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Coming back to a Commons approach to construct the Great Green Wall in Senegal

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Abstract

Since the 1970s, the Sahel region has been struck by severe droughts that has brought suffering to human populations. Scientists also observed declining rainfall leading to desertification in the zone. Against this backdrop, in 2007, several African states launched the international Great Green Wall (GGW) project that aimed to create a strip of forest from Senegal to Djibouti, crossing areas mostly devoted to pastoralism. We examined the social, land tenure and environmental implications of the GGW in Senegal, in the light of policies for pastoral intensification of the zone. The colonial heritage of the foresters from the Senegalese National Green Wall Agency who implement the project on the ground influences how reforestation is managed today. To understand how local populations relate to the space affected by the project and their resources, we organized participatory workshops in four contrasted study sites along the Senegalese portion of the GGW path. Our results show that trees are of great importance for lo-

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cal populations, whether agricultural or pastoral, but even more so in pastoral areas. Despite this, the national and international narrative considers Sahelian pastoralism and overgrazing as strong drivers of desertification. The paradox is that overgrazing is linked to the public policy of boreholes densification. Taking a Commons approach, we show the current and past role played by water in pasture management, and how water accessed by boreholes no longer regulates grazing practices. A Commons approach would pave the way for assisting stakeholders at different levels to favour greening the Sahel.

Keywords: Sahel, Great Green Wall, Commons, water management, water, forestry, pastoralism

2021 MSC: 04-02

1. Introduction

The concept of "desertification" emerged in the international community in the 1970s, but it was shaped 25 years prior to that. Elie (2015) traced the concept back to the early 1950s in the works of colonial agronomists and tropicalists. 5 Aubréville (1949) proposed this concept in association with savannisation to describe plant successions resulting from bush fires and the felling of vegetation by man, which were already devastating the tropical forests at that time in French colonial Africa.

Later, in 1968 and 1972, major droughts caused unprecedented famines in 10 the Sahelian zone. The United Nations Assembly decided to "combat desertification" and launched a series of conferences (1977) which resulted in the gain of popularity of the concept¹. The UNCCD currently defined desertification as: "land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities, that is 15 encompassing both biophysical and social factors" UNCCD (1994).

¹UN General Assembly resolution 3337 (XXIX), 17 December 1974, 'International co-operation to combat desertification

Up until the end of the 1980s, the GIMMS model showed a downward trend in plant cover at global scale². The desertification process was directly linked to a reduction in rainfall available to plants, due to a southward shift in isohyets. These observations tallied with the results of foresight models, pointing to a global desertification trend (Le Hou  rou, 1996).
20

More recently, the spatial shift of the concept of "desertification" from tropical forest areas to sub-Saharan and Sahelian areas has reinforced the false idea of desertification as an extension of the desert. In this interpretation, the problem in the Sahel is equated with that of the Sahara desert extending southward. This vision conveys two false ideas: *i*) it focuses attention more on the formation of dunes, and less on issue of declining soil fertility, and *ii*) the image of advancing deserts promotes the idea that giant "green belts and walls" could "stop the desert".
25

Nevertheless, desertification is clearly a serious issue worldwide. Reynolds et al. (2007) note that 41% of the world's arable land is threatened by desertification and it poses a threat to 6.5 billion people. On the African continent Reich et al. (2001) estimate that approximately 46% of the land is undergoing desertification, affecting roughly 485 million people. Face with increasing desertification over the past decades and supported by the international community, eleven African states joined forces and in 2002, on World Desertification Day held in N'Djamena (Chad), they defined the common objective of establishing a Great Green Wall (GGW) in zones with less than 400 mm of rainfall per year. The project would involve "restoring" and planting a 7,675 km long forest strip from the coast of Senegal in the West to Djibouti in the East. The multinational project was officially launched in 2007 and the Pan-African Agency of the Great Green Wall (PAAGGW) was set up in 2010 to coordinate operations in the 11 participating countries (Dia and Duponnois, 2013). Seen from the Western world, the ambitions of the GGW are commendable and have provided increased visibility for the Sahelian zone (several articles on the topic
30
35
40

²GIMMS: Global Inventory Modeling and Mapping Studies, version 3 by Guay et al. (2015).

45 were published in the French newspaper Le Monde, broadcast on France 24³
television channel, on the BBC⁴, etc.). This has undeniably created a window
of opportunity for development actions (Goffner et al., 2019).

Herein, by specifically examining the GGW in Senegal in four contrasting
sites, we show that the relationship between local populations and trees does
50 not match with the narrative conveyed by national or international communities.
By mobilizing a Commons approach (Committee, 2017), we are able to revisit
the dynamics and socio-spatial issues of the area and see it as a confrontation
between two contrasting perspectives: the first held by the former colonial State
and in the continuity, the current modern State (through its forestry corps) and
55 the second by local pastoral populations.

Finally, we propose an alternative to the ongoing top-down reforestation
process, one in which authorities work more closely with local populations us-
ing community-based approaches. The community-based management idea was
developed in the 1970s, but became more mainstream in 1992 at the Rio Earth
60 Summit when the Commission on Sustainable Development recognized the role
that local populations could play in resource management (Maraseni et al.,
2019). Herein we use a Community-based approaches one that is aligned with
the French Land Tenure and Development Technical Committee.⁵.

³Le Monde: 25 September 2012, 15 April 2016; reports on France 24 in August 2018, March
2019, etc.

⁴BBC: 26 September 2017, 20 October 2019.

⁵The French Technical Committee "Land Tenure and Development" (*Comité technique
Foncier et Développement*) is a group created in 1996 for debate and exchange on rural and
urban land issues in Southern countries (Africa, Asia and Latin America), on the initiative
of French Cooperation. It is co-chaired by the French Ministry of Europe and Foreign Affairs
(MEAE) and the French Development Agency (AFD) [http://www.foncier-developpement.
fr/](http://www.foncier-developpement.fr/) consulted in Feb. 2021.

2. Background: the historical roots of the Great Green Wall governance in Senegal

In this section, we emphasize how the colonial legacy of the forest corps has created a paradoxical situation between its interventions that are aimed at reducing poverty and conserving biodiversity, while at the same time, often neglecting the real needs of local populations (Benjaminsen et al., 2008)

2.1. The Senegalese National GGW Agency: A Colonial legacy

Most current GGW staff are graduates of National Water and Forestry engineering schools. They carry a strong identity of their institution, which dates back to 1932. At that time, the colonial Water and Forestry service essentially replicated the Water and Forestry Corps of mainland France (Foury, 1953). Its original, overarching mission was to preserve forest areas, and more generally natural resources, with a vision of generating income⁶. Like in mainland France, the Water and Forestry officers in Senegal also played a policing role in matters concerning natural resource management.

The Senegalese foresters have, however seen changes in their functions and prerogatives since Independence (1960). International aid donors encourage them to operate in "project mode", similar to that in development administrations. Indeed, projects provide attractive posts for those in charge of their implementation (remuneration, job security, means and ease of travel, etc.). Blundo and Sardan (2001) underlined the attractiveness for forestry officers' positions as "posts with a high density of transactions, posts where there is direct contact with users, field posts rather than administrative posts".

In parallel with changes in the functions of the Water and Forestry service, the decentralization policies introduced in Senegal with the *Domaine National*

⁶Forests have been widely used for lumber, building timber, and firewood since the beginning of the 20th century (Bernard, 1993)

law (1964)⁷ led to natural resource management being entrusted to the mu-
90 nicipalities. At the same time, laws of decentralization and land policy reform
have also affected local actors' accountability for natural resources. These in-
stitutional reforms all proceeded in the same direction, i.e., they attempt to
increase the engagement of local actors in resource management policies. This
led foresters to rethink their functions and operate less like a police authority
95 and more like leaders and facilitators for rural communities (Blundo, 2014).

The Senegalese ANGGW clearly resonates with this more modern project
logic. The Senegalese government was proactive in launching its GGW National
Agency (ANGGW) as early as December 2008, to implement the project on its
own soil⁸. Today, Senegal is one of the most advanced countries in terms of
100 actions taken.

The agency is under the authority of the Senegalese Environment and Sus-
tainable Development Ministry. Beyond an annual financial contribution from
the Senegalese government, it mainly depends on funding from the Global Envi-
ronment Fund (GEF) through the Pan-African Agency of the Great Green Wall
105 PAAGGW, the World Bank through the PDIDAS project (Senegal Sustainable
and Inclusive Agribusiness Project, 2014-2020), the IUCN (International Union
for Conservation of Nature) and from FAO (Pape Sarr, 2017, former ANGGW
technical director, personal communication). The prerogatives of the ANGGW
staff differ from those of the Water and Forestry foresters as their challenge is to
110 fulfil the international reforestation commitments pledged by the State to the
PAAGGW.

