Dynamiques environnementales

Journal international de géosciences et de l'environnement

46 | 2020
De Varia

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Electronic version

URL: <https://journals.openedition.org/dynenviron/2747>

DOI: 10.4000/dynenviron.2747

ISSN: 2534-4358

Publisher

Université d'Orléans

Printed version

Number of pages: 2-23

ISBN: 978-2-9576053-0-9

ISSN: 1968-469X

Electronic reference

Julien Andrieu, "Rice and trees: Agrarian and landscape dynamics over 40 years on the coast of southern Senegal and The Gambia", *Dynamiques environnementales* [Online], 46 | 2020, Online since 01 February 2022, connection on 20 April 2023. URL: <http://journals.openedition.org/dynenviron/2747> ; DOI: <https://doi.org/10.4000/dynenviron.2747>

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Rice and trees: Agrarian and landscape dynamics over 40 years on the coast of southern Senegal and The Gambia

Des rizières et des arbres : 40 ans de dynamiques des paysages agricoles sur le littoral du Sud du Sénégal et de la Gambie

Julien Andrieu

Introduction

- 1 The current environmental crisis has highlighted the urgent need for the assessment of environmental changes (Fyfe, 1981), the identification of the change drivers (Evans and Geerken, 2004), and the integration of these changes in social systems or anthroposystem (Lévêque, 2019) to understand how society has been impacted (Santos and Filho, 2005). Regarding changes in the environment with climate drivers, West Africa has played an interesting role in science with its recent fluctuations in rainfall (Descroix *et al.*, 2015) and its impacts on society and the economy (Bernus, 1995). In the research on ecology or physical geography, the dynamics of the environment resulting from climate fluctuations and/or changes in resource management systems have been studied. However, in these approaches, a stable environment is frequently expected, and that environment would be considered as degraded if it becomes unstable (Gunnell, 2009). On the contrary, women and men manage agricultural (Lericollais, 1972), pastoral (Marega, 2016), and forest (Ndiaye, 1990) areas, exploit resources (Gallup *et al.*, 2019), and build landscapes (Pélissier, 1966), thus making changes to the environment and not necessarily leaving the environment in worst state than before (Fairhead and Leach, 1995). These studies combine to create a growing consensus on West Africa: references from the colonial period, if not from colonial science, imposed a pessimistic view of environmental dynamics (Ballouche, 2016; Alexandre and Mering, 2018). The

coastal zone of West Africa comprising a succession of mangrove-dominated estuaries and deltas (Figure 1) have been studied in this optic (Cormier-Salem, 1999). Furthermore, most of the studies have used a simplistic analysis of human activities and have combined resource utilization and degradation, particularly in mangroves (Carney *et al.*, 2014), as discussed by Andrieu *et al.* (2019).

- 2 Among the ways to extract environmental studies out of this paradigm, one is to consider the present as a reference period and to lead diachronic studies in a retrospective manner in order to avoid considering the 1960s, 1970s, or 1980s as reference periods. First, the 1960s marked the end of the colonial era, and, at the century level, it was amid a humid anomaly. The 1970s and 1980s were, on the contrary, amid a dry anomaly at the century level. Today's rainfall is considered on the level of the century's mean (Descroix *et al.*, 2015), and, therefore, it is the best way to avoid taking both humid and dry anomalies into account. In addition, with more information on the present than the past, the former is a better reference period.
- 3 Most of the studies on rainfall recovery, regreening, and mangrove regeneration are built on the regional scale and geomatics, mostly remote sensing. This paper uses a local point of view based on village-scale enquiries and field observations, in addition to remote sensing. Most papers have studied these changes using a physical approach (vegetation–climate links). This paper employed an anthroposystemic point of view. The anthroposystem is being understood here as a system composed of two subsystems (ecological and social) whose interactions are more important in the overall systemic functioning.
- 4 Based on the diachronic mapping of landscapes that has already been published (Andrieu, 2018) and on interviews, we described and explained the landscape dynamics of this region. We took, as a common thread to this description, two elements of these rural systems: the rice fields and the different forest coverings, to describe the dynamics of the nature–society couple. These dynamics are, then, linked with the climatic chronology, to identify the processes of the changes in the management of resources.
- 5 The objective was also to study the link between tree cover and rice cultivation taken as an example of larger links between crops and spontaneous vegetation. Some systems are simple as a crop or a forest, some are agroforests. Along a north–south gradient, we aimed to look for common points and differences in the links between tree cover and rice cultivation.
- 6 Based on these results, a discussion was conducted on how some concepts (degradation vs. metastability and resilience) fit to these dynamics. Resilience of the ecosystems is here understood in its first definition by Holling (1973). The overall resilience of the anthroposystems is here intended as close as possible as the definition concerning the ecosystems: a capacity of change that ranges within the metastability range without changing the nature or the structure of the system.

