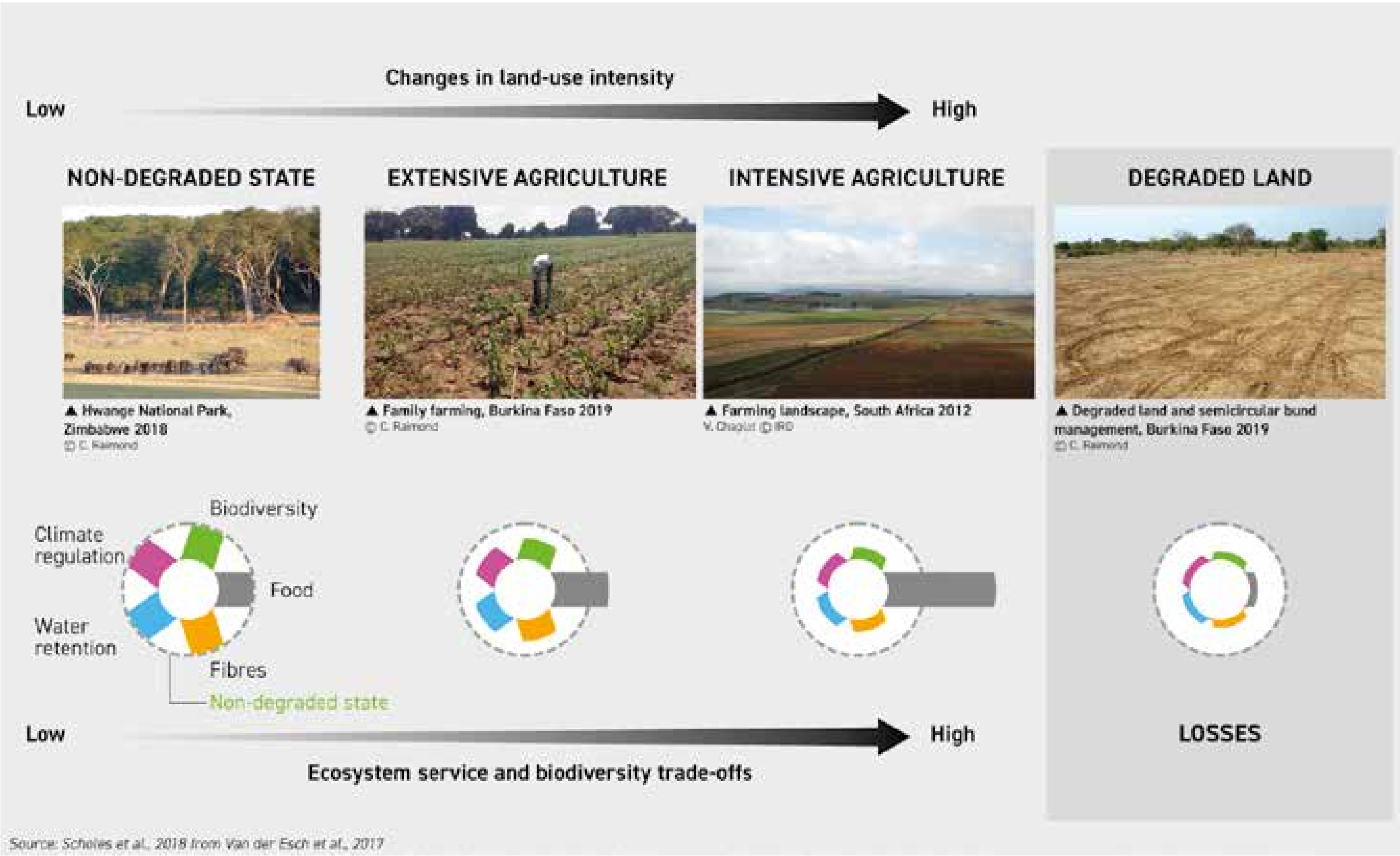
Agricultural production systems and development models are crucial for understanding the potential links between human population growth and desertification. Historically, population phenomena—combined with agricultural techniques that had not progressed or were unsuitable—led to environmental overuse and land degradation, e.g. the 1930s Dust Bowl storms in USA (linked to agricultural over-mechanization, migratory flows and prolonged droughts, among other factors, in Oklahoma, Kansas and Texas). Agricultural production systems change as the population density increases (see Roose, 1994, p. 24). Over-intensification of farming systems, which has been attributed to the rising food demand (local, regional or global) and population growth, can be blamed for driving the usage of lands beyond their carrying capacity, hence leading to land degradation (see figure below).

Yet the linearity in the loss of ecosystem services (i.e. benefits that ecosystems offer to human societies) according to the extent of production intensification (as highlighted in this figure) is not systematic because this picture does not take into account the practices and timeframes that enable the maintenance of these services, e.g. fertilization practices using manure derived from transhumant livestock herds (Hiernaux, 1998), fallow land, agroforestry and the rehabilitation of land considered nonarable (Collectif, 1993).

Moreover, very production-oriented technical models (e.g. highly intensive farm production supported by agrochemical inputs) can lead to land degradation that is not correlated with population density and growth—land in sparsely populated areas with no population growth can thus become degraded. Not all forms of intensification linked to population growth can be labelled as a land degradation factor, i.e. local impacts may vary depending on the extent of population growth, the production potential and production systems combined, but also on other factors, as illustrated by the three cases in sub-Saharan Africa exemplified hereafter.

The first example (see Focus opposite) concerns a small-scale intensification situation involving imputs of livestock manure in a setting characterized by extensive agricultural production and high population growth (western Niger). Land productivity may also decline when insecurity impedes pastoral livestock farming, thereby reducing the potential for boosting land productivity.

▼ Intensified anthropization of natural ecosystems and impacts on ecosystem services and biodiversity
Source: Scholes *et al.*, 2018, from Van der Esch *et al.*, 2017.
Cartography: Catherine Valton, 2025



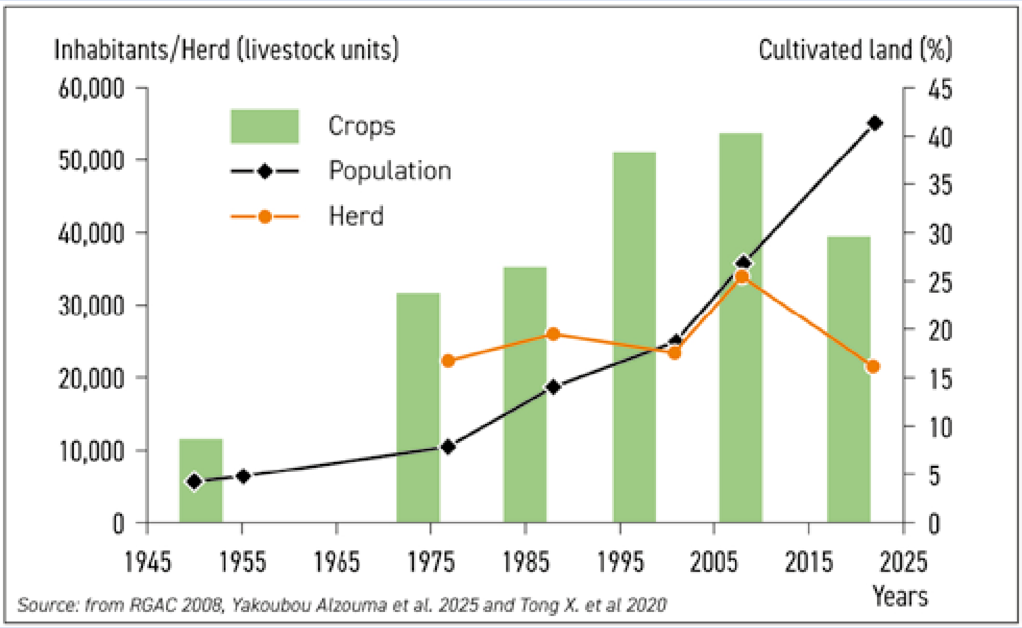
FOCUS Negative impacts of insecurity on livestock and land fertility in western Niger (Dantchandou)

Pierre Hiernaux

The population in the western Niger rural commune of Dantchandou (13°24'N; 2°45'E) has grown exponentially at an average annual rate of +3.26%/year (figure below) since 1950. In 2022, 6,431 Djerma farming families were living in 40 villages in the area, along with 623 Fulani pastoral herding families who had been settled in camps since the 1970s. The population density is 60 inhabitants/km², with 71% of these people being under 15 years old.

All families grow millet along with some cowpeas and roselle (*Hibiscus sabdariffa*). Sowing and weeding are done manually, without ploughing. Soil fertility is conventionally managed by leaving the land fallow for 3 years after 5 years of cultivation. In the vicinity of villages and settlements, organic fertiliser—derived from grazing livestock or applied by spreading household waste and manure—facilitates crop intensification and diversification.

Until 1995, population growth was combined with a 3.2% average annual increase in cultivated land, before levelling off until 2010 (~40% under crops, 40% fallows and 20% rangelands). From 2010 to 2020, this balance was upset by insecurity (cattle thefts, kidnappings by armed groups for ransom), i.e. a reduction in cropland and rangeland, and impediments to pastoral livestock herding, which in turn reduced the field manuring potential. This Sahelian region was therefore impacted by a reduction in manured land, thereby ultimately diminishing the agricultural intensification capacity, combined with the gradual decapitalisation of pastoral livestock herders (whereas village livestock herds remained stable).



▲ Comparison of human population, livestock (tropical livestock units) and cropland area (%) trends in the rural commune of Dantchandou (919 km²) in Niger.
Sources: RGAC, 2008; Tong *et al.*, 2020; Yakoubou *et al.*, 2025.
Production: Catherine Valton, 2025

▼ Millet harvest, Niger
© IRD – C. Mariac

The second example concerns the intensive agricultural production system that prevails in the Mandara Mountains of Cameroon, where soil is formed using a terracing technique, and agricultural productivity downturns are associated with social phenomena (migration, insecurity). In this region, which hosts >250 inhabitants/km², techniques developed over the long term (Hallaire, 1991) have substantially boosted agricultural productivity. Terracing has helped generate soil suitable for growing crops in previously rock-strewn places, and a highly diverse range of crop varieties have been adapted to be intercropped over two crop seasons—the rainy season and off-season—supported by small-scale irrigation. These production systems began declining as the farm labour force dwindled because the male workers had emigrated (leaving only women in the villages, who were unable to maintain the structures) or because the cropfields were no longer accessible due to insecurity along the Nigeria border (Boko Haram), for instance.

The third example illustrates how Sahelian wetland activity systems can foster high productivity while safeguarding natural functioning and ecosystem services. The so-called 3 M system prevails in these areas: multi-activity households spatial multifunctionality and activity and resource mobility. The lands are extremely attractive due to their high agricultural potential, with productivity paralleling that of corporate farming systems (Rangé and Cochet, 2018). These areas are also experiencing increasingly severe flooding and exceptional vegetative regeneration as a result of the resumption of rainfall and regreening of the Sahel (Hiernaux *et al.*, 2021), which in turn is reconfiguring the areas and the interplay between activities and social groups (Raimond *et al.*, 2024). Insecurity is accentuating this regeneration process in the Lake Chad and Central Niger Delta regions by curbing agricultural production activities. The trajectories differ in other wetland areas, i.e. they are once again the focus of large-scale hydroagricultural development programmes designed to meet the growing food demand and address climate change issues. This model mirrors that which produced the development 'white elephants'—large-scale projects that failed before the 1990s and structural adjustment policies (Bertoncin and Pase, 2012)—which led to land degradation due to major technical and organizational malfunctions.