The way reforestation takes place has also changed since the initial ideas
launched in 2002 in N'Djamena. Today, there is no longer talk of continuous

⁷The Senegalese *Domaine National* law, enacted in 1964, placed all non-registered lands in
the national domain: the management and attribution of lands was entrusted to the munic-
ipalities, thus making it possible to maintain existing customary land management at village
level.

⁸ANGGW was founded by Decree 2008-1521 dated 31/12/2008 (Serigne Mbodji
(DPS/ANGGW), Presentation of GMV-Senegal, October 2012, 47 p).

reforestation. As a result of local conflicts, cost of implementation, and expert
115 opinions expressed that a wall-of-trees configuration was neither doable or de-
sirable, the GGW has evolved into a network of plots, reforested and/or under
deferred grazing with a system of enclosures. The plots form a mosaic along
the GGW path, along with other activities under the GGW umbrella, such as
communal women-run fruit and vegetable gardens, that provide diversification
120 of local livelihoods (Goffner et al., 2019).

That said, reforestation is still a main GGW action. The reforestation pro-
cess consists first in identifying, at the national level, the zones to be reforested,
then seeking local consensus with the municipal authorities to delineate the
plots to be placed under deferred grazing. This consensus must satisfy both
125 the foresters, by identifying the target of 5,000 ha per year to be enclosed and
reforested, and local stakeholders by choosing where plots are to be located (see
sec. 5.1).

The position of the ANGGW in this negotiation process is ambiguous, fluc-
tuating between mistrust of local communities with regards to their awareness
130 of environmental issues (Blundo, 2014, §44) and the obligation to involve them
under the National Domain law (*Loi du Domaine National*). In the field, this
leads to more or less perceptible tensions between ANGGW staff and local com-
munities. Be that as it may, local stakeholder uphold intimately entwined rela-
tionships with nature, including trees. It is therefore essential to understand the
135 local communities' perception of their space and the natural resources located
within it.

2.2. Reforestation, territorialities and identity along the GGW

The reforestation process is leading to the creation of new territorialities
and control over resources by foresters. In Mali Gautier and Hautdidier (2012)
140 stated that when it comes to forest protection: "the objectives of controlling
people and resources through the creation of State territories interact with pre-
existing territorialities to produce new territoriality" (p.252). With these spaces
come new subjectivity associated with their supporters/promotors (Dreyfus and

Rabinow, 1982; Heyes, 2012). These new subjectivities are, for example, held by
145 water and forestry agents who are, they themselves, shaped by their institutions.
Their subjectivities are in tension with the subjectivities of the users of the
territories in which they are asked to intervene.

The international desertification narrative is based on the fact that there
is increasingly limited natural resources in the face of growing human demand
150 (Benjaminsen, 2012). The ANGGW aligns with this narrative and results in
a mutually-reinforced high-level interplay between the State and the interna-
tional development community operating in the zone. This results in massive
reforestation without taking into account the context and complexity of the
social-ecological system diversity along the GGW path.

155 This high-level loop excludes local populations, i.e. the direct beneficiaries
of GGW actions. When faced with reforestation schemes that alter their land
use rights, the latter express themselves with great fervor, occasionally leading
to conflict at the local level. This is even more true for transhumant pastoralists
with mobile lifestyles; they are completely sidelined from negotiations and re-
160 forested plots are major obstacles to their mobility. Indeed, extensive livestock
herding – with herds combining cattle, sheep and goats – is the primary land
use (Ancey et al., 2008). Large areas of land are needed to satisfy daily feed
requirements (Ellis and Swift, 1988): consequently, establishing vast reforested
and deferred grazing areas⁹ hinders the freedom of movement of the herds and
165 creates local mistrust towards massive reforestation projects such as the GGW.

In this paper, we illustrate the close links between reforestation practices
associated with the GGW and national identity-building, and more specifically
the roles played by foresters in these territories, ranging from that of environ-
mental policemen and scouts, to representatives of the State in its outer reaches.
170 However, it is important to point out a recent shift in the State foresters' roles
towards those of development agents acting in closer collaboration with local

⁹The size of a deferred grazing plot reforested by the National Agency of the Great Green
Wall in Senegal varies between 100 ha and 1,000 ha. Source : M. Mauclaire, 2017.

populations, but today, these State foresters are still in the minority.

Since the 1964 land reform, although land ownership rights in Senegal still belong to the State, land management has been delegated to the municipalities. This implies that decisions in relation to land rights issues are shared among
175 State authorities, municipalities and traditional authorities. These include the right to use and to delegate use (under traditional jurisdiction) and the right to ownership (inherited from French law currently under municipal jurisdiction) (Colin, 2008).

180 Despite decentralization policies, The State maintains a strong hold in these areas based on the following assumptions: *i)* local populations do not perceive the importance of the resources they use, *ii)* consequently they are incapable of managing the corresponding land, *iii)* the State must, therefore, act as a guarantor and judge of the rational use of natural resources. Withdrawing part
185 of the Commons for reforestation purposes can be considered as a paternalistic emergence of the State subjectivities (Heyes, 2012).

By employing large scale subtractive strategies, meaning the withdrawal of land use rights from local users¹⁰, in areas that are usually managed by the municipalities. By withdrawing areas from traditional collective management
190 by installing fences and gates, the State imposes new rules of land use, and distorts and delegitimizes the existing system of social relations.

3. Materials and methods

3.1. Selection of four contrasted study sites

In 2016, an interdisciplinary research team carried out an exploratory field
195 mission along the entire 545-km long path of the GGW in Senegal. The aim was to observe and document, firsthand, the diversity and complexity of social-ecological systems along the GGW path. Different landscape units along the

¹⁰For example, gathering fruit from trees does not interfere with grazing, while the installation of cultivated plots, protected by a fence, prohibits grazing.

path were identified and photographed (9 photos of landscape units are provided in appendix Appendix A). Our on-site observations, combined with GIS data
200 obtained from the National Agency for Land Use Planning¹¹, the Ecological Monitoring Center¹², and the IUCN¹³, were used to select the four contrasted study sites described herein.

3.2. *Microgeography of lived space*

Two workshops were organized with local stakeholders at each site, one in
205 the center of the village and the other on the outskirts. Workshop participants were asked to *i*) describe their lived space (Frémont, 1976) in the form of a mental map, *ii*) identify and quantify their uses associated with trees (Fig.1), and *iii*), determine the relative importance of the different landscape units with the various uses. Data collection and the specific methodologies used during the
210 workshops are described in appendix Appendix B.

The participatory mapping exercise was used to describe the territoriality of the stakeholders at the four study sites. The justification for this exercise is based on the work of Di Méo (2008) for whom the daily territory "brings together [...] the places of our experience" (p.4). On the one hand, Di Méo formalizes the links between the understanding that each individual has of his/her
215 environment and the network of relationships that comprises it, with the reality of this network of inter-relationships strongly anchored in space. On the other hand, the individual perception of the environment also has a collective reality (shared by the members of a community). According to this author, the fact
220 that some of these perceptions are shared produces a sense of spatial and social stability. In other words, stability is the result of a form of social control by tradition. During the workshops, the collective explanation of the 'lived' space

¹¹In French, "l'Agence nationale pour l'aménagement du territoire" : <http://www.anat.sn/>, consulted in March 2021

¹²In French "Centre de suivi écologique" : <https://www.cse.sn/> consulted in March 2021

¹³International Union for Conservation of Nature, <https://www.iucn.org/>, consulted in March 2021



Figure 1: Photograph of a workshop carried out in Widou (October 2017). The facilitator (A. Ka) finished drawing the landscape elements on the mental map (bottom right of the picture). He is now setting up the landscape unit quantification process. He is holding containers in which a certain number of marbles will be placed, reflecting the participants' quantification of the importance of each landscape use for tree uses. Workshop participants are sitting around him, discussing and negotiating the results throughout the process.

thus enabled us to access this collective frame of reference in terms of delimited spaces (Appendix Appendix B, stage S3 of the workshops). The quantification
225 of trees and landscape unit uses (Appendix Appendix B, stages S4 and S5 of the workshops) enabled us to understand the importance of the territorialized resource.