Studied area

- 7 The studied area comprised a coastal zone with a length of 200 km, bordering the Atlantic Ocean in West Africa from the south of Senegal and The Gambia. The northern part receives around 500 mm of rainfall annually, with significant variability, whereas

the southern part receives around 1500 mm annually, also with significant variability. The 4 studied villages have been chosen randomly in 2004 for a PhD and have revealed various configurations on the relationship between rice crop and tree cover described hereafter.

Figure 1: Map of the studied area.

Diamniadio in the Gandoul Islands (Saloum Delta, Senegal)

- 8 Rice paddies on the Gandoul Islands are quite rare and Diamniadio is probably the northernmost position of this region rice cultivation (also found in different systems in the Senegal River Valley). Rice paddies consist of an open landscape with few trees and bushes (Figure 2). Rice is cultivated on almost the entire island (except the tidal zone). Two patches of spontaneous vegetation complete the landscape. Some open and low savannas can be found, mainly a small patch at the extreme north of the Island, considered a sacred wood, and another three patches of wooded fallows dominated by *Faidherbia albida*. Mangroves surround the island in the lower tidal zone. The mangroves in Diamniadio are low (1 to 3 m) and they mostly occupy a thin band of a few trees close to the channel.

Figure 2: Rice paddies in Diamniadio (Senegal) (Andrieu, 2005).

- 9 The people of Diamniadio only cultivate rice on the island, but they also fish (mostly *Ethmalosa fimbriata*) and sell most of their fish to Guinean merchants who transform (dry and smoke) the fish and sell them in Guinea. The people of Diamniadio own cattle, mostly cows, bought using money earned from the fishing economy.

Bani in the southern Saloum (Senegal)

- 10 Rice plots in the south of the Saloum Delta are a very secondary, local crop in Bani's land management. Only a few small basins with clay soils (retaining water in the soil longer than most common sandy soils) are dedicated to rice (Figure 3). They are confined to areas under a large amount of tree cover, mostly *Khaya senegalensis*, and, therefore, they are managed as agroforests. Women engage in irrigated market gardening close to these agroforests. The main crops, millet and peanut (usually in yearly turns), are, on the other hand, open landscape elements.
- 11 The southern Saloum landscapes include savannas and mangroves. Savannas can be found in protected areas (classified forests), and they are much higher and much denser than those of Northern Saloum, but none are strictly situated in Bani's territory (southern Saloum). The mangroves are also much higher and denser than those around Diamniadio.
- 12 The people of Bani define themselves as farmers, but they own a few pirogues and they also fish. They also invest their savings into cattle.

Figure 3: Agroforest in Bani (Senegal) (Andrieu, 2017).