▲ Mandara Mountains in northwestern Cameroon
© IRD – Y. Boulvert

▲ Ancient artesian well, Tunisia
© IRD – S. Massuel

RESOURCE EXTRACTION ACTIVITIES AND LAND DEGRADATION

Population growth can trigger increased demand for underground and soil-derived raw materials sourced via extraction-based production systems—these extraction activities may contribute to land degradation. Such systems are qualified as 'extractivist' when they are exclusively geared towards maximizing economic profit to the detriment of other ecosystem services. Extractivism has historically been driven by Global North actors, particularly through investment and resource tapping in the Global South. Nowadays, this trend is also being fuelled by emerging and recently emerged countries, such as China, through investment in and implementation of resource extraction activities in the Global South. Many countries in the latter region are also actively and willingly involved in this process. Note that the extractive resource demand varies according to the size of the consumer base and its potential growth, as well as to the degree of development, economic systems and lifestyles. The impacts of resource extraction activities may differ depending on the nature of the concerned projects and environments. Agribusiness and mining examples are presented in the box on the next page.

The links between population growth and density, economic systems and desertification are hence not mechanical or uniform, and are highly dependent on the socioeconomic and political setting. Societies may modify their agricultural systems and diversify their income sources in response to constraints (environmental, economic or political). These changes can lead to severe land degradation, particularly when highly intensive and extractive agricultural models or others involving massive deforestation are implemented. Yet this degradation is often unrelated to population trends and could be explained by changes in economic activities—more agribusiness (production oriented towards export or cities in producing regions) or excessive extractivism—which may lead to overexploitation of natural resources, particularly water and land.

FOCUS Examples of resource extraction activities

Argentinian Chaco region – a case of export-oriented extensive agriculture in a lightly populated area

Alberto Preci

The Chaco region in northern Argentina is a broad, sparsely populated plain that has long been marginalized in the country's development efforts. Since the 1990s, this forest ecosystem has been impacted by one of the fastest-advancing settlement fronts in South America (see photograph opposite) (Morello and Rodríguez, 2009). This has resulted in massive deforestation, combined with rapid expansion of intensive livestock farming and extensive crop farming focused mainly on cereal crops for export.

These anthropogenic changes have weakened the soil, with a marked loss of fertility, a reduced water retention capacity and serious erosion (Baldassini and Paruelo, 2020). Due to overgrazing and forest fires—increasingly prevalent in recent years—this situation has become particularly serious in the arid Chaco region, which features the most extremely arid conditions in South America. As illustrated by several studies on the increased soil salinity in the region, the clearing and cultivation of forest land in the Chaco region is altering the soil's organic carbon content, leading to its gradual degradation (Torres *et al.*, 2015; Maertens *et al.*, 2022). The contemporary desertification process, i.e. the result of biophysical and socioeconomic changes that have been underway for some 30 years, has a direct impact on the forest ecosystem services and livelihoods of local communities (Verón *et al.*, 2018). Given the difficulties in continuing their hunting, gathering, beekeeping, and livestock farming activities in the forest areas, most of these people are migrating to urban centres.

▼ Roadway 86 in the vicinity of Tartagal, a town in Salta province, Argentina.
© A. Preci, June 2016
In the forefront, vegetation regrowth following the summer crop harvest on a very sandy soil. At the back, trees mark the limit between the crop field plots and are meant to curb soil erosion according to the current regulations.

Saharan oases – demographic and environmental transformations

Saharan oasis communities have coped with the prevailing aridity for 2,000 years by implementing agricultural production techniques adapted to the local conditions and social structures in tune with them (Guillermou, 1993). Oasis water management is vital—expertise and a substantial labour force are required to maintain the palm groves and the complementary interactions between crop and livestock farming. Several oases are currently fragile and some are very old, particularly in Tunisia and Algeria. Some oases have been transitioned into mechanized monoculture production areas, with the harvested crops geared towards meeting market economy needs rather than those of the local communities (Amrani, 2020). The oasis palm groves were formerly based on a range of different date varieties, but the Deglet Nour variety is now predominant (grown in 70% of Algerian oases). This export date variety is highly water-consuming and dependent on fertilizer and pesticide inputs.

In Tunisia, agribusiness and tourism have developed in certain oases (e.g. Douz and Tozeur), but have also proved to be problematic (Carpentier and Gana, 2013). These activities have generated fierce competition for water resources, and the number of skilled farm workers is declining. Family farming therefore seems less profitable. Monoculture systems make palm groves more vulnerable to years of drought. However, the three-tier cultivation system—market gardening, arboriculture and palm cultivation—that constitutes the oasis ecosystem helps combat desertification and sand encroachment in the oases, while limiting soil evaporation and thus regulating moisture. Land degradation, and more generally the deterioration of production conditions, has mainly affected the most vulnerable people. In oases, as elsewhere, land degradation has exacerbated existing inequalities between socioeconomic levels and genders (Droy, 2017).

◀ Aerial view – sand encroachment threat in southern Tunisia
© IRD - IRA – C. Lamontagne, 2017

Hydroagricultural extractivism, privatization and land degradation in North Africa

Charline Rangé

Like other arid and semiarid regions worldwide, North African countries have developed large-scale hydroagricultural policies in steppelands and Saharan areas, which are often mistakenly considered to be empty and therefore unsuitable for agricultural modernization. Various programmes have been implemented since State independence, with objectives varying according to the period and national context. These programmes have been facilitated by policies fostering the individualization and privatization of land and (in Tunisia) of groundwater, while targeting a diverse range of actors (small resident or migrant farmers, young graduates, major national investors, elites close to power, businesses) (Derderi *et al.*, 2022; Gharbi and Elloumi, 2023).

Land plots of variable sizes (from a few to several thousand hectares) were allocated and subsidies were granted (for access to water, energy and credit, or even to promote exports) for production (arboriculture, market gardening, cereal farming) intended for the domestic market or mainstreamed into relatively globalized value chains. Everywhere this development has turned out to be unsustainable (groundwater depletion, water and soil quality degradation due to monocultures), with farmers reacting to the groundwater overexploitation situation by abandoning their crop plots and creating new ones—an extractivist approach facilitated by the virtual absence of any kind of water access regulation (proliferation of ever deeper and illegal boreholes) (ibid). In steppeland areas, the expansion of irrigation schemes has led to a reduction in grazingland, grassland degradation and the loss livestock farmers' historical land-use rights (Saad, 2011).

▲ A borehole in southern Tunisia
© IRD

Mines and land degradation

"Industrial or artisanal and small-scale mining operations set up in arid, semiarid and dry subhumid areas generally cause major soil degradation, with the levelling of surface layers and the removal of large volumes of earth and rock. Mining operations also consume considerable amounts of water for ore processing or mine de-watering. Whether the groundwater is not replenished or the fossil water is not recharged, this can lead to water shortages that then trigger population displacement (e.g. copper mining in the Atacama region of Chile). Not only does mining physically degrade the soil and impact water resources, but it can also pollute the soil and water with chemicals. This is mainly due to the leaching of spoil tips* and ore processing products (e.g. cyanide and mercury pollution at the Koma Bangou gold panning site in Liptako, Niger). Restoring these polluted transformed areas is very costly."

Source: Bonnet *et al.*, 2024, p. 35.

*Leaching of mine tailings: soluble compound extraction from a solid mixture by washing and percolation.

▲ Aerial view of a gold mining site, Côte d'Ivoire
© IRD - Minerwa

▼ Soil pollution due to gold mining activities, Burkina Faso
© IRD – J. Gardon

Impact of urbanization on desertification

Urbanization and urban sprawl may give rise to environmental issues in terms of water and energy supply, waste management, pollution (water, air, soil), deforestation and temperature surges. The impact of urbanization on land degradation can be assessed on a local scale for individual cities and surrounding areas (rings of degradation associated with resource consumption patterns). Yet other factors may also have a bearing on this impact in drylands: changes in urban lifestyles (such as eating and consumption customs), and especially urbanization management by political authorities (e.g. regulation or not of urban sprawl, infrastructure policies, etc.).

▲ Road traffic in Nigeria
© Shally Imagery - www.pexels.com

URBAN DEVELOPMENT AND SPRAWL IN DRYLANDS

Land artificialization in suburban areas due to urban sprawl – a model

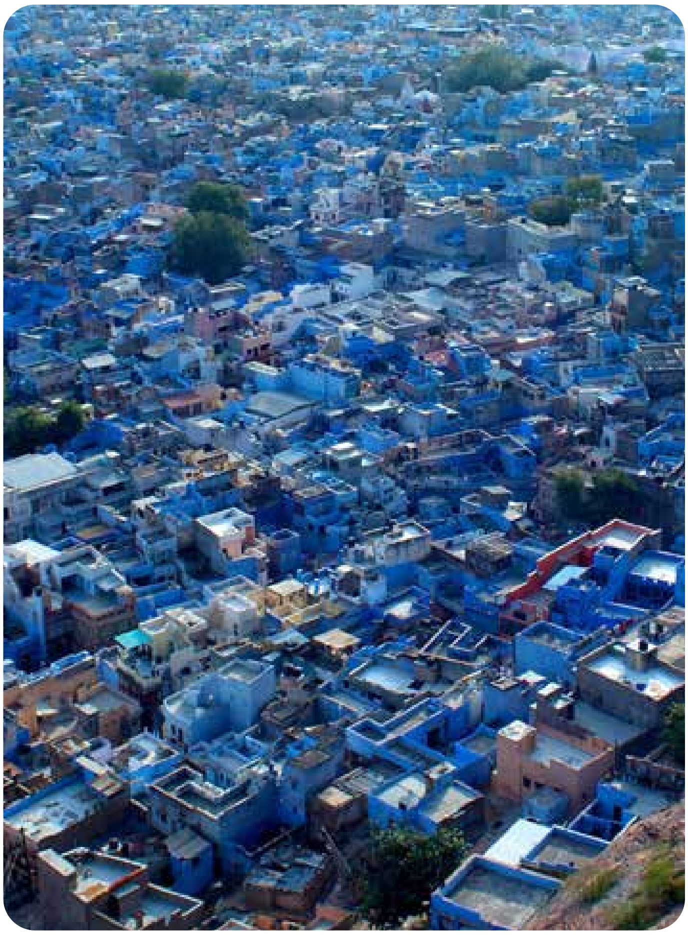
Urban sprawl—which involves expansion of a city's surface area—is fuelled by the prevalence of automobiles, and generally by the use of individual motorized vehicles (so-called motor cities) for travel. Transport via cars, motorbikes and other three-wheeled vehicles, unlike public transport along fixed routes, can promote sprawl in all directions in low-density urban areas (see figure below). This trend applies worldwide, including in dryland areas, and particularly in regions undergoing rapid urban growth (Africa, Asia), where there is generally a lack of urban planning policies, sprawl control measures and commitment to the 'compact city' model, which represents a trade-off between urban density and quality of life (Guilhot *et al.*, 2018).