The conceptions of the interdependence network of stakeholders explained by Di Méo (2008) are compatible with the definition of land tenure defended
230 by Barrière and Barrière (1996) and also Le Roy (2019): land encompasses two different realities the space itself and the resources located on that space. These authors consider land as a total social fact, based on the anthropology of the law. This led Le Roy (2019) to highlight the co-evolution of social practices and how societies relate to space throughout the world. Considering space from
235 the point of view of social geography, or considering land from the point of view of anthropology of the law, enabled us to grasp the relations between the inhabitants and their environment, notably the nature of their relations with spaces.

Our work is also aligned with the participatory mapping approaches described by Lardon et al. (2008). In our approach, participatory mapping became
240 an object of mediation (Cash et al., 2003) with the stakeholders, enabling them to evoke symbolically their relationship with the territory. Finally, the work by Sinare et al. (2016) in Burkina Faso and Jagoret et al. (2014) in Cameroon inspired the participatory and quantitative methodologies carried out in the
245 workshops (see Appendix Appendix B).

4. Results

4.1. Identification and description of the four contrasted study sites

Based on observations from the exploratory mission and data collected from national and international agencies, we identified four socially and ecologically
250 contrasted study sites along a west-east gradient along the GGW path: Sakal, Widou, Lougré Thioly and Ranérou (Fig. 2). Sakal and Ranérou are well-

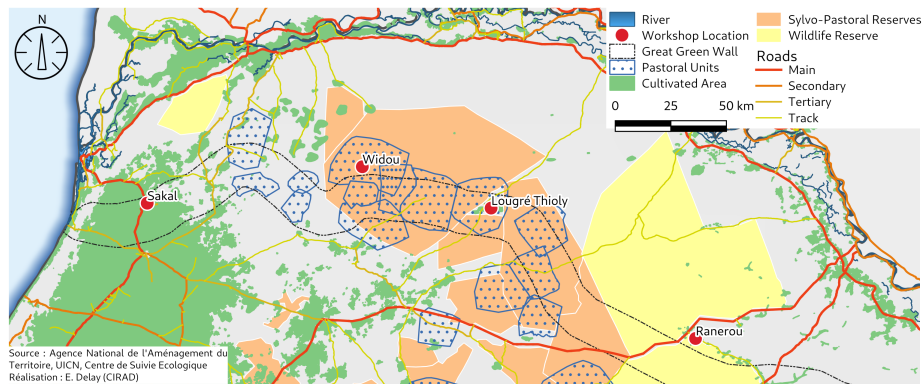


Figure 2: Map of the study sites. The theoretical path of the Great Green Wall in Senegal is shown by the dotted lines. The four study sites were located along it from West to East: Sakal, Widou, Lougré Thioly, Ranérou.

connected to the main road network (the latter, since 2017), while Lougré, and even more so Widou, are extremely remote.

Sakal is in an agricultural zone, whereas Widou and Lougré are in the
 255 sylvopastoral reserves which are vast spaces dedicated to pastoralism ("*pas-
 toral vocation*" in French). In planning documents for the region, the notion
 of "vocation" implies specific bundles of laws and rights to preserve pastoralism
 (Colin, 2008; Le Roy, 2019). It does not exclude other practices, but addresses
 the responsibilities associated with crop production and protection differently.
 260 In pastoral areas, it is up to the farmers to keep the livestock out of the fields,
 whereas in agricultural areas, it is up to the herders to keep their animals out
 of the croplands. Ranérou is located within a Wildlife reserve which is itself in-
 corporated into the Ferlo UNESCO "Man and Biosphere" (MAB) reserve. The
 MAB program promotes sustainable development based on the combined ef-
 265 forts of local communities, supported by local and scientific knowledge. This
 national and international label highlights locally managed natural resources
 and recognize the importance of society/nature interactions.

In Table 1, some of the socio-economic indicators for site selection obtained
 from municipality planning documents are indicated. The proportion of herders

270 varies among the sites, as does the ethnic composition. In Table 2 climatic indi-
 cators for the different sites are reported. Annual precipitations varies substan-
 tially: between 207 mm in the most arid municipality (Widou) to 378 mm in the
 least arid site (Ranerou). The annual mean temperature increases from West to
 East, Ranerou having the highest annual average. Finally, population growth
 275 is higher in the eastern sites compared to the western sites when comparing
 annual growth between 2016 and 2017

Table 1: Socio-economic criteria from the different study sites. Data was taken from the
 planning documents of the municipalities.

Sites	main livelihood	herder activity (%)	Main ethnic groups*
Sakal	agriculture	23	87% Wolof 10 % Peulh
Widou	pastoralism	77	83% Peulh 10% Maure
Lougré Thiouly	pastoralism	57	87% Peulh 10% Maure
Ranérou	pastoralism	43	93% Peulh

Table 2: Climatic indicators for the different study sites. Population growth data comes from
 "RGPHEA", precipitation was extracted from the CHRIPS database and temperatures from
 the national weather service.

Sites	Average annual temperature (°C)	Average annual precipitation (mm)	Population growth (%) 2016-2017
Sakal	26.5	241	2.8
Widou	28.2	206	2.8
Lougré Thiouly	28.6	273	3.8
Ranérou	29.1	378	3.8

4.2. Local uses of trees: between pasture and reforested plot

280 A primary assumption was made in this study: that people living in con-
 trasted social-ecological systems use trees and the landscape differently. The
 results from the workshop for the different landscape units and their tree-based
 uses are shown in Fig. 3. In this article, we specifically focus on two landscape
 units: pastures (bush) on the one hand, and reforested areas placed under de-
 285 ferred grazing by the GGW (reforested plot) on the other.

At all four sites, the bush was the most useful landscape unit when considering the five tree uses (construction, firewood, fodder, food, medicine) combined, albeit to varying degrees. Reforested plots were also useful for providing provisioning ecosystem services (ES)¹⁴ at all the sites, with the exception of Sakal
290 (the most western site and predominantly agricultural). However, it should be noted that when we refer to ecosystem services, this is our interpretation, as the workshop participants spoke of uses and did not specifically employ the term ES.

Another significant result is the relative importance of homesteads in providing ES. Currently, large-scale reforestation efforts are being invested in vast,
295 isolated plots, but very few trees are being provided to families to plant around their homes. Our results suggest that this essential landscape unit should not be neglected as re-greening them could provide significant social benefits for local populations. Indeed, homesteads participate between 8 to 20% of the total lived
300 space with respect to ES supply.

In Sakal, which is located outside the dedicated livestock herding zone, populations use the bush less compared to the other sites, even though it was used for all five tree ES. Construction remained the smallest use there, mostly likely because alternative building materials are readily available. The absence of tree
305 use in reforested plots around Sakal also provided clues as to the different land uses that exist in predominantly agricultural vs pastoral zones. An enclosed plot in an agricultural area tends to signify to other potential users that the plot is privately owned and this is an accepted fact. This means that withdrawing a plot from collective use for reforestation in an agricultural zone would tend to
310 upset human-environment relations to a lesser extent in an agricultural vs a predominantly pastoral zone.

¹⁴A provisioning service is any type of benefit to people that can be extracted from nature. Along with food, other types of provisioning services include drinking water, timber, wood fuel, natural gas, oils, plants that can be made into clothes and other materials, and medicinal benefits.

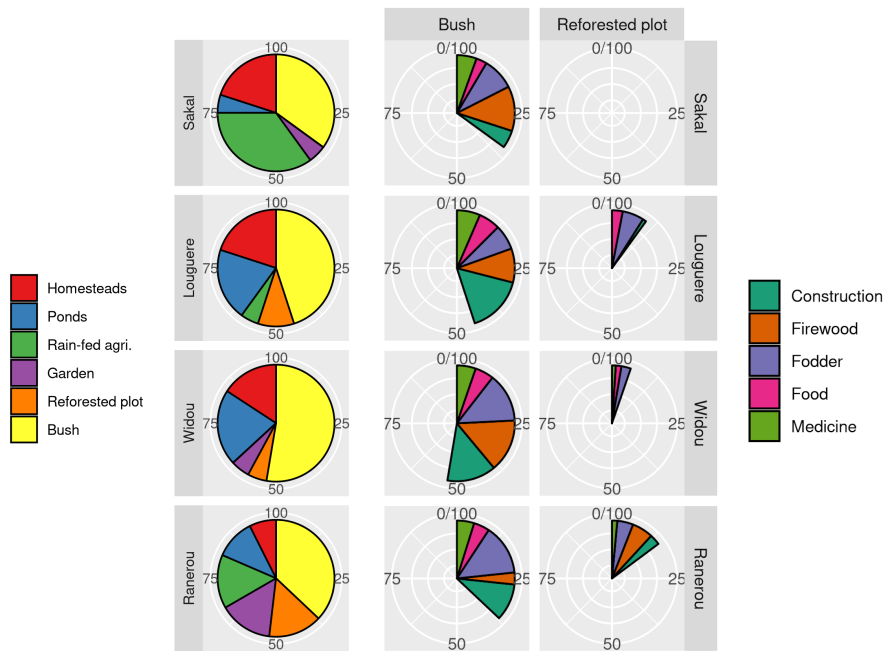


Figure 3: For each of the four study sites (left column), the quantification (middle and right columns) of tree uses per landscape unit and per usage type. First column on the left: relative importance of the landscape units identified as a function of all tree uses combined (quantification by the stakeholders at stage S4 of the workshops). Middle and right-hand columns (bush, reforested plot respectively): relative importance of each use identified by the stakeholders during stage S5 of the workshops.