Brefet in the Fogni (The Gambia)

- 13 Most rice plots in Brefet (Figure 4) are paddies formed in the upper tidal zone using dams since, at least the end of the 1990's. These open landscape elements exhibit almost no tree cover. They are managed by women, while men manage the inland crops (millet and peanut). Other rice plots can be found on higher ground under tree cover (mainly *Borassus flabellifer*).
- 14 The people of Brefet also fish and own cattle. Forestry confers to Brefet an original economy. The village of Brefet labelled its forest as a community forest in the 1990s and it has since successfully managed it as a common good, with interests in both resource conservation and income growth.

Figure 4: (a) Lowland rice paddies in Brefet (Andrieu, 2006); (b) plateau rice plots in Brefet (Andrieu, 2018).

Kamobeul in the Kassa (Senegal)

- 15 The rice plots in lower Casamance (Figure 5) form a complex agrarian system, which has been described well in previous publications (Pelissier, 1966; Cormier-Salem, 1999). Very briefly, the rice culture is based on two types of land. Inland, in forests or home gardens, young rice is grown. Then, rice is transplanted into mangrove rice paddies. Mangrove rice paddies are built-up on mangrove soils after dam building and mangrove destruction. These landscapes are old (much older than the time span of this study) and are recognized for providing important ecosystem services.

Figure 5: (a) Mangrove rice paddies in Casamance (Andrieu, 2006); (b) agroforest and rice in Kamobeul (Andrieu, 2006).

- 16 The people of Kamobeul also perform market gardening and fishing, they possess cattle, and they extract a large panel of nontimber forest products, mainly originating from *Elæis guineensis*: palm oil and palm wine.
- 17 We can already summarize that the relationships between rice and trees are different in the four cases. Diamniadio has either rice or trees in one area. Bani cultivates rice underneath rare and threatened trees. Brefet cultivates both lowland rice without trees and upland rice under forest cover. Kamobeul requires both agroforests and lowland rice paddies without trees for the same yield.

Materials and Methods

- 18 In order to understand how today's situation results from changes in the last 40 years and whether these changes must be considered as environmental degradation, we applied a method based on remote sensing, botanical observations, and interviews.
- 19 Remote sensing data, methods, and results have already been published (Andrieu, 2018), so they are not presented in detail here. Briefly, we used LANDSAT imagery data (multi-spectral satellite data with a 60 or 30 m pixel resolution, composed of images from the 1970s onwards) and the stacked unsupervised classification method with the K-means algorithm. The accuracy was 93% (Andrieu, 2018). The satellite data produced, for every date (1979, 1988, 2000, and 2015), a map containing 5 classes (water, mangrove, mudflats, nonwooded drylands, and wooded drylands). These imprecise categories are the only categories we can expect to map in the same manner in different periods when acknowledging the limits and the method (the LANDSAT

program changes over time; images at the exact moment of the year without clouds cannot be found, etc.). The cross-tabulation of pairs of maps enables the mapping and quantification of stable land cover and changes in land cover.

- 20 Between 2004 and 2007, and between 2016 and 2018, campaigns of field studies were carried, coupled with botanical observations and interviews.
- 21 Botanical observations were located by random sampling on the map of changes. In selected places a 50m transect was followed to: 1) assess the accuracy of maps (the on-field quantification of the vegetation cover rate to validate land cover mapping); 2) describe vegetation with species identification and physiognomy descriptions; 3) obtain as much information as possible on past changes (the estimation of tree ages and indices of the factors of change (cut trees, burnt areas, and past cultivation indices). A very large number of observations were made in the 2000s and much fewer were made in the 2010s.
- 22 Interviews were carried out during both these periods, and, in the 2010s, they were carried out in a lighter manner than before. In 2005, immersive interviews (over 2 to 3 weeks) were conducted for each of the four villages. They were divided into periods of immersion with visits and informal discussions with the people of the village. During the immersion period I did guided visits of various landscape elements and a participatory approach (work in the fields and in the forest, fishing campaigns, and cattle surveys). Then, unsupervised individual interviews were conducted about the activities (then, and recent changes) and changes in the environments. The first interview was with the village chief, who usually listed other people to meet until I was able to meet as many people as possible and try to cover a panel. A precise sampling within the village is not build-up because the social scale targeted is the village, not its various gender, ages, professions. These interviews usually led to other guided visits of the sites cited as having undergone changes in their use, management, or landscape. Twelve years later, these villages were revisited with the same protocol, but only over a few days because immersion was not possible (due to time constraints) and not necessary, and because the people of the villages were already familiar with the author.
- 23 The changes were validated for consistency between the remote sensing mapping, botanical field observations, and interviews. When consistent, remote sensing provided spatial accuracy to the extension of observations (avoiding very localized facts from being generalized), and botanical observations usually supplied the most objective and accurate identification of factors. The interviews recorded the decisions on activities and trajectories of the village leading to the creation of a frame to analyze the changes the society had undergone. The finest sociological scale of this study is the village.