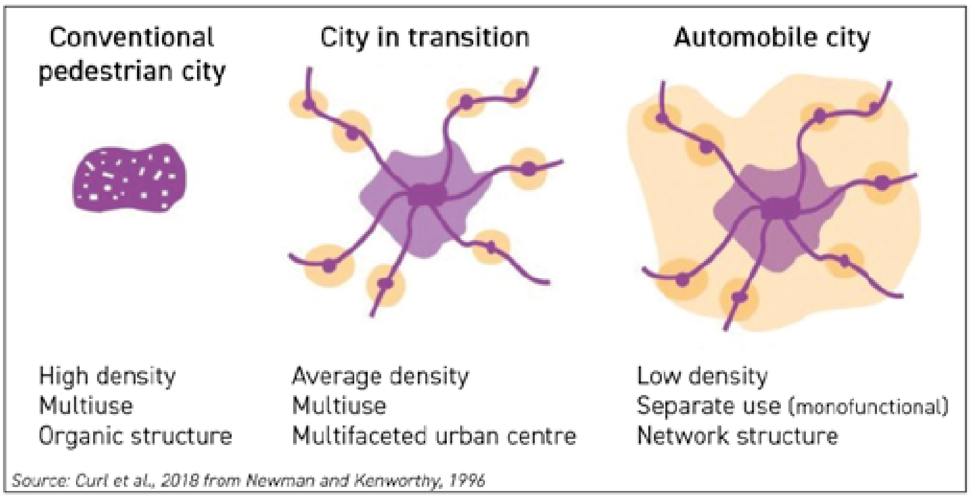
Environmental challenges of urbanization in dryland areas

Environmental challenges facing cities in arid and semiarid areas generally revolve around water and air pollution issues, but they vary depending on urban forms and city locations. Ancient cities were often built near sources of water available year-round, such as permanent rivers, springs or canals channelling water from distant locations (e.g. in Jodhpur, India). The very high urban growth rate during the 20th century considerably boosted needs and led to water supply crises during drought periods. This trend may be exemplified by the major water system management issues that emerged in Cape Town (South Africa) in the early 2020s, where the lack of system maintenance prompted heavy water losses. Seasonal waterlogging may also lead to devastating floods during heavy rainfall events, which are increasing in number with climate change, or as a result of groundwater upwelling due to poor drainage conditions.

Regarding cities in dryland areas—where urbanization is recent and occurring rapidly owing to the dearth of land-use planning policies—urban sprawl is encroaching on agricultural land and natural ecosystems (Alexandre, 2017). This land artificialization process can trigger erosion and substantially alter water flow (Capozzi *et al.,* 2018). In coastal areas where most large cities are located, this process impacts lagoon ecosystems and causes coastline recession, often due to massive sand extraction (e.g. in Dakar, Senegal). The fast growth of small- and medium-sized cities is also contributing to the conversion of farmland into built up areas with sealed surfaces, as well as to the relocation of production activities to peripheral areas.

▼ Jodhpur, a city in Rajasthan state, India
© IRD





◄ Transport systems and urban forms
Source: Curl *et al.*, 2018, from Newman and Kenworthy, 1996
Production: Catherine Valton, 2025

Despite this uncontrolled sprawl trend, cities are not necessarily environmentally unfriendly. They are also places of creativity, waste recycling and various greening projects (see below). The relationship between city dwellers and vegetation is also changing and impacting urban building designs, often in a modern mineral architectural style. While cities are worrisome heat islands in the current climate change setting, studies have shown that some urban configurations—including more vegetation and smaller sizes—can create a cool oasis effect (Fan *et al.*, 2017).

▲ Aerial view of Ngor, Dakar (Senegal)
© IRD – S. O. Boye

FOCUS

Green belt model to meet the challenge of controlling urban growth

An example at N'Djamena (Chad)

Ronan Mugelé

Green belts are band-like areas that have been created on the outskirts of urban centres. These often quite small (<500 ha) green belts may include wooded areas, hedgerows and even market gardens. Their roles may be to provide protection against erosion or sand encroachment, preserve degraded ecosystems or create recreational areas. Such schemes are designed with the stated aim of controlling urban sprawl, yet their sustainability may be jeopardized by the rapid urban growth patterns in many countries located in semiarid zones, as illustrated by the situation in N'Djamena (Chad).

The project to create a green belt in N'Djamena dates back to 2008. Presented by the authorities as Chad's first version of the Great Green Wall (GGW)*, it has been entrusted to an interministerial body under the supervision of the Ministry of the Environment. This project is the third generation of urban reforestation operations coming in the wake of the ornamental plantations set up during the colonial era (Klemat and Djambal Bahr neighbourhoods), and the creation of an initial green belt in the 1970s—traces of which are still visible despite its advanced degree of deterioration (Sabangali and Dembé neighbourhoods).

The belt, which spans an 840 ha area on the outskirts of the city (from Gaoui to Gassi), is designed to curb wind damage to the roofs of nearby homes, protect outlying neighbourhoods from water erosion that regularly causes flooding, and create a less arid microclimate around the capital. Its deployment has been delegated to various stakeholders, including political institutions, national and international companies and associations, which share the 22 sectors allotted in 4-ha plots for reforestation initiatives. There are many difficulties. The lack of coordination is highly noticeable in the landscape, the low water and labour availability is to blame for the very low seedling survival rate, while politicians' pursuit of short-term visibility hinders territorialization of the plantations.

Critics condemn the authoritarian conditions under which the belt was created, which resulted in many people being evicted from these sites, despite the fact that they were inhabited by people who had been driven out of the city core by land and property speculation and who cultivated market garden produce in the lowlands. The high installed fences are disrupting local mobility, thereby forcing inhabitants to cross via tracks or an occasional paved road.

The project has remained in its infancy for 15 years. Local residents have shown little interest in it, and developers and managers have made few long-term investments. The total lack of urban planning has led to sprawl within the green belt, which is currently undergoing urbanization. Local real estate and speculative dynamics have also taken their toll on this symbol of renaturation and urban sustainability advocated worldwide.

Note that while the green belt is not a key factor in the restoration of vegetation cover on soils, a less conspicuous and anticipated process is contributing greatly to this process, i.e. land grabbing. These secondary plots of land, locally referred to as 'gardens', are being acquired by some wealthy individuals in N'Djamena for recreational purposes (Mugelé, 2023). They are springing up throughout the city and are reviving the tree cover, which in turn is being safeguarded by multiple fencing and security measures (walls, fences, ditches). This genuine assisted natural regeneration process is, paradoxically, having much more decisive impacts than achieved via the green belt.

* For further information on the GGW, see:
www.grandemurailleverte.org

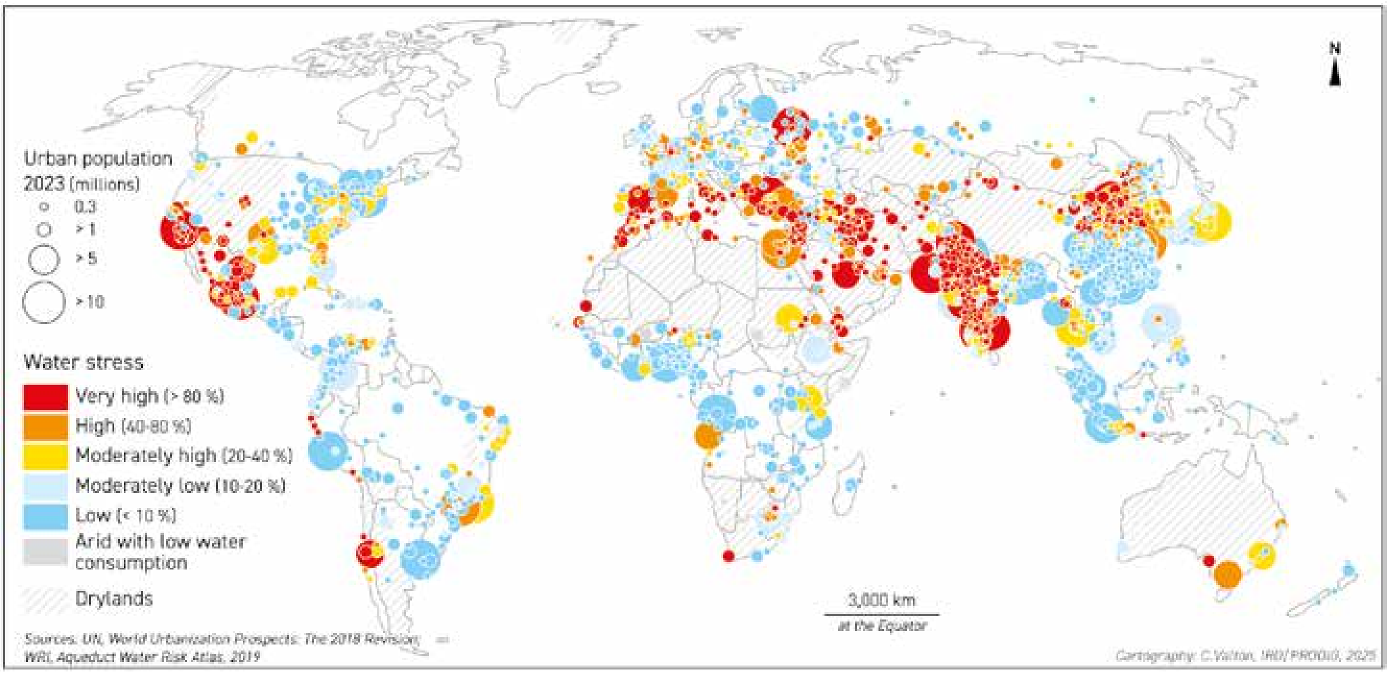
IMPACT OF URBAN RESOURCE CONSUMPTION ON SURROUNDING AREAS

Water and heat issues in cities

The water needs of large cities are steadily increasing due to population growth and changing consumption patterns. In 2016, 933 million city dwellers worldwide were living in areas where water is in short supply (He *et al.*, 2021). India, China and USA host the most urban populations affected by water shortages. The urban water supply issue is particularly acute in arid regions (see map below). Phoenix and Tucson (Arizona, USA), with populations of 1.7 million and 550,000, respectively, are experiencing structural water supply shortages in a region where aridity is gaining ground and domestic water consumption rates are among the highest in the US.

Individual consumption patterns highlight substantial inequalities between the poorest people living in the hottest neighbourhoods and the richest people living in green tree-covered neighbourhoods. In these so-called oasis cities, a host of private and public initiatives are underway to remedy water shortages for individual, agricultural and industrial use (e.g. water price increases, rainwater harvesting). However, initiatives geared towards adaptation to water shortages have their limits. The sustainability of arid cities where inequality prevails—even wealthy ones like Tucson, Phoenix and Abu Dhabi—is being challenged (Boyer *et al.*, 2022; Cohen *et al.*, 2021).

▲ Affluent neighbourhood, 6 of October City located in the Western Desert, west of Cairo, Egypt



▲ Large cities located in areas with water shortages

Only cities with over 10 million inhabitants (in 2016) are shown.
Sources: United Nations, 2018 ; WRI, Aqueduct Water Risk Atlas, 2019.
Cartography: Catherine Valton, 2025

▲ Periurban farming in Mexico
© IRD – P. Labazee

Increased urban food demand – what links with desertification?

Urban growth in dryland areas raises the question of how to increase agricultural production to feed a growing non-farmer population in regions under adverse climatic conditions.