In the other three sites, the trees in the reforested plots were mostly used for fodder and to a lesser extent human food. The GGW plots are fenced, which allows the grass to grow without being grazed. This means that people can
315 not only use the fodder from the trees, but they can also harvest grass for the animals that remain around the homesteads year round (Fig. ??). However, access to the plots is under the control of ANGGW authorities. Residents have to request for authorization from the local agency officer, an effective way of demonstrating who controls the space.

320 Together, the results presented herein demonstrate the undeniable consideration and attachment of local populations for trees, as well as their knowledge and dependence on natural resources. This dependency has a tendency to increase with the distance from State infrastructures and services (i.e. transportation, healthcare facilities). State infrastructure is more common in the western agricultural zones (e.g. Sakal), and becomes increasingly more sparse in the sites
325 dedicated to pastoralism towards the east.

4.3. Divergence national narratives and local needs

From a local perspective, the GGW raises the issue as to whether the aspirations of local populations are sufficiently taken into account when designing
330 on-the-ground actions. The GGW staff negotiates plot locations with rural communities. However, this tends to operate within a context of negative perception of pastoralism inherited from colonial times.

GGW actions must satisfy both foresters (representing state interests) and a variety of different stakeholders at the local level. Negotiations such as these
335 must allow the State to fulfill reforestation obligations promised at global scale, while at the same time, not comprising the land use that supports local needs. In reality, this is further complicated by the fact that local needs are not the same, for example, for a crop farmer or a livestock herder. Land tenure is also not the same in zones devoted to agriculture, where fenced plots are common to grow
340 crops compared to pastoral zones where land is unfenced and used collectively and intermittently. This presumably implies fewer conflicts when edifying a

GGW plot in Sakal (agricultural area), where land use is less dependent on open grazing for livestock compared to dedicated silvo-pastoral zones (Fig.2).

As indicated in Fig. 3, local populations in the four study sites are highly
345 dependent on ES provided by trees. The local stakeholders are therefore in a tricky position. They recognize the importance of trees for their daily lives, but the current top-down solutions of large-scale reforested plots are unsatisfactory. Large-scale enclosures mean *i)* significant loss of readily available natural resources (i.e. everything inside the plot), and *ii)* drastic changes in
350 transhumance trajectories if a plot is edified on a transhumance corridor. An interesting paradox is that local populations tend to perceive fencing positively, i.e. when they can decide when and where to install it and what to do within its boundaries, whereas they perceive it negatively when it is imposed on them in a top-down manner as it is, the case of large-scale reforestation plots. A fence in
355 the landscape is not bad *per se*, it is more the way it is imposed in the landscape that is at the origin of the conflicts observed.

5. Discussion

The national and international discourse continues to support a vision of herders as the main drivers of land degradation, by rehashing once again the
360 tragedy of the Commons. However, on the contrary, our results show to what extent local population perceive the importance of trees for their daily lives and livelihoods. This is particularly true in communities dominated by pastoral activities (Widou, Lougré, Ranerou).

Herein we provide an explanation as to what is perceived as overgrazing
365 throughout the Sahel. It is less the result of local disrespect of nature and more a indirect repercussion of state interventions (i.e. multiplication of boreholes). Interventions are often poorly aligned with the belief systems and practices ingrained in pastoralism. One potential leverage point for land restoration could consist in supporting local populations towards the construction of a new Com-
370 mons in reforestation protocols which would not result in the subtraction of large

portions of land, but by promoting and reinforcing the capacity of communities to collectively manage natural resources including trees.

5.1. From an old common pool resource perception to a new one

Herein we propose to operationalize the theoretical framework as described
375 by Ostrom (1990). The Commons concept was widely legitimized by E. Ostrom
in response to the wellknown example described by Hardin (1968). He described
shared pastureland, for which he demonstrated that it is impossible for a natural
resource to persist without private or centralized management. Ostrom (1990)
endeavoured to show that the example given by Hardin was a particular case
380 linked to the nature of the regulation (open access), and that there is a wide
range of conditions that favour collective management (Moritz et al., 2018).
Taking the resource as the entry point enabled her to think about management
rules and interactions, notably through the lens of the prisoner’s dilemma and
game theory, while remaining critical of the fixed nature of rules in theoretical
385 approaches (Cárdenas and Ostrom, 2001).

The perception of space in the sense of Di Méo (2008) is compatible with
the view of land tenure defended by Le Roy (2019). Both these authors inform
us about the types of representation and relations, formal or informal, that link
societies and their environment(s). In other words, by enquiring into formal
390 or informal relations with land, one also questions the way in which humans-
resource relations are mediated by space. Examining the status of the space
makes it possible to investigate the social relations provided by the space itself.
Considering land uses can also be considered as markers of certain appropriation
regimes as legitimate as land titles. Paying attention to the social rules for
395 the use of resources and spaces is referenced in many works in the Commons
literature.

Along the lines of previous work on Commons, specific studies on land tenure
by Le Roy (1996-2019) led to an update of conceptual frameworks of resource
appropriation. Focused on relations between society and their environment,
400 the Commons approach means investigating interdependency networks between

humans and non-humans from a systemic angle (Descola, 2015). By drawing graphs of interactions between users and resources (as a representation for solidarity networks), it is possible to bring out key Commons, and thereby investigate appropriation regimes. The third principle of the French Land Tenure and Development Technical Committee (2017) states that a key Commons is
405 "in a pragmatic approach [...] likely to have a significant knock-on effect on the resilience of other, interlinked Commons" (p.64).

5.2. *Overgrazing is paradoxically an issue of water abundance*

Water was traditionally the key Commons in the Sahelian pastoral zone of
410 Senegal. The introduction of modern water access infrastructure (boreholes) helped to increase the productivity of previously underused spaces. However, water then changed from being a Common Good (in the form of temporary ponds) to being a Club Good (reserved for a small group of people). The multiplication of boreholes means that water access has gone from being natural
415 to artificial. At the same time, , the densification of boreholes increases land degradation. This degradation, notably through overgrazing, is blamed on livestock herders, while the root cause remains the multiplication of boreholes, an ongoing public policy implemented throughout the Sahel. Walker (2005) highlighted almost 15 years ago that "undermining these land users keen localized
420 environmental knowledge and long histories of successful adaptation to sometimes harsh and unpredictable environments (e.g., Watts (1983)), creating a situational rationality that could potentially force land users to degrade their environments in acts of desperate ecocide (Blaikie and Brookfield, 1987)".

When considering conflicts between livestock herders and ANGGW staff, it
425 intrinsically implies re-examining the roots causes of overgrazing. However, by mainly focusing on the fodder resource itself, the key Commons that has until now, serve as a "system regulator" is overlooked: water.

The installation of the borehole network in the Ferlo region in Senegal started during the colonial era (Foury, 1953), but accelerated in the mid-1990s (Fig. 4)
430 and deeply disturbed the social regulation systems in place. Rangeland manage-

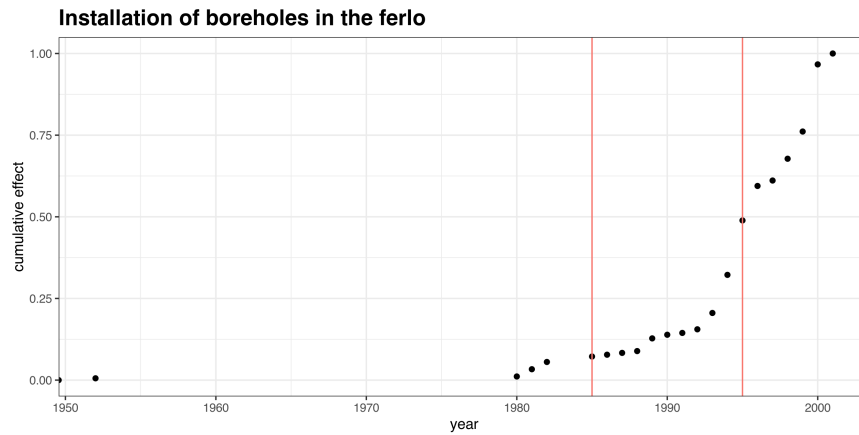


Figure 4: Cumulative frequency curve of borehole installation in the Ferlo region. The Ferlo is the silvopastoral zone located in northern Senegal where the three pastoral study sites are located. The vertical red lines are the class boundaries used in Fig. 5 (Source : DGPRE). The number of boreholes has increased over time, with a marked acceleration from the mid-1990s up until today.

ment was achieved through traditional collective rules of access to water points applied at the local level. Water was spatially and temporally rare, and was the key social regulator (Gonin, 2018). This explains why overgrazing was inversely proportional to livestock watering capacity: when a pond dried up, the herds
 435 would naturally leave, which regulated the renewal of grazing areas. With the increasing number of state and international-funded boreholes throughout the region (Fig.5), water has literally become abundant (Bookchin, 1977). Water scarcity on which collective management was formerly based gradually saw the very environment under its control deconstructed. Indeed, as Sall (1978) and
 440 Watts (1985) pointed out, the abundance of water and the overgrazing that this has provoked created a new social problem resulting in the disorganization of space.

In reality, this situation is a typical shift in the construction of modern water: according to (Linton, 2010), "Modern water is an intellectual achievement. [...]"
 445 Modern water reduces all water to this essential substance, this homogenous

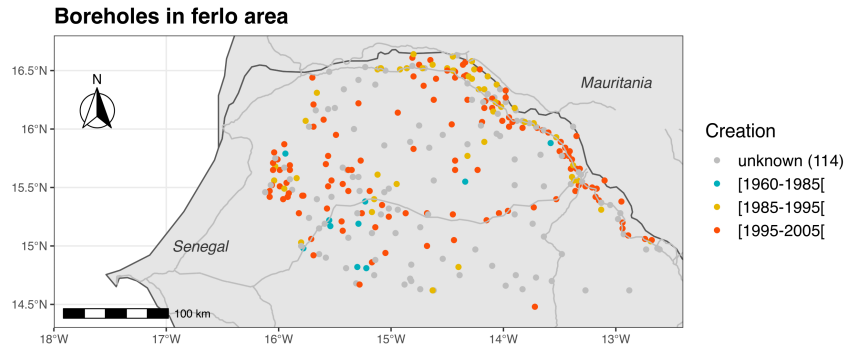


Figure 5: Map of boreholes in the Ferlo region of Senegal according to the Department of Water Resources Management and Planning (DGPRE). A fine mesh of boreholes throughout the region helps to explain the disappearance of pastoral zones that are accessible only during the rainy season.

chemical compound, both spatially and temporally" (p.18).

Considering modern water, meaning water as a chemical compound, helps to transform it into a manipulable and interchangeable object: this is currently the vision promoted by the State. The act of constructing a borehole therefore
 450 disregards the existing, traditional networks of relations between human (local populations) and non-human (plants, animals, etc.). It assumes that any water can replace any water. But this is not true; for local actors, water is part of a hydro-social cycle (Linton and Budds, 2014). It mobilizes rules of use inherited from ancestors, forms of attachment to the place of water (sacredness), it induces
 455 land use concerned by time, etc. There is no relationship of equivalence between the State's vision and the local visions of water in which the actors evolve. However, introducing a new water point (in the form of a borehole) immediately inscribes it in the hydro-social cycle of local actors. All the actions compatible with water in the traditional system (ponds) are transposed into the borehole
 460 system, however without the necessary accompanying measures. But this has consequences, the rules are not the same and everything must be renegotiated;

from the use of water to the land use that depended on the traditional vision.

The failure to consider all of the intricate relationships with water has led to grazing resource degradation, by eliminating the markers of water rarefaction. Fodder has now become the limiting factor, without it being considered as a Commons. Today, due to its "induced abundance", water has been stripped of its regulatory role and its symbolic and social values, and the traditional rules linked to them have become obsolete. This results in State and development agency interventions in the area that are modifying interrelations between resources and users without taking the potential consequences into account. (Delay et al. under review).

Finally, this process is not necessarily irreversible: "Bernus (1974) refers to a case in which Illabakan Tuaregs in Niger actually turned off a mechanical pump because the new source of water severely exacerbated interethnic relations, the regulation of which was a key element in the control and maintenance of pastures" (Watts (1985) p.20). In other words, once the source of the overgrazing problem is identified, even the most radical solution is possible. But before reaching this point, support should be given to local populations for the creation of new key Commons.

5.3. *Rethinking reforestation in a pastoral Commons context*

Since the creation of the ANGGW in Senegal in 2008, the agency staff has perceived the limits of their own actions¹⁵. The change in the orientation of the project, which was initially seen as a forest strip crossing Africa from West to East, is now a project comprising a mosaic of plots laid out along the GGW path. Since 2012, tree planting field trials set up along the path of the Great Green Wall in Senegal have been subjected to long-term monitoring. The results of these different field trials tend to show highly variable, albeit low, survival rates depending on the tree or shrub species and on the location of the plot.

¹⁵In 2019, the ANGGW as such was dissolved and englobed into the National Reforestation and Green Wall Agency that covers the entire Senegalese territory.

For example, in Widou, survival rates for the most robust species were, at best,
490 around 15% two years after transplantation from nurseries to field plots (Wade
et al., 2018). In the same field trial, a spontaneous regeneration rate of 89%
was observed for woody species when grazing was deferred, suggesting that, for
regreening, natural regeneration is a viable alternative to reforestation. In other
areas in the Sahel, farmer assisted natural regeneration, which involves farmers
495 managing and protecting the growth of trees and shrubs that regenerate natu-
rally in their fields (Reij and Winterbottom, 2015), has also proven extremely
effective in increasing plant biomass production on a large-scale basis.

Natural regeneration of woody species is not new in Africa (Reij et al., 2009;
Reij and Winterbottom, 2015), but the results of the GGW experimental plots in
500 Senegal pave the way for new solutions in pastoral zones. These solutions need to
enable young plants to become established perennially, without being hindered
by herd movements in space and over time. One solution was suggested to us by
livestock farmers around Widou (personal communication, 2017): these farmers
suggested they should be provided with fencing so that they could close off areas
505 for a limited time, such as three years; once the woody species were established,
the livestock herders would move the fences elsewhere. For them, the fact of
freely choosing the location of the plots and their size radically contrasted with
current ANGGW practices. Likewise, they would no longer need to ask for
permission to seek fodder in those areas. This change in practice would be far
510 better adapted to local land management (d'Aquino and Bah, 2013; Scoones,
1994) than that of permanent enclosures of large reforested plots commonly
found along the GGW.

In this context, it is worth citing the six steps of Reij and Winterbottom
(2015) described in their report "Scaling up Regreening: Six Steps to Success.
515 Practical Approach to Forest and Landscape Restoration": "1- Identify and
analyse existing regreening successes; 2- Build a grassroots movement for re-
greening; 3- Address policy and legal issues to enable conditions for regreening;
4- Develop and implement a communication strategy; 5- Develop or strengthen
agroforestry value chains; and 6- Expand research activities" (p. 4). Regarding

520 step 1, the research work undertaken in the experimental plots revealed promis-
ing regreening practices. For step 2, voluntary champions of the initiative, to
whom wire fencing could be distributed, for example, have already been iden-
tified. To address the political and legal issues (step 3) that deferred grazing
established by the livestock farmers would entail, existing collectives could be
525 called upon, such as the "Land Use and Allocation Plan" committees (POAS,
which are land occupation agreements signed between local authorities and the
State): they can decide on the temporary allocation of areas for deferred graz-
ing. Lastly, with a view to disseminating practices and developing value chains
(steps 4 and 5), the plots under deferred grazing could also serve as a forage re-
530 serve to feed herds at the end of the rainy season, prior to transhumance. Some
collective harvesting rules could be negotiated there and introduced. This en-
tire process would have to be monitored by research teams to identify inflection
points (step 6) and help to disseminate these practices.