Firstly, urban and periurban agriculture can help meet the urban food demand. In Sahelian drylands, for instance, this agriculture is multifunctional in that it contributes to satisfying food needs while generating family income, as well as safeguarding the environment in urban neighbourhoods (Ba and Moustier, 2010). In cities and periurban areas, it is threatened by urban sprawl, land artificialization and speculation. Moreover, this agriculture will only be sustainable if there is a sufficient water supply for crops. Yet this aspect is hard to assess as it is mainly dependent on individual initiatives tapping shared resources (wells, rivers) or the rerouting of water supply networks. In addition, market gardening plots located around cities are often cultivated with heavy pesticide and fertiliser inputs, hence raising questions as to their sustainability given the inevitable ensuing soil depletion.

Secondly, urban supply needs are fulfilled via more distant supply flows. Many supply chains serving urban markets have been structured around sources of production (cereals, beans, tubers, fruit and vegetables) located at various distances from the cities. The environmental impacts of this agricultural development are very hard to assess at different scales because the supply areas depend on the concerned products and cropping systems.
Urban and periurban livestock farming may also rely on supply flows from remote rural areas to meet the fodder demand (legume tops, cereal stalks, crop residues, straw, etc.). In Niamey, for example, straw sold in bundles via a network of 112 outlets throughout the city is harvested within a ~100 km radius around the city (Ousseini and Mamman, 2017). Few analyses have actually focused on the impact of these urban and periurban practices on soil degradation in the surrounding countryside. Policies are also lacking regarding the return flow of organic and mineral matter (compost, manure, septic tank waste, etc.) from cities to rural areas to help curb soil fertility erosion in rural areas that supply the cities.

Urban food systems, especially in dryland areas, also rely on import policies for supplies produced in other regions. In poor countries, urban communities are highly vulnerable to food insecurity and access to affordable food is a social stability factor. When food supplies have to be sourced from other regions, the fragility of these production systems surfaces during crises (Dury *et al.*, 2021), and the quality of the imported food may be dubious.

▶ Urban livestock farming, Dakar, Senegal
© IRD – M. Cavaleyra

Impact of fuelwood supplies to cities on tree resources – an example in the Sahel

"In the Sahel, fuelwood—both unprocessed and in charcoal form—is the main source of energy for rural and urban people, and the growing demand from large cities is placing increased pressure on nearby forest resources, potentially threatening their sustainability" (Gazull, 2009, p. i). This pressure may be exerted in the immediate vicinity of cities, but not solely. In Mali, Laurent Gazull highlighted that fuelwood source areas may be located far from Bamako, not only where wood resources are abundant, but above all where the logging network is centred around a dynamic sales market. Similarly, in Senegal, several fuelwood source areas have been identified to supply the small town of Bakel, including one located ~400 km to the south (Cisse, 2020). Irrespective of whether or not these supply areas are located far from the consumption sites, it is essential that people have access to and use alternative sources of energy given the growing pressure exerted by towns and cities on wood resources. However, the low living standards of the concerned communities hampers the transition to these alternative energies. There has been an increase in the use of gas, but the adoption of this fuel is still very limited due to the high equipment costs, fuel prices and regular supply disruptions. Solar ovens have proven to be very efficient but they have not been widely adopted as they are not compatible with local city dwellers' regular cooking habits.

▼ Lumber and fuelwood distribution in the Niger River Delta, Mali
© IRD – O. Barrière

In conclusion, urban sprawl is driven by the use of a range of building materials (e.g. wood, bricks, sand and cement) sourced from within the urban environment. As is the case regarding food and energy, the impacts are far-reaching, while the resulting damage—sometimes occurring in remote locations—is seldom associated with the desertification process. Urban policies must include a number of elements to be able to meet the prevailing urbanization and climate change challenges, including the urban models to be developed, management of urban sprawl, greening, urban planning, architecture, the use of materials that will withstand extreme (low or high) temperature conditions, greater emphasis on urban agriculture and outflow management.

▲ Charcoal burner, Madagascar
© IRD - HARDI – T. Vergoz

Desertification drives migration and settlement policies drive desertification

This section focuses on interactions between land degradation in drylands and human migration. Is desertification responsible for environmental migration from these areas, i.e. long-term relocation of people primarily due to environmental change (Véron and Golaz, 2015)? If so, how can this migration process be assessed? How also can settlement policies geared towards changing the population spatial distribution—often via involuntary (forced) relocation—impact the extent of land degradation in a given area?

▲ Migrants heading for Libya in the Ténéré Desert, Niger

DESERTIFICATION AS A SECONDARY MIGRATION FACTOR

Coauthor: Axelle Samba

Sudden environmental degradation, e.g. incurred by a natural disaster, can sometimes be a single isolated human migration catalyst. Forced migration may occur an environmental crisis, with those involved being referred to as environmental migrants. Yet land degradation is usually a slow process, and just one of many migration drivers (Gemenne and Dun, 2008; Van Der Geest, 2011). "As desertification may be a medium- to long-term phenomenon, it cannot be considered as a migration-triggering factor, but rather as a feature that may impact mobility systems depending on the local dynamics" (Boyer, 2017, p. 66). People often migrate as a result of a complex decision-making process involving diverse interdependent spatial scales and a combination of macro (environmental, social, political, demographic and economic), meso (intermediate obstacles and factors) and micro (individual characteristics) factors (see figure below).

Among the various multiscale factors that drive migration decisions, land degradation could be seen as a minor precipitating factor. Gradual environmental changes like desertification often tend to amplify the already adverse and unstable initial conditions, thereby indirectly having a 'multiplier effect' on migration processes (Piguet *et al.*, 2011). Desertification hence often plays an indirect rather than decisive role in the migration process (Samba, 2023). In some cases, the environment is not perceived as a major issue in discussions with actors, compared to political or economic aspects (see Focus opposite).

FOCUS Migration flows from Dlonguébougou village (Mali)

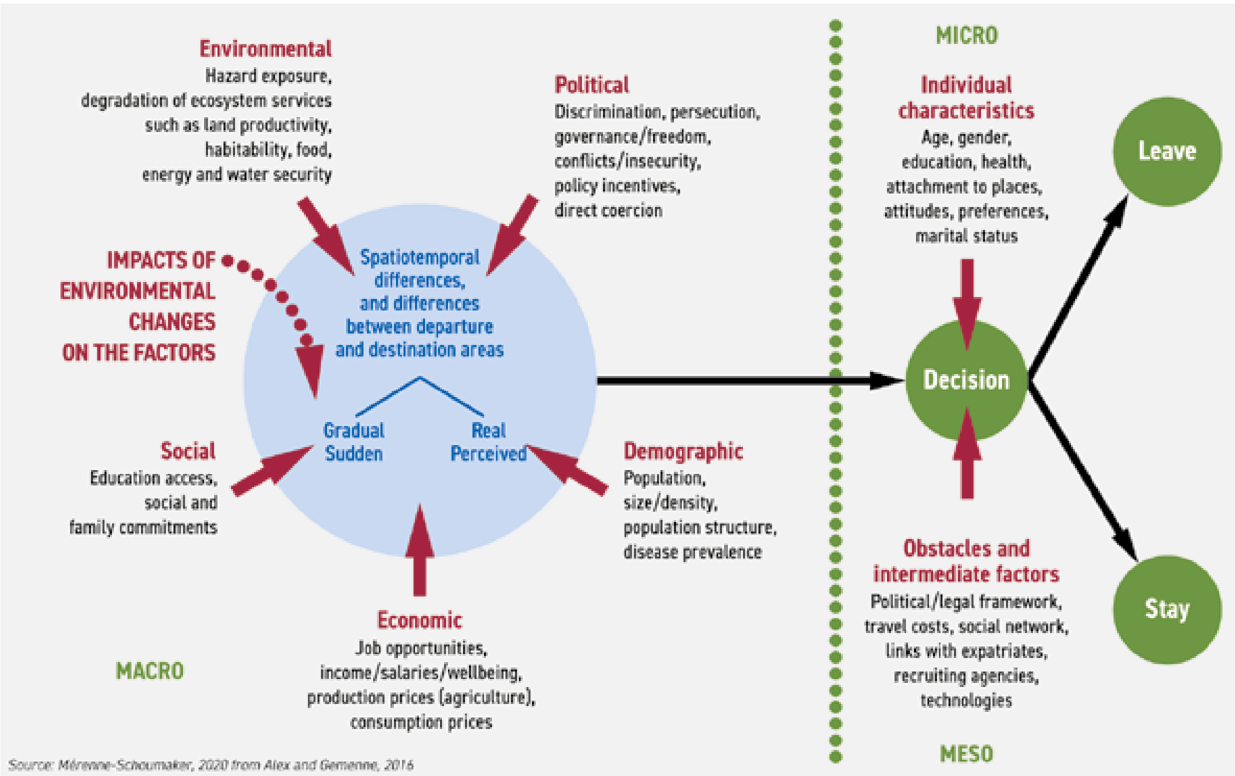
In her book *Land, Investment and Migration*, Camilla Toulmin chronicled life in the small Sahelian village of Dlonguébougou, central Mali, during three periods: 1980–1982, 1997–1998 and 2016. The author stressed the key role of migration in the village system: temporary and seasonal migration of youths to plantations and mines in Mali and Côte d'Ivoire, and longer-term migration to major Malian cities (Bamako, Ségou, Kayes) or Europe to work in odd jobs. Migrant remittances sent to villagers and their view of migration as a way to sidestep village social obligations were found to be the two main factors triggering departures. The environment did not seem to influence the relocation dynamics. However, the study only focused on residents who remained in the village (at least part of the time) but did not cover the major 1983-1984 drought period, which may have prompted large-scale migration, as has been documented in the Sahel. Poverty and sociopolitical factors were the main drivers of migration.

Source: Toulmin, 2024.

In addition, migration is not the sole response to land degradation. Both human and resource (e.g. livestock transhumance) mobility are typical responses to environmental change. Production system adaptation, such as income diversification or cropping system change, is another response. Yet there is not always a correlation between environmental degradation and high migration rates in a given area (see Focus on next page).

▼ Conceptual framework illustrating human migration factors at different scales

Source: Mérenne-Schoumaker, 2020, from Alex and Gemenne, 2016.
Production: Catherine Valton, 2025



FOCUS Life in Androy (Madagascar) during drought periods

The climate in the Androy region, southern Madagascar, is very arid. There have been 17 famines since the early 19th century. The 1989-1992 drought caused several thousands of deaths and led to many human migrations to the large commercial plantation regions in western and northern Madagascar, and to the city of Tulear (Canavesio, 2015). These migrations were a survival strategy geared towards finding ways to earn a living. Migrants relied on well-established migration networks while maintaining strong ties with their home regions. Some settled near their home communities, while others returned once the crisis subsided.

▼ Ilakaka, a pioneer sapphire mining town, Madagascar
© IRD – S. Tostain

▲ A sapphire miners' village south of Ilakaka, Madagascar
© IRD – S. Tostain

This migration phenomenon in the early 1990s was intense but limited in scope, which is in line with general climate-related migration trends. It was actually during the rainy seasons that major migration movements took place. Large-scale emigration occurred in 1999—described as an excellent year from a climate standpoint—with 5% of the population migrating to the Ilakaka-Sakaraha region where a sapphire deposit had just been discovered. Many factors contribute to migration in this arid region, including the climatic, economic and political conditions. Yet the region is not losing its inhabitants despite the relatively harsh living conditions. Instead, the population density has increased since 2020. The fertility rate (6 children/woman in 2018) is also higher than the national average.

OFTEN TEMPORARY SHORT-DISTANCE MIGRATION

Several authors have sought to analyse human migration patterns (duration, distance, destination) that could arise in the wake of desertification. Land degradation is a slow gradual process that tends to give rise to temporary short-distance (local) migration, whereas more sudden environmental changes, such as natural disasters (including droughts), may lead to more permanent long-distance relocation (see adjacent table).