6. Conclusion

535 This study allowed us to highlight the diversity and specificities of tree use in
four contrasting sites along the GGW in Senegal. This diversity demonstrates
not only the dependence of local communities on trees for their livelihoods,
but also a sense of attachment to nature. Yet these values are not commonly
recognized in national and international narratives. Our results shed light on
540 this fundamental misunderstanding between decision-makers and local actors,
each with their different relationship with natural resources and to nature itself.

In Senegal, the State, by way of the ANGGW, is introducing reforested
plots with deferred grazing in the Sahelian pastoral zone. It is thus pursuing its
crusade to maintain control over these spaces located in its outlying territories.
545 Although the rules for managing borehole water have been taken on board by
livestock herders as they are compatible with traditional water use methods, this
is yet to be the case for the standards and values promoted around reforestation.

If the reforestation objectives fixed by the State and the international com-

munity to combat desertification are to be achieved, it will be necessary to facilitate the constitution of a pastoral Commons. This could involve setting up "assisted natural regeneration" initiatives that are co-constructed with PAAGGW, ANGGW staff and local stakeholders. Allocating wire fencing for deferred grazing could be done in return for a commitment over a limited time to prevent livestock from entering the plot. Thus, the area does not fall into a land titling regime, but remains accessible to everyone over a long period, while being withdrawn from direct grazing the time that it is necessary for the trees and shrubs to regenerate. Fodder could also be cut there to feed animals during the dry season.

As of early 2021, a new UN platform, the GGW Accelerator, has been launched to coordinate the activities and projects of international donors and research and development teams around the GGW initiative. The creation of this platform constitutes a window of opportunity for donors and partner countries of the project: "The Accelerator will support the Great Green Wall countries to adopt a more comprehensive approach to rural development, including improving the production systems that underpin livelihoods of smallholder farmers and pastoralist communities [...]"¹⁶. Within this initiative, our results show that for States and national agencies involved in the GGW project, changes are needed in governance of reforestation projects, for example by delegating more power at the community level. At the same time, external stakeholders including international donors, development agents and researchers must be aware, despite good intentions, of their potential negative impact on the system, so as to not find themselves supporting paradoxical solutions.

Finally, while taking on a Commons approach could lead to local empowerment, the shift from State management to community-based management could also be seen as a way for the State to reduce its expenditure. However, mo-

¹⁶UNCCD, 2021. The Great Green Wall Accelerator. <https://www.unccd.int/actions/great-green-wall-initiative/great-green-wall-accelerator>, consult 13th of July.

bilizing a Commons approach should not be perceived as a retreat from State prerogatives. It is more about delegating decision-making and action to those who are most directly concerned by the issues at the appropriate scales of intervention.

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595 **References**

- Ancey, V., Ickowicz, A., Corniaux, C., Manoli, C., Magnani, S., 2008. Stratégies pastorales de sécurisation chez les Peuls du Ferlo (Sénégal). *Journal des africanistes* , 105–119 URL: <http://journals.openedition.org/africanistes/2280>. ISBN: 9782908948318 Number: 78-1/2 Publisher: Société des africanistes.
600
- Aubrėville, A...A., 1949. *Climats : forėts et dėsertification de l’Afrique tropicale*. Sociėtė d’ėditions gėographiques, maritimes et coloniales. Paris.

- Barrière, O., Barrière, C., 1996. Approches environnementales : systèmes fonciers dans le delta intérieur du Niger : de l'implosion du droit traditionnel à la recherche d'un droit propice à la sécurisation foncière, in: La sécurisation foncière en Afrique: pour une gestion viable des ressources renouvelables. Karthala, Paris. Economie et développement. URL: https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers15-07/010065117.pdf.
- 605
- Benjaminsen, T.A., 2012. Changements climatiques et conflits au Sahel, in: Gautier, D., Benjaminsen, T.A. (Eds.), Environnement, discours et pouvoir : L'approche Political ecology. Quae éditions, Versailles.
- 610
- Benjaminsen, T.A., Kepe, T., Bråthen, S., 2008. Between Global Interests and Local Needs: Conservation and Land Reform in Namaqualand, South Africa. Africa 78, 223-244. URL: <https://www.cambridge.org/core/journals/africa/article/abs/between-global-interests-and-local-needs-conservation-and-land-reform-in-namaqualand-south-africa/1E2430A4A96F0C353A9EAA088F7EB7AF#>, doi:10.3366/E0001972008000144. publisher: Cambridge University Press.
- 615
- Bernard, C., 1993. Les débuts de la politique de reboisement dans la vallée du fleuve Sénégal (1920-1945). Outre-Mers. Revue d'histoire 80, 49-82. URL: https://www.persee.fr/doc/outre_0300-9513_1993_num_80_298_3081, doi:10.3406/outre.1993.3081. company: Persée - Portail des revues scientifiques en SHS Distributor: Persée - Portail des revues scientifiques en SHS Institution: Persée - Portail des revues scientifiques en SHS Label: Persée - Portail des revues scientifiques en SHS Publisher: Société française d'histoire d'outre-mer.
- 620
- 625
- Bernus, E., 1974. Possibilités et limites de la politique d'hydraulique pastorale dans le Sahel nigérien. Cahiers ORSTOM.Série Sciences Humaines 11, 119-126. URL: https://horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_4/sci_hum/04162.pdf.
- 630

- Blaikie, P., Brookfield, H. (Eds.), 1987. Land degradation and society. Ré-
édition 2016 ed., Methuen, London ; New York. OCLC: 953886270.
- Blundo, G., 2014. Les Eaux et Forêts sénégalais entre participation et militari-
635 sation. *Ethnographie d'une réforme*. *Anthropologie & développement* , 185-
223 URL: <http://journals.openedition.org/anthropodev/481>, doi:10.
4000/anthropodev.481.
- Blundo, G., Sardan, J.P.O.d., 2001. La corruption quotidienne en Afrique
de l'Ouest. *Politique africaine* N° 83, 8-37. URL: [https://www.cairn.
640 info/revue-politique-africaine-2001-3-page-8.htm](https://www.cairn.info/revue-politique-africaine-2001-3-page-8.htm). publisher: Edi-
tions Karthala.
- Bookchin, M., 1977. Post-scarcity anarchism. Number No. 071 in *Black Rose
Books*. 2. ed ed., Black Rose Books, Montréal. OCLC: 255623588.
- Cash, D.W., Clark, W.C., Alcock, F., Dickson, N.M., Eckley, N., Guston,
645 D.H., Jäger, J., Mitchell, R.B., 2003. Knowledge systems for sustainable
development. *Proceedings of the National Academy of Sciences* 100, 8086-
8091. URL: <http://www.pnas.org/content/100/14/8086>, doi:10.1073/
pnas.1231332100.
- Colin, J.P., 2008. Disentangling intra-kinship property rights in land: a
650 contribution of economic ethnography to land economics in Africa. *Journal
of Institutional Economics* 4, 231-254. URL: [https://www.cambridge.org/
core/product/identifier/S1744137408000970/type/journal_article](https://www.cambridge.org/core/product/identifier/S1744137408000970/type/journal_article),
doi:10.1017/S1744137408000970.
- Committee, L.T.a.D.T., 2017. The opportunities and challenges presented by a
655 land-based commons approach. Technical Report. MEAE and AFD. Paris
(France). URL: [http://www.foncier-developpement.fr/wp-content/
uploads/Land-based-commons-approach.pdf](http://www.foncier-developpement.fr/wp-content/uploads/Land-based-commons-approach.pdf).
- Cárdenas, J.C., Ostrom, E., 2001. What do people bring into the game? How

- norms help overcome the tragedy of the commons. 4eme Journées dEconomie
de lEnvironnement de Toulouse .
- d'Aquino, P., Bah, A., 2013. A bottom-up participatory modelling process for a multi-level agreement on environmental uncertainty management in West Africa. *Journal of Environmental Planning and Management* 56, 271–285. URL: <https://doi.org/10.1080/09640568.2012.665361>, doi:10.1080/09640568.2012.665361. publisher: Routledge _eprint: <https://doi.org/10.1080/09640568.2012.665361>.
- Descola, P., 2015. Par-delà nature et culture. Folio, Paris.
- Di Méo, G., 2008. Une géographie sociale entre représentations et action. *Montagnes méditerranéennes et développement territorial* , 13–21URL: <https://halshs.archives-ouvertes.fr/halshs-00281573>.
- Dia, A., Duponnois, R., 2013. Le projet majeur africain de la Grande Muraille Verte: concepts et mise en oeuvre. IRD Editions.
- Dreyfus, H.L., Rabinow, P., 1982. Michel Foucault : Beyond Structuralism and Hermeneutics. 2nd revised edition ed., University of Chicago Press, Chicago.
- Elie, M., 2015. Formulating the Global Environment: Soviet Soil Scientists and the International Desertification Discussion, 196891. *The Slavonic and East European Review* 93, 181–204. URL: <https://www.jstor.org/stable/10.5699/slaveasteurorev2.93.1.0181>, doi:10.5699/slaveasteurorev2.93.1.0181. publisher: [Modern Humanities Research Association, University College London, School of Slavonic and East European Studies, University College London].
- Ellis, J.E., Swift, D.M., 1988. Stability of African Pastoral Ecosystems: Alternate Paradigms and Implications for Development. *Journal of Range Management* 41, 450. URL: <https://www.jstor.org/stable/3899515?origin=crossref>, doi:10.2307/3899515.

- Foury, P., 1953. Politique forestière au Sénégal. *Bois et Forêts des Tropiques* 30, 8–21. doi:<https://doi.org/10.19182/bft1953.30.a18501>.
- Frémont, A., 1976. *La région, espace vécu*. Réédition de 2009 ed., Flammarion.
- Gautier, D., Hautdidier, B., 2012. Political ecology et émergence de territorialités inattendues : lexemple de la mise en place de forêts aménagées dans le cadre du transfert d'autorité de gestion au Mali, in: Gautier, D., Benjamin-sen, T.A. (Eds.), *Environnement, discours et pouvoir : L'approche Political ecology*. Quae éditions, Versailles, pp. 241–257.
- Goffner, D., Sinare, H., Gordon, L.J., 2019. The Great Green Wall for the Sahara and the Sahel Initiative as an opportunity to enhance resilience in Sahelian landscapes and livelihoods. *Regional Environmental Change* 19, 1417–1428. URL: <http://link.springer.com/10.1007/s10113-019-01481-z>, doi:10.1007/s10113-019-01481-z.
- Gonin, A., 2018. Le foncier pastoral au Sahel, des mobilités fragilisées. *Bulletin de l'Association de géographes français* 95, 175–186. URL: <http://journals.openedition.org/bagf/3049>, doi:10.4000/bagf.3049.
- Guay, K., Beck, P.S.A., Goetz, S.J., 2015. Long-Term Arctic Growing Season NDVI Trends from GIMMS 3g, 1982-2012. Technical Report. Oak Ridge National Laboratory. Oak Ridge, Tennessee, USA. URL: <http://dx.doi.org/10.3334/ORNLDAAC/1275>.
- Hardin, G., 1968. The Tragedy of the Commons. *Science* 162, 1243–1248. URL: <http://www.sciencemag.org/content/162/3859/1243>, doi:10.1126/science.162.3859.1243.
- Heyes, C.J., 2012. Subjectivity and power, in: Taylor, D. (Ed.), Michel Foucault. Acumen Publishing Limited, Durham, pp. 159–172. URL: https://www.cambridge.org/core/product/identifier/CB09781844654734A020/type/book_part, doi:10.1017/UP09781844654734.012.

- Jagoret, P., Kwesseu, J., Messie, C., Michel-Dounias, I., Malézieux, E., 2014. Farmers assessment of the use value of agrobiodiversity in complex cocoa agroforestry systems in central Cameroon. *Agroforestry Systems* 88, 983–1000. URL: <https://link.springer.com/article/10.1007/s10457-014-9698-1>, doi:10.1007/s10457-014-9698-1.
- Lardon, S., Caron, P., Bronner, A.C., Giacomme, G., Raymond, R., Brau, F., 2008. Jeu collaboratif de construction de territoire: interagir par les représentations spatiales. *Revue internationale de géomatique* 18, 507–530. URL: <http://www.emse.fr/site/SAGE02007/CDROM/CQFD01.pdf>.
- Le Houérou, H.N., 1996. Climate change, drought and desertification. *Journal of Arid Environments* 34, 133–185. URL: <http://www.sciencedirect.com/science/article/pii/S0140196396900993>, doi:10.1006/jare.1996.0099.
- Le Roy, E., 2019. Pourquoi et comment la juridicité des communs s'est-elle imposée dans nos travaux fonciers ? Récit d'une initiation. Number 8 in *Regards sur le foncier*. 1 ed., Comité technique n° Foncier & développement z, AFD, MEAE, Paris.
- Linton, J., 2010. *What is Water?: The History of a Modern Abstraction*. UBC Press. Google-Books-ID: vjwJoObk4zAC.
- Linton, J., Budds, J., 2014. The hydrosocial cycle: Defining and mobilizing a relational-dialectical approach to water. *Geoforum* 57, 170–180. URL: <https://www.sciencedirect.com/science/article/pii/S0016718513002327>, doi:10.1016/j.geoforum.2013.10.008.
- Maraseni, T.N., Bhattarai, N., Karki, B.S., Cadman, T., Timalina, N., Bhandari, T.S., Apan, A., Ma, H.O., Rawat, R.S., Verma, N., San, S.M., Oo, T.N., Dorji, K., Dhungana, S., Poudel, M., 2019. An assessment of governance quality for community-based forest management systems in Asia: Prioritisation of governance indicators at various scales. *Land Use Policy* 81, 750–761. URL: <https://www.sciencedirect.com/science/article/pii/S026483771831038X>, doi:10.1016/j.landusepol.2018.11.044.

- Moritz, M., Behnke, R., Beitzl, C.M., Bird, R.B., Chiaravalloti, R.M., Clark, J.K., Crabtree, S.A., Downey, S.S., Hamilton, I.M., Phang, S.C., Scholte, P., Wilson, J.A., 2018. Emergent sustainability in open property regimes. *Proceedings of the National Academy of Sciences* 115, 12859–12867. URL: <https://www.pnas.org/content/115/51/12859>, doi:10.1073/pnas.1812028115. publisher: National Academy of Sciences Section: Perspective.
- Ostrom, E., 1990. *Governing the commons: The evolution of institutions for collective action*. Cambridge university press. URL: http://books.google.com/books?hl=en&lr=&id=4xg6oUobMz4C&oi=fnd&pg=PR11&dq=info:UNqd5tMI_jUJ:scholar.google.com&ots=aN8ou01DYj&sig=TTmHzigIRcsiukbdrGD2nCea4k.
- Reich, P.F., Numbem, S.T., Almaraz, R.A., Eswaran, H., 2001. Land resource stresses and desertification in Africa, in: *Response to Land Degradation*. CRC Press, pp. 101–116.
- Reij, C., Tappan, G., Smale, M., 2009. Agroenvironmental transformation in the Sahel: Another kind of "Green Revolution". volume 914. *Intl Food Policy Res Inst*.
- Reij, C., Winterbottom, R., 2015. *Scaling up Regreening: Six Steps to Success*. URL: <https://www.wri.org/publication/scaling-regreening-six-steps-success>.
- Reynolds, J.F., Smith, D.M.S., Lambin, E.F., Turner, B.L., Mortimore, M., Batterbury, S.P.J., Downing, T.E., Dowlatabadi, H., Fernandez, R.J., Herrick, J.E., Huber-Sannwald, E., Jiang, H., Leemans, R., Lynam, T., Maestre, F.T., Ayarza, M., Walker, B., 2007. Global Desertification: Building a Science for Dryland Development. *Science* 316, 847–851. URL: <https://www.sciencemag.org/lookup/doi/10.1126/science.1131634>, doi:10.1126/science.1131634.
- Sall, A., 1978. Quel aménagement pastoral pour le Sahel ? *Revue Tiers Monde* 19, 161–169. URL: https://www.persee.fr/doc/tiers_0040-7356_1978_

num_19_73_2785, doi:10.3406/tiers.1978.2785. publisher: Persée - Portail des revues scientifiques en SHS.

Scoones, I., 1994. Living with uncertainty: new directions in pastoral development in Africa. ITDG Publishing, London.

775 Sinare, H., Gordon, L.J., Enfors Kautsky, E., 2016. Assessment of ecosystem services and benefits in village landscapes A case study from Burkina Faso. *Ecosystem Services* 21, 141–152. URL: <http://linkinghub.elsevier.com/retrieve/pii/S2212041616302170>, doi:10.1016/j.ecoser.2016.08.004.