Other authors have assessed migration destinations according to the land degradation timeframe and intensity: sudden intense degradation unexpected by the local population could trigger migration to urban slums or areas benefiting from national or international humanitarian aid, whereas gradual degradation may lead to migration to nearby rural areas (within-country or to a neighbouring country) (Suhrke, 1993). Yet there are marked differences in the extent to which drought and desertification impact migration trends, as observed in the semiarid northeastern region of Brazil (see Focus on next page).

Environmental processes		Migratory responses	
Temporal	Spatial	Temporal	Spatial
Gradual	Local	Temporary	Local
Sudden	National	Seasonal	Rural to rural
	Global	Annual	Rural to urban
		Permanent	Urban to rural
			International

▲ Environmental processes and migratory responses – temporal and spatial
Source: OIM, 2009 *in* Mérenne-Schoumaker, 2020.

FOCUS

Migration and desertification in semiarid Brazilian regions

Sylvain Souchaud

The Brazilian semiarid region offers a perfect opportunity to study the links between human population dynamics and desertification. Over the past 80 years, Brazil—a continental-sized Global South country—has undergone a simultaneous demographic and urban transition, accompanied by intense population redistribution and growing pressure on the environment. In this setting, the semiarid region, which is historically a source of emigration (Ojima and Fusco, 2014), has a positive population growth rate, is undergoing rapid urbanization, while also having a population density that is relatively high for a dry region (23 inhab./km²). It officially hosts 1,477 municipalities scattered over a 1,335,288 km² area according to the Brazilian Institute of Geography and Statistics (IBGE), with a population of 31,035,363 in 2022, with two-thirds of these people being urban dwellers (84% in Brazil). This region occupies a large portion of the Nordeste region and extends beyond it into the Minas Gerais, Maranhão and Espírito Santo states.

To assess environment-population interactions in semiarid regions, and especially the impact of desertification on migration (Black *et al.*, 2011; Thiede *et al.*, 2016), it is vital to distinguish between drought and desertification, which are related but do not have the same causes, do not produce similar damage, and have not been politically managed with the same degree of commitment.

Sertão—where devastating droughts frequently occur—is highly illustrative of conditions that prevail in semiarid environments (CGEE, 2016). Droughts are pivotal in weaving the social fabric of this semiarid region while also shaping the national mindset. These dry periods are occasional but may last several years and have sparked mass outmigration of starving rural populations. Droughts occurred repeatedly during the 20th century, leaving a lasting impression on communities and fuelling public fears of being overwhelmed by impoverished refugees. Yet most of these migrations were clearly just short- or medium-distance movements to nearby towns, or at most to the national capital, often located on the coast and thus beyond the arid zone. Authorities sometimes dealt with these situations through authoritarian measures geared towards stemming the outflow of people, but also via water infrastructure development programmes (Buriti and Barbosa, 2018) undertaken throughout the 20th century in the wake of the 1906 construction of the Açude do Cedro dam, which created the first artificial reservoir in Brazil (125 million m³ capacity). Many hillside reservoirs were built alongside these large-scale projects, especially from 1950 onwards. Finally, in recent years, assistance programmes have further reduced the scope of intervention by prioritizing domestic cisterns supplied by rainwater or tanker trucks. Nowadays, widespread drilling of deep boreholes has further softened the impact of droughts. For instance, since the severe 2012–2017 drought did not prompt mass migration, it went almost unnoticed compared to the major droughts of the 20th century, which were perhaps less severe from a climatic viewpoint but were much more catastrophic in human terms.

▲ Semiarid Nordeste Region, Brazil
© IRD – J. Servain

Desertification marks a gradual deterioration in the biological health and economic productivity of soils. This process may be aggravated by certain land-use practices, e.g. intensive crop farming, extensive and semiextensive sheep and goat farming in semiarid regions of Brazil, as well as urbanization. Fallow periods may be reduced when population densities rise, thereby increasing pressure on the environment, hence further worsening the situation, while climate change is accelerating this process. Migration is a coping strategy of populations in response to deteriorating livelihoods. As occurs during droughts, most people migrate to places within the country, heading towards the State capitals and metropolitan São Paulo. When desertification is defined as land degradation in drylands, taking the starting points of international human migration into account—as first pinpointed in the 2010 census—cannot reveal correlations between semiarid climatic conditions and emigration. Conversely, semiarid conditions do not seem to be a major factor in international emigration flows, with the exception of one municipality located in the southernmost part of the region, i.e. a medium-sized city with over 200,000 inhabitants that is the starting point of considerable emigration flows to the United States. The fact that the environmental damage associated with desertification is a gradual process tends to generate more complex migration scenarios. This is illustrated by the temporary/seasonal and cyclical migration flows that take place towards metropolitan employment areas, particularly in the southeastern region (mainly São Paulo).

It should nevertheless be stressed that here—as in many rural areas in the Global South—it is very hard to precisely determine the extent to which the natural environment dynamics contribute to people's decision to migrate. The latter is generally the result of a host of economic, social and generational factors that often culminate in a rejection of rural lifestyles and attraction to the presumed opportunities available in cities.

◀ *Açude* (artificial lake), Nordeste Region, Brazil
© IRD – C. Leduc

POPULATION RESETTLEMENT POLICIES AS DESERTIFICATION FACTORS

Settlement policies that aim to alter human population spatial distributions can lead to land degradation. In this respect, policies to combat desertification based on regulating or limiting residential and mobility choices can, paradoxically, promote land degradation. In Mongolia, for instance, the resettlement of populations around urban centres has contributed to excessive use of the surrounding lands. Migration policies, such as the resettlement of refugees in camps, can also contribute to the desertification process (see Focus pages 46-47).

The potential impacts of population settlement or migration/mobility regulation policies on land degradation should hence be taken into account before their implementation. Moreover, systems whereby populations adapt through mobility in response to high environmental variability in dryland areas, and whereby societies self-regulate in relation to available natural resources, sometimes prove more effective than measures imposed by authorities. The latter are often counterproductive when striving to enhance land management sustainability and combat desertification.

The examples provided in this section (Mali, Brazil, Mongolia, Madagascar) confirm that migration is a complex phenomenon in dryland areas.

Long-term desertification in an area, or occasional or repeated droughts over several years, do not always lead to mass human population displacement. People usually migrate over short distances and for temporary periods. Desertification is just one of several factors (economic, social, political) influencing mobility, and populations have many ways of coping with desertification. This section also focuses on the impact on land quality of planned population relocations, e.g. refugee camps in Kenya or the settlement of herders around towns in Mongolia. The effects of such population concentrations can have environmental and land degradation impacts. However, the extent and causes of this degradation may vary according to political and economic settings and population influx patterns (large numbers of people sometimes arriving in confined already environmentally/economically fragile areas); and the way these influxes are managed (in terms of housing, services and income access).

▲ Cross-border migration in Burkina Faso

© IRD – S. Bredeloup

▲ Loading a truck in Niger (returning from Libya) transporting migrants and goods
© IRD – J. Brachet

FOCUS

Unsuitable resettlement policies as a land degradation factor

Impacts of resettlement policies on land degradation – the case of Mongolian herders

Jeanne Riaudel

Mongolia, with a population of ~3.3 million, is one of the least densely populated countries in the world (2 inhab./km²). Around 69% of the Mongolian population lives in cities and 48% in Ulan Bator, the capital. Pastoralism is a pillar of the Mongolian economy and culture, i.e. roughly 30% of the working population is involved in nomadic herding.

Pastoralism gradually developed in Mongolia on the basis of the seasonal movements of nomadic herders, while also undergoing changes in response to major shifts in the political system. In the 20th century, this nomadic lifestyle was disrupted by transformations sparked by the socialist regime. Forced land collectivization reshaped conventional livestock farming structures. Previously independent herders were integrated into State cooperatives, thereby altering their herding movement strategies. Then the collapse of the socialist regime in the early 1990s led to rapid economic liberalization and the collapse of collective structures, leaving herders without any institutional support. Herd privatization prompted a surge in livestock numbers—increasing from 20 million to over 30 million head between 1990 and 2000—but also to more individualized grassland management. This increase accelerated land degradation, which scientists ascribe to overgrazing and a lack of appropriate regulation of livestock and herder movements (You *et al*., 2024).

Mongolia then gradually rolled out regulations to combat desertification, which has been worsening as a result of climate change. The Mongolian government's initial efforts were focused on regulating land access and promoting sustainable management practices. For instance, it introduced legislation governing grassland access and implemented reforestation programmes. Yet these measures not only restricted herder mobility, which is vital for effective herd management, particularly given the increased annual climate variability and extreme weather events (*zud,* i.e. heavy snowfall making grazing impossible, and summer droughts), but also resulted in increased population concentrations around cities.

A growing number of livestock herders were thus forced to migrate hundreds of kilometres from their region of origin seeking better grazing conditions or move closer to the capital to find employment after losing their herds (Xu *et al*., 2021).

This rural-to-urban migration trend worsened environmental issues in the outskirts of the cities. The yurt neighbourhoods in the Ulan Bator suburbs are known to be the city's main source of pollution since the heating system implemented to cope with the extreme winter temperature conditions mainly runs on coal. Moreover, there was an absence of sufficient support for self-managed pastoral farming practices as the overall livestock population was growing. The resettlement policies sought to protect the environment but actually forced herders to settle around cities, hence leading to overgrazing and land degradation in these areas, especially around Ulan Bator.

This Mongolian scenario illustrates an environmental situation that has been degraded by many factors due to the unsuitability of new pastoral farming practices and also to the more complex political, cultural, economic and climatic setting.

▲ An image from Daesung Lee's *Futuristic Archaeology* project

Source: www.daesunglee.com and @daesunglee.photo

Refugee camps and land degradation patterns in Kenya

▲ Refugees in Kenya
© IRD – C. Médard

Refugees are regularly accused of degrading resources in their host countries, particularly through deforestation and land degradation around the refugee camps due to their firewood consumption habits. Several scientific studies have nevertheless cast doubt on the opinion that refugees are an environmental threat (see Black, 2018). This opinion reflects a security-oriented stance aimed at limiting refugees' freedom, or a paternalistic stance geared towards 'educating' refugees on so-called good environmental management practices.

The fact that States opt to host refugees in camps can contribute to environmental degradation through the concentration of refugee populations and concomitant resource extraction in a confined area. In eastern Kenya, for example, the rings of degradation that appear around refugee camps are caused less by refugees collecting firewood than by the camp support team using available resources to meet needs associated with opening the camp and gradually turning it into a permanent structure (infrastructure, buildings, etc.) (Cambrézy, 2001). Otherwise, settling refugees in several different villages could help reduce the environmental burden that they pose.

▲ Food aid in a Kenyan refugee camp
© IRD – L. Cambrézy

▲ Refugee camp in Kenya
© IRD – L. Cambrézy

Conclusion – complex links recontextualized according to societies' cultural, economic and political orientations

▲ School transport, Dakar, Senegal
© IRD - Ifremer/Campagne AWA - O. Dugornay

This *Dossier* focuses on the links between human population dynamics (population growth, density, mobility, urbanization) and desertification (traits and dynamics). These links have been assessed from two angles, i.e. the impact of populations on desertification dynamics and that of desertification on the lifestyles of these populations. Here we should mention the methodological challenges encountered—as pointed out, the desertification concept is controversial and the spatial scale of population measurement differs from that of desertification measurement. It is vital to analyse the issues on spatial (local, continental, global) and temporal (short, medium, long term) scales. Access to water, land and jobs can only be understood if the continental or global scale is taken into account (e.g. agricultural commodity prices are dependent on global markets). Meanwhile, it is essential to closely monitor family dynamics, production methods, security conditions, resource access rules and power dynamics at local, national and regional levels to gain insight into links between demographic and environmental changes.

Through a host of examples pooled from several continents, this *Dossier* demonstrates that the root cause of desertification is not associated with population growth metrics or even population density, but rather with certain agricultural and non-agricultural production methods, resource use, unequal wealth distribution and misguided public policies. Yet under some conditions rapid increases in population density can have dire impacts on the natural environment and contribute to desertification. Note that population trends are just one of the many factors involved, but seldom the key one. Several of the examples we selected illustrate that deteriorated production conditions and livelihoods, as well as poorly managed urbanization, are features that boost pressure on natural resources, while increased population densities further accentuate these problems. This *Dossier* highlights that the relationship between population dynamics and desertification is not mechanical or systematic and that we need to consider society in all of its cultural, economic and political aspects to be able to grasp the links.

Living conditions are harsh in drylands and drought-prone areas, yet they are far from being depopulated. Some large cities are even thriving in such areas (e.g. Phoenix and Abu Dhabi), although their sustainability could be questioned, particularly during periods when they struggle to meet community water needs. Many practices are available to help communities adapt to the scarcity of water or arable land. Farmers in arid regions are generally experienced in soil maintenance (organic fertilization) and erosion control techniques. In both urban and rural areas, however, these adaptation strategies sometimes fall short when communities have to cope with extremely uncertain conditions and crises (climatic, political, economic) An analysis of lifestyles in these arid cities also revealed that there are marked inequalities between the wealthiest residents (who have access to water and air conditioning) and others, and certainly—although not documented in this *Dossier*—between genders, youths and seniors, indigenous and non-indigenous people, etc. We also stress that populations often decide to migrate when the overall conditions become too harsh, but usually only temporarily and to nearby areas. Some people may even return home if the conditions improve (if land degradation is reversible).

When assessing the relevance of the links between population dynamics and desertification, we reviewed the key ideas concerning natural resource degradation and societies' ability to deal with and remedy this issue. Our findings highlight the complexity of these links and the need to recontextualize the processes, to take a diverse range of examples into account, while avoiding oversimplification and hasty sweeping generalizations. This calls for public policy interventions tailored to given settings rather than off-the-shelf solutions that depend on preset thresholds beyond which degradation would be irreversible. Questioning these links enables us to deal directly with natural resource management issues when facing the challenges of increased demographic pressure and global warming in certain environments, particularly those where water-related issues are most acute.

For further information…

BIBLIOGRAPHY

Abel G.J., Sander N., 2014. Quantifying global international migration flows. *Science*, 343(6178): 1520-1522.

Alex B., Gemenne F., 2016. Impacts du changement climatique sur les flux migratoires à l'horizon 2030. *Observation des enjeux géopolitiques de la démographie*, n°1, May 2016, DGRIS, Futuribles, IRIS.

Alexandre F., 2017. Les conséquences de l'urbanisation sur la dégradation des terres en Afrique de l'Ouest sahélienne et soudanienne. *Revue Liaison Énergie-Francophonie*, 105: 75-78.

Amrani K., 2020. Les oasis sahariennes, rempart menacé contre la désertification. *The Conversation* (online), published online on 29 September 2020, queried on 15 December 2024. https://theconversation.com/les-oasis-sahariennes-rempart-menace-contre-la-desertification-145795.

Ba A., Moustier P., 2010. La perception de l'agriculture de proximité par les résidents de Dakar. *Revue d'Économie Régionale & Urbaine*, December (5): 913-936.

Bai Z.G., Dent D.L., Olsson L., Schaepman M.E., 2008. Proxy global assessment of land degradation? *Soil Use and Management*, 24(3): 223 234.

Baldassini P., Paruelo J.M., 2020. Deforestation and current management practices reduce soil organic carbon in the semi-arid Chaco, Argentina. *Agricultural Systems*, 178.

Bertoncin M., Pase A., 2012. *Autour du lac Tchad. Enjeux et conflits pour le contrôle de l'eau*. Paris, L'Harmattan, 354 p.

Black R., 2018. *Refugees, environment and development* (1st ed.). London, Routledge. 240 p.

Black R., Adger W.N., Arnell N.W., Dercon S., Geddes A., Thomas D., 2011. The effect of environmental change on human migration. *Global Environmental Change*, 21: 3-11. https://doi.org/https://doi.org/10.1016/j.gloenvcha.2011.10.001

Bonnet B., Loireau M., Travi Y., Soubelet H., 2024. "How do certain practices lead to desertification?" In: Bonnet B., Chotte J.-L., Hiernaux P., Ickowicz A., Loireau M. (Ed.), *Desertification and Climate Change: Are They Part of the Same Fight?* Versailles, Quae: 35.

Boserup E., 1965. *The Conditions of agricultural growth: the economics of agrarian change under population pressure*. London, Routledge. 124 p.

Boubakri S., 2015. "Tunisie". In: Simon G. (Ed.), *Dictionnaire des migrations internationales : approche géohistorique*. Paris, Armand Colin: 308-315.

Boyer A.-L., Le Lay Y.-F., Marty P., 2022. L'adaptation urbaine à la rareté de l'eau à Phoenix et à Tucson (Arizona): une approche de political ecology. *Cybergeo: European Journal of Geography* (online), published online on 13/01/22, queried on 05/03/25. https://journals.openedition.org/cybergeo/38002#quotation

Boyer F., 2017. Migration et désertification des terres : un lien non évident. *Liaison Énergie-Francophonie*, 105: 64-66.

Buriti, C.D.O., Barbosa H.A., 2018. *Um Século de Secas : Por Que as Políticas Hídricas Não Transformaram o Semiárido Brasileiro?* Chiado Books, 434 p.

Burrell A. L, Evans J.P, De Kauwe M.G., 2020. Anthropogenic climate change has driven over 5 million km² of drylands towards desertification. *Nature Communications*, 11(1): 3853.

Cai X., Zhang X., Wang D., 2011. Land availability for biofuel production. *Environmental Science & Technology*, 45(1): 334 339.

Cambrézy L., 2001. "Camps de réfugiés et environnement au Kenya : enjeux et contradictions", In: Cambrézy L., Lassailly-Jacob V. (Ed.), *Populations réfugiées : de l'exil au retour*. Paris, IRD: 211-232.

Campbell J.E., Lobell D.B., Genova R.C., Field C.B., 2008. The global potential of bioenergy on abandoned agriculture lands. *Environmental Science & Technology*, 42(15): 5791 5794.

Canavesio R., 2015. Les migrations dans le sud de Madagascar. Entre sécheresses occasionnelles et crise socio-économique structurelle. *Autrepart*, 2(74-75): 259-258.

Capozzi F., Di Palma A., De Paola F., Giugni M., Iavazzo P., Topa M.E., Adamo P., Giordano S., 2018. Assessing desertification in sub-Saharan peri-urban areas: case study applications in Burkina Faso and Senegal. *Journal of Geochemical Exploration*, 190: 281-291. https://doi.org/10.1016/j.gexplo.2018.03.012

Carpentier I., Gana A., 2013. "Les oasis de Tozeur et Chenini Gabès : diversité et durabilité des formes de valorisation à l'ère de la mondialisation et des crises du développement", In: Marshall A., Lavie E., Chaléard J.-L., Fort M., Lombard J. (Ed.). *Actes du Colloque Les oasis dans la mondialisation : ruptures et continuités*. https://hal-univ-paris13.archives-ouvertes.fr/hal-01024643/document

CGEE, 2016. *Desertificação, degradação da terra e secas no Brasil*. Centro de Gestão e Estudos Estratégicos. 252 p.

Chaouad R., Verzeroli M., 2018. Réalités et enjeux de l'urbanisation du monde. *Revue internationale et stratégique*, 112(4): 47-65. https://doi.org/10.3917/ris.112.0047

Chatel C., Moriconi-Ebrard F., 2018. Les 32 plus grandes agglomérations du monde : comment l'urbanisation repousse-t-elle ses limites ? *Confins* (online), 37, published online on 08/10/18, queried on 04/11/24. http://journals.openedition.org/confins/15522; https://doi.org/10.4000/confins.15522

Cherlet M., Hutchinson C., Reynolds J., Hill J., Sommer S., von Maltitz G. (Ed.), 2018. *World Atlas of Desertification*. Luxembourg, Publications Office of the European Union, 252 p.

Cisse I., 2020. *Le bassin d'approvisionnement en combustibles ligneux de Bakel (Sénégal) : la transcription spatiale d'une filière transfrontalière pour alimenter une petite ville*. Nanterre: Université de Nanterre, PhD thesis in Geography, 349 p.

Cohen M., Dubucs H., Clauzel C., Grésillon É., Kyriazis A., 2021. Verdir une ville désertique ? Entre politique urbaine, pratiques habitantes et matérialité écologique à Abu Dhabi (United Arab Emirates). *L'Espace géographique*, 50(34): 136-152.

Collectif, 1993. *Les terres Hardé. Caractérisation et réhabilitation dans le bassin du Lac Tchad*. Paris, CIRAD-Forêt, IRD (Cahiers Scientifiques 11, Mémoires et travaux de l'IRA 6). 122 p.

Cornet A., 2024. "Which regions and populations are affected by desertifiction?", In: Bonnet B., Chotte J.-L., Hiernaux P., Ickowicz A., Loireau M. (Ed.), *Desertification and Climate Change: Are They Part of the Same Fight?* Versailles, Éditions Quae: 13-16.

Curl A., Fitt H., Dionisio-McHugh R., Ahuriri-Driscoll A., Fletcher A., Slaughter H., 2018. *Autonomous vehicles and future urban environments. Exploring changing travel behaviours, built environments, and implications for wellbeing in an ageing society*. Christchurch: National Science Challenge 11, Building Better Homes, Towns and Cities, 43 p.

Derderi A., Daoudi A., Colin J.-P., 2022. Durabilité du foncier irrigué en zones steppiques d'Algérie, le risque de l'effondrement hydraulique. *Cah. Agric.*, 31: 18. https://doi.org/10.1051/cagri/2022015

Descroix J.L., 2021. *Sécheresse, désertification et reverdissement au Sahel* (online). www.unccd.int/sites/default/files/relevant-links/2021-05/S%C3%A9cheresse%2C%20d%C3%A9sertification%20et%20reverdissement%20au%20Sahel%20Final%20.pdf

Dolidon H., 2007. La multiplicité des échelles dans l'analyse d'un phénomène d'interface nature/société. L'exemple des feux de brousse en Afrique de l'Ouest. *Cybergeo: European Journal of Geography* (online), published online on 08/03/07, queried on 22/11/24. http://journals.openedition.org/cybergeo/4805 ; https://doi.org/10.4000/cybergeo.4805

Dresch J., 1982. *Géographie des régions arides*. Paris, PUF, 277 p.

Droy I., 2017, Dégradation des terres et pauvreté : des liens complexes. *Liaison Énergie Francophonie*, 105: 70-72.

Dubresson A., Raison J.P., Barthélémy A.-M., 1998. *L'Afrique subsaharienne : une géographie du changement*. Paris, Armand Colin, 248 p.