UNCCD, 1994. Implementation of the United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or
780 Desertification, Particularly in Africa : resolution / adopted by the General Assembly, in: U.N. Doc. A/AC.241/27, 33 I.L.M.1328, United Nations, 1994), p. 58. URL: https://www.unccd.int/sites/default/files/relevant-links/2017-01/English_0.pdf.

785 Wade, T.I., Ndiaye, O., Mauclaire, M., Mbaye, B., Sagna, M., Guissé, A., Goffner, D., 2018. Biodiversity field trials to inform reforestation and natural resource management strategies along the African Great Green Wall in Senegal. *New Forests* 49, 341–362. URL: <https://doi.org/10.1007/s11056-017-9623-3>, doi:10.1007/s11056-017-9623-3.

790 Walker, P.A., 2005. Political ecology: where is the ecology? *Progress in Human Geography* 29, 73–82. URL: <http://journals.sagepub.com/doi/10.1191/0309132505ph530pr>, doi:10.1191/0309132505ph530pr.

Watts, M., 1983. Silent violence: food, famine, and peasantry in northern Nigeria. *Geographies of justice and social transformation*. re-edition 2013 ed.,
795 University of Georgia Press, Athens.

Watts, M.J., 1985. Social Theory and Environmental Degradation, in: Gradus, Y. (Ed.), *Desert Development: Man and Technology in Sparse lands*. Springer Netherlands, Dordrecht. The GeoJournal Library, pp. 14–

32. URL: https://doi.org/10.1007/978-94-009-5396-3_2, doi:10.1007/

800 978-94-009-5396-3_2.

Appendix A. Landscape units

Prior to workshops, taking a landscape ecology approach, we identified nine major landscape units existing along the GGW in Senegal (Fig. 2). These photos were shown to the stakeholders one-by-one during the workshops, in phase S2 (see Appendix Appendix B), while creating the mental maps described below.

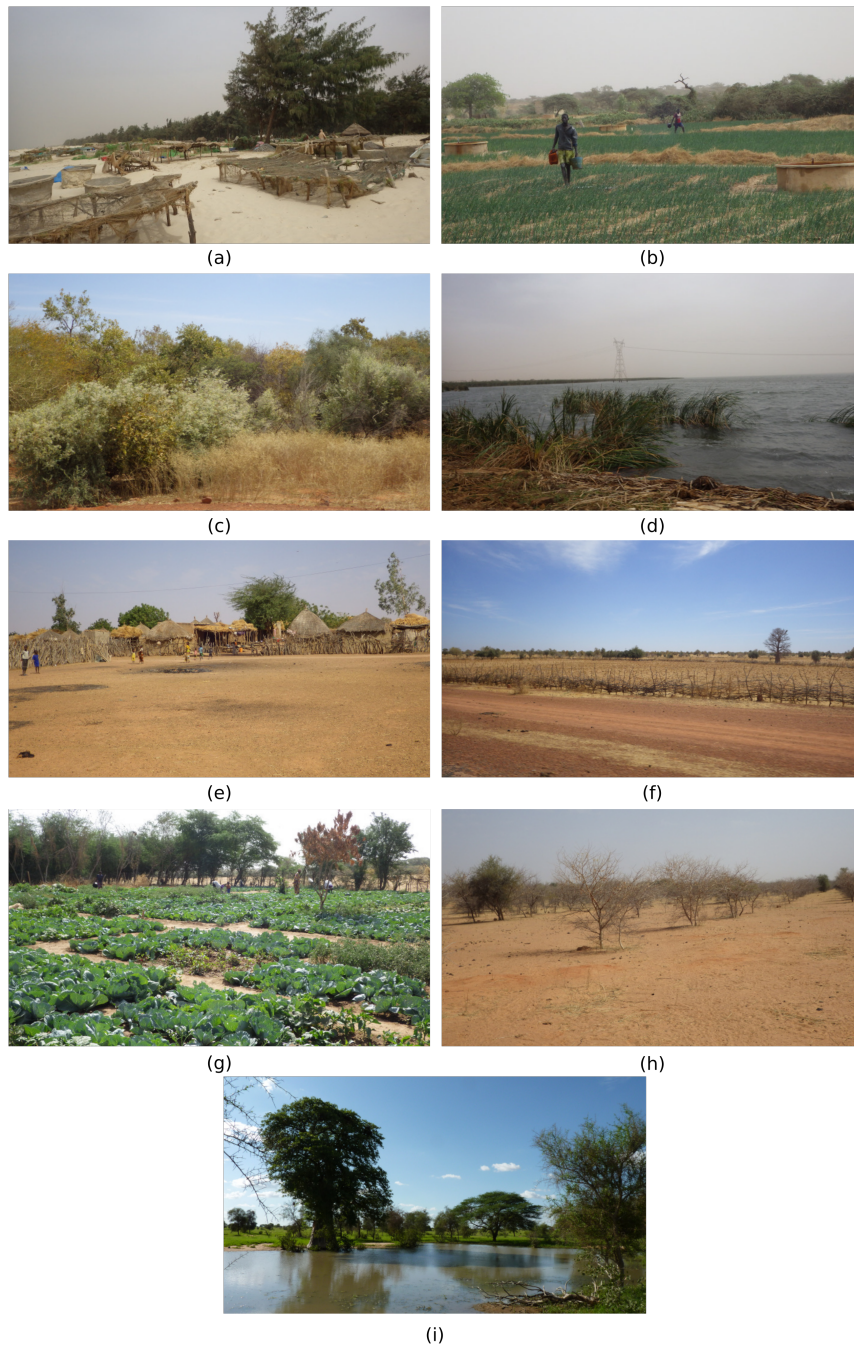


Figure A.1: Photos shown to the stakeholders during the workshops: a) Atlantic coast, b) irrigated agriculture, c) sparse bush, d) shore of Lake Guiers, e) homesteads, f) rainfed agriculture, g) multi-purpose garden, h) Great Green Wall reforested plot, i) pond.

Appendix B. Workshop methodology

For each workshop (two workshops were held at each of the four sites, one in the centre of the village, the other on the outskirts). Our research team was constituted of at least five members: a facilitator who could speak the three languages used (French, Pulaar, Wolof) and who was responsible for the smooth operation of the workshops; two translators, one translating from the stakeholders language into French, the other taking notes; and at least two Frenchspeaking researchers who followed the discussion and quantification process. Each workshop had 15 participants. Each workshop took place in seven stages:

- Stage S0 - This first stage served to place the stakes in context and explain them. It enabled the stakeholders to feel confident enough to answer the questions as honestly as possible. We made a link between the work of the National Agency of the Great Green Wall (ANGGW) and the work of the project covering our own (XXXX project references), emphasizing the potential contributions of workshop outputs for future GGW natural resource management decisions.
- Stage S1 - We began by presenting the space on a white A0 sheet of paper. The workshop leader marked out the space inhabited by the populations using spatial landmarks and the points of the compass (North, South, East, West) (Frémont, 1976). To make their collective mental map, the participants were then invited to indicate the location of, for example water points, hills or roads. The delimited area was considered as their daily living space, i.e. the places they might move around throughout the day.
- Stage S2 - All the photos of the landscape spatial units taken during the exploratory field mission (Appendix Appendix A) were shown to the participants to whom two questions were asked: i) Do you recognize the spatials units? ii) Does this spatial unit exist in the space you mapped

out in stage S1 as being a part of your daily living space? If spatial units appeared to be missing they were discussed and added if necessary. In the following four stages (S3 to S6), only spatial units identified by the participants were considered for further analysis.

- 840 • Stage S3 - Each spatial unit was drawn on the map, with the help of the landmarks established in stage S1. Three quantification stages then followed (S4, S5). Each consisted, for the stakeholders, in agreeing on the relative importance of each spatial unit. A number of tokens were distributed according to the importance that the group of stakeholders collectively assigned to the landscape unit in question. As the number
845 of tokens was arbitrarily fixed at ten for each stage, at the end of the workshop we were able to weigh each category of tree usage according to each landscape unit.
- Stage S4 - We asked the stakeholders to quantify the relative importance
850 of each landscape unit according to their use of trees. For this purpose, the group of participants used ten tokens distributed in the different units. This collective distribution was done by seeking a consensus in the group, which necessarily led to an exchange of opinions.
- Stage S5 - For each landscape unit, we proposed the five ecosystem services, or uses (food, fodder, construction, medicine, firewood). We asked
855 the participants to quantify the importance of each in relation to their use of trees.