Dumont R., 1997. *Famines, le retour : désordre libéral et démographique non contrôlée*. Paris, Arléa, 62 p.

Durand-Dastès F., 2015. Les hautes densités démographiques de l'Inde. *Géoconfluences*. https://geoconfluences.ens-lyon.fr/informations-scientifiques/dossiers-regionaux/le-monde-indien-populations-et-espaces/articles-scientifiques/les-hautes-densites-demographiques-de-linde

Dury S., Alpha A., Zakhia-Rozis N., Giordano T., 2021. Les systèmes alimentaires aux défis de la crise de la Covid-19 en Afrique : enseignements et incertitudes. *Cahiers Agriculture,* 30: 12. https://doi.org/10.1051/cagri/2020052

Fan C., Myint S.W., Kaplan S., Middel A., Zheng B., Rahman A., Huang H., Brazel A.J., Blumberg D.G., 2017. Understanding the impact of urbanization on surface urban heat islands—A longitudinal analysis of the oasis effect in subtropical desert cities. *Remote Sensing*, 9(7): 672. https://doi.org/10.3390/rs9070672

Fouache E., Beuzen Waller T., 2022. Entre désert et oasis. Les fluctuations climatiques dans la péninsule arabique. *La Géographie,* 1586(3): 14-21.

Gazull L., 2009. *Le bassin d'approvisionnement en bois-énergie de Bamako. Une approche par un modèle d'interaction spa¬tiale*. Paris: université de Paris VII, PhD thesis in Geography, 402 p.

Gemenne F., Dun O. 2008. Defining environmental migration: why it is difficult, why it is controversial, why it matters and some practical processes which may help move forward. *Forced Migration Review*, 31: 10-11.

Géoconfluences, 2022. "Urbanisation", *Géoconfluences* (online), published online on 02/20, queried on 01/03/2025. https://geoconfluences.ens-lyon.fr/glossaire/urbanisation-1

Gharbi I., Elloumi M. 2023. L'agriculture irriguée en Tunisie : politiques hydrauliques et politiques de régulation foncière. *Cah. Agric.*, 32: 17. https://doi.org/10.1051/cagri/2023010

Gibbs H.K., Salmon J.M., 2015. Mapping the world's degraded lands. *Applied Geography*, 57: 12 21.

Giovanni F., 2013. *Essentiel méthodologique : l'analyse multi-échelles d'un espace urbain* (online), queried on 05/03/24. www.enseignementsup-recherche.gouv.fr/ressources-pedagogiques/notice/view/oai%253Awww.uoh.fr%253Asuplomfr-bed04adc-7ebb-4f1f-9ec6-1f291adc301b

Gonin P., Mary K., 2015. "Mali", In: Simon G. (Ed.), *Dictionnaire des migrations internationales : approche géohistorique*. Paris, Armand Colin: 454-457.

Guilhot L., Meunie A., Pouyanne G., 2018, La ville compacte : vers un dialogue entre Orient et Occident ? *Pollution atmosphérique* [online]: 237-238. Published online on 10/04/19, queried on 21/03/25. www.peren-revues.fr/pollutionatmospherique/6579

Guillermou Y., 1993. Survie et ordre social au Sahara - Les oasis du Touat-Gourara-Tidikeit en Algérie. *Cahiers des Sciences Humaines*, 29(1): 121-138.

Hallaire A., 1991. *Paysans montagnards du Nord-Cameroun. Les monts Mandara*. Marseille, IRD Éditions. 253 p.

He C., Liu Z., Wu J., Pan X., Fang Z., LI J., Bryan B. A., 2021. Future global urban water scarcity and potential solutions. *Nature Communications*, 12(1): 4667.

Hiernaux P., 1998. Effects of grazing on plant species composition and spatial distribution in rangelands of the Sahel. *Plant Ecology*, 138: 191-202.

Hiernaux P., Turner M.D., Eggen M., Marie J., Haywood M., 2021. Resilience of wetland vegetation to recurrent drought in the Inland Niger Delta of Mali from 1982 to 2014. *Wetlands Ecol. Manage*. https://doi.org/10.1007/s11273-021-09822-8

Hoffmann R., Abel G., Malpede M., Muttarak R., Percoco M., 2023. *Climate Change, Aridity, and Internal Migration: Evidence from Census Microdata for 72 Countries*. IIASA Working Paper. Luxembourg, WP-23-008.

International Organization for Migration, 2009. *Migration, Environment and Climate Change: Assessing the Evidence*. Geneva, IOM, 448 p.

IPBES, 2018. *The IPBES assessment report on land degradation and restoration*. Montanarella L., Scholes R., Brainich A. (Ed.). Bonn, Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. 744 p.

Klein Goldewijk K., Beusen A., Doelman J., Stehfest E., 2017. Anthropogenic land use estimates for the Holocene, HYDE 3.2. *Earth System Science Data,* 9: 927-953.

Lamprey H., 1975. *Report on the Desert Encroachment Reconnaissance in Northern Sudan*. Khartoum, National Council for Research/Ministry of Agriculture, Food and Natural Resources. 16 p.

Lesnoff M., Saley M., Adamou K., N'Djaffa H., 2006. *Enquête démographique 2006 sur le cheptel domestique au Niger : sites du Fakara, de Gabi et de Zermou*. Niamey, ICRISAT/Brussels, DGCD/Addis Ababa, ILRI.

Loireau M., Ickowicz A., 2024. Why should we foster complementarity between local, regional and local scales? In: Bonnet B., Chotte J.-L, Hiernaux P., Ickowicz A., Loireau M. *Desertification and Climate Change: Are They Part of the Same Fight?* Versailles, Quae: 80-83.

Loyer B., 2012. Les crises géopolitiques et leur cartographie. *Hérodote*, 146-147: 90-107.

Maertens M., De Lannoy G.J.M., Vincent F., Massart S., Giménez R., Houspanossian J., Gasparri I., Vanacker V., 2022. "Spatial patterns of soil salinity in the central Argentinean Dry Chaco", *Anthropocene*, 37: 100322.

Mérenne-Schoumaker B., 2020. Les migrations environnementales : un nouvel objet d'enseignement. *Géoconfluences* (online), published online on 10/07/20, queried on 03/03/25. https://geoconfluences.ens-lyon.fr/informations-scientifiques/dossiers-thematiques/changement-global/articles-scientifiques/migrations-environnementales

Mirzabaev A., Wu J., Evans J., García-Oliva F., Hussein I.A.G, Iqbal M.H., Kimutai J., Knowles T., Meza F., Nedjraoui D., Tena F., Türkes M., Vázquez R.J., Weltz M., 2019. "Desertification", In: Shukla P.R., *et al.* (Ed.), *Climate change and land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*. 874 p.

Monsutti A., 2015. "Afghanistan", In: Simon G. (Ed.), *Dictionnaire des migrations internationales : approche géohistorique*. Paris, Armand Colin: 666-672.

Morello J.H., Rodríguez A.F. (Ed.), 2009. *El Chaco sin bosques: la Pampa o el desierto del futuro*. Buenos Aires, Orientación Gráfica Editora, 432 p.

Mortimore M.J., Adams W.M., 2001. Farmer adaptation, change and ‘crisis’ in the Sahel. *Global Environmental Change*, 11: 49-57.

Mugelé R., 2023. Les “jardins” des élites citadines à N’Djamena (Tchad), entre accaparement foncier, investissement productif et loisirs périurbains. *Norois* [online], 267, published online on 01/01/23, queried on 19/12/24. http://journals.openedition.org/norois/13441; https://doi.org/10.4000/norois.13441

Newman P.W.G., Kenworthy J.R., 1996. The land use–transport connection: an overview. *Land Use Policy*, 13(1): 1-22.

Noin D., 1998. Population et environnement dans le monde aride. *Espace, populations, sociétés*, 16(1): 13-22.

Ojima R., Fusco W., 2014. *Migrações Nordestinas no Século 21. Um Panorama Recente*. Sao Paulo, Blucher, 195 p.

Oldeman L.R., Hakkeling R.T.A., Sombroek W.G., 1990. *World map on status of human-induced soil degradation. An explanatory note*. Wageningen, International Soil Reference and Information Centre, 26 p.

Ousman L.H., Seignobos C., Teyssier A., 2002. *Éléments d’une stratégie de développement rural pour le Grand Nord du Cameroun : III - Annexes*. Yaoundé: Ministry of Agriculture and Rural Development of Cameroon, 62 p.

Ousseini M C., Mamman M., 2017. Pratique et utilisation des sous-produits de légumineuses dans l’alimentation du bétail à la communauté urbaine de Niamey : cas de fanes et cosses de niébé (*Vigna unguiculata*). *Journal of Applied Biosciences*, 120: 12006-12017.

Piguet E., Pécoud A., De Guchteneire P., 2011. Changements climatiques et migrations : quels risques, quelles politiques ? *L’Information géographique*, 75: 86-109.

Pison G., Couppié E., Caporali A., 2022. Tous les pays du monde. *Population et sociétés*, 603, 4 p.

Raimond C., Bémadji B., Ndoutorlengar M., 2024. Dérèglement climatique et zones humides au sahel : une accélération des départs en migration ? *Hérodote*, 195: 201-222.

Rangé C., Cochet H., 2018. Multi-usage familial et agriculture de firme sur les rives du lac Tchad : une comparaison des performances économiques. *Natures Sciences Sociétés*, 26(1): 33-48. https://doi.org/10.1051/nss/2018021

Requier-Desjardins M., Bied-Charreton M., 2009. *Évaluation des coûts économiques et sociaux de la dégradation des terres et de la désertification en Afrique*. Paris/Saint Quentin-en-Yvelines AFD, Centre d’économie et d’éthique pour l’environnement et le développement. 163 p.

Requier-Desjardins M., Jauffret S., Ben Khatra N., 2009. “Lutter contre la désertification”, In: CIHEAM, Plans bleus annuels (Ed.), *MediTERRA. Repenser le développement rural en Méditerranée.* Paris, Presses de Sciences Po: 137-182.

RGAC, 2008. *Rapport de synthèse du recensement général de l’agriculture et du cheptel au Niger*. Niger, 187 p.

Ripple W.J., Wolf C., Newsome T.M., Galetti M., Alamgir M., Crist E., Mahmoud M.I., Laurance W.F., 15364 scientist signatories from 184 countries. 2017. World scientists’ warning to humanity: a second notice. *BioScience*, 67(12): 1026-1028.

Roose E., 1994. *Land husbandry – Components and Strategy*. Rome, FAO, 392 p. (FAO Soils Bulletins, 70). ISBN 92-5-203451-X.

Saad A., 2011. Les conseils de gestion des terres collectives en Tunisie entre mauvaise gouvernance et marginalisation. Cas de la région de Tataouine, In: Elloumi M., Jouve A.M., Napoléone Paoli J.C. (Ed.), *Régulation foncière et protection des terres agricoles en Méditerranée*. Montpellier, CIHEAM: 73-84.

Safriel U.N., 2010. “The assessment of global trends in land degradation”, In: Sivakumar M.V.K., Ndiang’ui N. (Ed.), *Climate and Land Degradation*. Berlin, Heidelberg, New York, Springer: 1-38.

Samba A., 2023. *Désertification et migration, un lien évident ?* L’apport scientifique sur la question. Toulouse: Université Toulouse Jean Jaurès, UMR LISST, CSFD, Master’s 1 dissertation 1, 92 p.

Stringer L.C., Mirzabaev A., Benjaminsen T.A., Harris R.M.B., Jafari M., Lissner T.K., Stevens N., Tirado-von der Pahlen C., 2021. Climate change impacts on water security in global drylands. *One Earth*, 4(6): 851-864.

Suhrke A. 1993. Pressure points: environmental degradation, migration and conflict. *Environmental Change and Acute Conflict Project, Occasional Paper Series, 3*. University of Toronto, University College, Science and Peace and Conflict Studies Program and American Academy of Arts and Sciences, International Security Studies Program. 41 p.

Taïbi A.N., 2015. *Désertification et dégradation. Ré-interrogation des concepts à la lumière d’exemples africains*. French Habilitation to supervise research (HDR), Angers, Université d’Angers. 170 p.

Thiede B., Gray C., Mueller V., 2016. Climate variability and inter-provincial migration in South America, 1970–2011. *Global Environmental Change*, 41: 228-240. https://doi.org/10.1016/j.gloenvcha.2016.10.005

Tiffen M., Mortimore M., Gichuki F., 1994. *More people, less erosion: environmental recovery in Kenya*. London, John Wiley & Sons, 311 p.

Tong X., Brandt M., Hiernaux P., Herrmann S., Vang Rasmussen L., Rasmussen K., Tian F., Tagesson T., Zhang W., Fensholt R., 2020. The forgotten land use class: mapping of fallow fields across the Sahel using Sentinel-2. *Remote Sens. Environ.*, 239: 111598. https://doi.org/10.1016/j.rse.2019.111598

Torres L., Abraham E.M., Rubio C., Barbero-Sierra C., Ruiz-Pérez M., 2015. Desertification research in Argentina. *Land Degradation & Development*, 26: 433-440.

Toulmin C., 2020. *Land, Investment and Migration. Thirty-five years of village life in Mali*. Oxford, Oxford University Press, 257 p.

United Nations, 1994. *United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa*. 14 October 1994. 56 p.

United Nations, 2018. *World Urbanization Prospects*. The 2018 Revision. New York, United Nations, Department of Economic and Social Affairs. Population Division. 103 p.

United Nations, 2024. *World Population Prospects 2024*. United Nations, Department of Economic and Social Affairs, Population Division. http://population.un.org/wpp.

Van der Esch S., Ten Brink B., Stehfest E., Bakkenes M., Sewell A., Bouwman A., Meijer J., Westhoek H., van den Berg M., 2017. *Exploring future changes in land use and land condition and the impacts on food, water, climate change and biodiversity: Scenarios for the UNCCD Global Land Outlook*. The Hague: PBL Netherlands Environmental Assessment Agency. www.pbl.nl/sites/default/files/cms/publicaties/pbl-2017-exploring-future-changes-in-land-use-and-land-condition-2076.pdf

Van Der Geest K., 2011. North-South migration in Ghana: what role for the environment? *International Migration*, 49(S1): e69-e94.

Véron J., 2013. *Démographie et écologie.* Paris, La Découverte, 128 p.

Véron J., Golaz V., 2015. Les migrations environnementales sont-elles mesurables ? *Population & Sociétés*, 522, May 2015, French Institute for Demographic Studies (INED), 4 p.

Véron J., Nanda A.K., 2011. Recensement de l’Inde de 2011 : 181 millions d’habitants de plus en dix ans. *Population et Sociétés*, 478, 4 p.

Verón S.R. Blanco L.J., Texeira M.A., Irisarri J.G.N., Paruelo J.M., 2018, Desertification and ecosystem services supply: the case of the Arid Chaco of South America. *Journal of Arid Environments*, 159: 66-74.

Withol de Wenden C., 2021. Réchauffement climatique et migrations. *Géostrategia* (online), Centre d'études stratégiques de la Marine, published online on 12/05/21, queried on 04/03/25. www.geostrategia.fr/rechauffement-climatique-migrations

WRI, Aqueduct Water Risk Atlas, 2019. www.wri.org/data/aqueduct-global-maps-30-data

Xu Y., Yaoqi Z., Jiquan C., 2021. Migration under economic transition and changing climate in Mongolia. *Journal of Arid Environments*, 185: 104333. https://doi.org/10.1016/j.jaridenv.2020.104333

Yakoubou Alzouma Y., Hiernaux P., Mahamane L., Kaire M., Garba I., Adamou Kalilou A., Bode S., Abdou Moussa M.M., Abdou Bawa H., 2025. Comment prendre en compte les mobilités saisonnières du bétail dans l'estimation de la charge animale d'un territoire sud-sahélien ?, *Rev. Elev. Med. Vet. Pays Trop.*, 77: 37386. https://doi.org/10.19182/remvt.37386

You Y., Z. Na, Wang Y., 2024. Policies and regulations for desertification prevention and control in Mongolia. *Land,* 13(4): 559. https://doi.org/10.3390/land13040559

WEBSITES
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Cartoprodig, France
www.cartoprodig.cnrs.fr/en/homepage

Centre for Advanced Migration Studies (AMIS), University of Copenhagen, Denmark
https://migration.ku.dk

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www.fao.org/migration/

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https://gret.org/en

Institut Convergences Migrations, France
www.icmigrations.cnrs.fr/en/about-us

Interdisciplinary Solidarity, Societies, Territories Laboratory (LISST), France
https://lisst.univ-tlse2.fr/home

Internal Displacement Monitoring Centre (IDMC), Switzerland
www.internal-displacement.org

International Organization for Migration (IOM), Switzerland
https://environmentalmigration.iom.int

Laboratoire médiations, France
https://laboratoire-mediations.sorbonne-universite.fr

Migration Data Portal, Switzerland
www.migrationdataportal.org/

Migration and Society Research Unit (URMIS), France
www.urmis.fr/en/home_en

Population Environment Development Laboratory (LPED), France
https://lped.fr/?PagePrincipale&lang=en

Space Observation, Models & Actionable Science (ESPACE-DEV), France
www.espace-dev.fr/en/home

Research Pole for the Organisation and Dissemination of Geographic Information (PRODIG), France
www.prodig.cnrs.fr

United Nations High Commissioner for Refugees (UN-HCR), (Operational Data Portal), Switzerland
https://data.unhcr.org

United Nations Population Fund (FNFPA), USA
www.unfpa.org/data

World Bank, USA
www.worldbank.org/en/topic

Glossary

Corporate farming. This form of agriculture involves large-scale farms spanning vast tracts of land, while being organized in myriad entities hosting different production units. It differs from family farming in its business-oriented nature, integration capacity, production concentration, capital-labour substitution, multi-specialization and standardization, in addition to its control over value chains and related services.

Coastline. A line considered to form the boundary between land and sea as defined by the highest sea level reached during calm weather. It varies due to erosion, sediment accumulation and human activities involving large-scale development projects.

Migrant remittances. Money transfers that migrants send to their relatives who have remained in their home country.

Remote sensing. This term encompasses all systematic and automated operations involving processing and interpretation of aerial photographs and satellite images. Digital technology is used to transform captured images into georeferenced data, including data layers that may structure information systems.

Settlement front. A spatial zone marking the limits of human settlement and separating developed from undeveloped territory. This typically temporary and shifting frontier advances as humans expand their activities (e.g. deforestation).

Spatial multifunctionality. Multifunctionality refers to a space in which different ecological and production functions overlap or occur in succession over time.

Acronyms and Abbreviations

CNRS	French National Centre for Scientific Research
CSFD	French Scientific Committee on Desertification
FAO	Food and Agriculture Organization of the United Nations, Italy
Frontex	European Border and Coast Guard Agency, Poland
GGW	Great Green Wall
IBGE	Brazilian Institute of Geography and Statistics
INED	French Institute for Demographic Studies
IRD	French National Research Institute for Sustainable Development
LISST	Interdisciplinary Solidarity, Societies, Territories Laboratory, France
LPED	Population Environment Development Laboratory, France
OPSE	Population, Health and Environment Observatory, Senegal
PRODIG	Research Pole for the Organisation and Dissemination of Geographic Information, France

▲ Onset of the rainy season. Kindi, Burkina Faso.
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Abstract

In dryland areas, can population growth, urbanization and migration be the cause or outcome of land degradation? With the linkages between climate, biodiversity and land currently tabled on the international agenda, this *Dossier* showcases the interplay between population growth, urbanization and migration dynamics and evolving desertification patterns. The authors and contributors argue that desertification and population dynamics are usually independent processes. Linkages between these processes—when they exist—are generally indirect and vary depending on the concerned regions, production systems and community lifestyles.

This *Dossier* focuses on population trends (growth or decline), changes in population spatial distribution (settlement patterns), particularly through urban concentration and migration (primary domestic and international residence shifts of populations). The definitions used and methodological precautions needed to characterize these processes at different spatiotemporal scales are reviewed. Linkages between population dynamics and desertification are assessed from two angles: the impact of populations on desertification dynamics, and of desertification on community lifestyles. The authors provide many examples on different continents to illustrate that the core desertification issue is not related to population growth metrics or even population density, but rather to certain agricultural and non-agricultural production methods, resource use, unequal wealth distribution, and unsuitable public policies. The population must therefore be viewed as just one among many factors, as the interplay between population dynamics and desertification is not mechanical or systematic. The target society as a whole—including all of its cultural, economic and political complexities—must be examined to get a clear picture of the interrelationships involved.

Keywords: population, desertification, population growth, urbanization, migration, dryland

Résumé

En zone sèche, la croissance démographique, l'urbanisation ou les migrations peuvent-elles être la cause ou la conséquence de la dégradation des terres ? Alors que les liens entre climat, biodiversité et terres sont mis à l'agenda international, ce dossier discute le lien entre, d'une part, les dynamiques de croissance démographique, d'urbanisation et de migration et, d'autre part, l'évolution de la désertification. Les auteurs et contributeurs montrent que la désertification et les dynamiques démographiques sont, le plus souvent, des processus indépendants. Les liens entre ces processus, quand ils existent, sont la plupart du temps indirects et varient selon les territoires, les systèmes de production et les modes de vie des sociétés.

Ce dossier s'intéresse à l'évolution des effectifs des populations (croissance ou déclin démographique), à la transformation de la répartition spatiale de la population (peuplement), à travers notamment la concentration urbaine, et aux migrations (changements de résidence principale des populations au sein d'un même pays ou à l'international). Il revient sur les définitions et les précautions méthodologiques pour caractériser les processus aux différentes échelles temporelles et spatiales. Les liens entre dynamiques démographiques et désertification sont examinés dans deux directions : l'impact de la population sur les dynamiques de la désertification d'une part, l'impact de la désertification sur les modes de vie des populations d'autre part. À travers de nombreux exemples, sur différents continents, le dossier montre que le cœur du problème de la désertification n'est pas lié aux métriques de la croissance de la population, ni même à sa densité, mais plutôt à certains modes de production agricole et non agricole, d'exploitation des ressources, à la répartition inégalitaire des richesses, ou à des politiques publiques inappropriées. Il convient ainsi de replacer la population comme un facteur parmi d'autres, le lien entre dynamiques démographiques et désertification n'étant ni mécanique ni systématique, et imposant, pour le comprendre, d'examiner l'ensemble d'une société dans ses dimensions culturelle, économique et politique.

Mots clés : population, désertification, croissance démographique, urbanisation, migration, zone sèche

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▲ **Cover photo: The city of Iquique located in a mining region in northern Chili**
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