Results

Diamniadio

- 24 The changes in the Diamniadio anthroposystem during the last 40 years are the most complex of the four studied villages. The remote sensing data, in Diamniadio but also globally and in the mangroves of all this coast, revealed a decrease in mangrove areas in the 1980s and 1990s, followed by their regeneration since then. In addition, for Diamniadio, and in general for the northern Saloum, there has been an increase in dryland vegetation cover in savannas since the 1980s (Figures 6 and 7). The field

observations offered some explanation. Mangroves suffered natural die-back during the droughts of the 1980s and 1990s, as proven by the observation of dead trees, which remain intact in the hypersaline soils to this day. The interviews revealed that the drought and mangrove regression appeared to lead to a change in fish resources. The fish targeted before the drought were strongly dependent on the mangroves, and these populations decreased with the decrease in the mangroves. However, in the same period, Guinean merchants arrived, and they proposed the purchase and transformation of *Ethmalosa fimbriata*, which had not been impacted by the drought. The drought also increased the salinity in some of the rice paddies that were abandoned (the fallows that were detected by remote sensing increased the dryland vegetation cover). An NGO proposed the planting of *Faidherbia albida*, which was expected to provide nutriment to the soil. *Faidherbia albida*, of course, did not resolve the salinity problem, but accelerated the overrunning of the fallows. In the same period, the fish trade changed the economy in an important way. In the 1980s, people declared that they only grew rice and exchanged fish with other products in the villages outside of the Delta. The trading with Guinean merchants started the monetization of the economy, the savings of which led to the rearing of cattle. These new patches of fallows were used as grazing areas during the rice season.

- 25 The rainfall recovery strengthened the remaining rice activity (and improved by the abundance of manure from the cattle), but never led to the recovery of abandoned rice paddies. It also led to mangrove regeneration, although not as far north in 2015 as it was in the late 1970s. Mangroves have regenerated both spontaneously (heterogeneous young mangroves can be observed almost everywhere) and with assistance (a replantation program was operated for the replantation of *Rhizophora* sp. north of the village).

Figure 6: Fallows over old rice paddies in Diamniadio (shown in green in Figure 7) (Andrieu, 2018).

Figure 7: Land cover change between 1979 and 2015 around Diamniadio.

Bani

- 26 Over the last 40 years, the land cover in Bani has changed. For the mangroves, the same trends can be seen, except with fewer changes both in the regression due to the drought during the 1980s and 1990s, and the regeneration since the 2000s, due to both spontaneous growth and replantation programs. Large patches of savanna were converted to cropland, while agroforests were converted to open cropland in the 1980s and 1990s; however, between 2000 and 2015, the dryland vegetation cover increased (Figures 8 and 9).

Figure 8: New cashew orchard in Bani (shown in green in Figure 9) (Andrieu, 2018).

Figure 9: Land cover change between 1979 and 2015 around Bani.

- 27 The rice plots observed in 2015 have been described by the people of Bani as a recovery of abandoned rice plots, which is consistent with the observations in 2005 when they had been abandoned during the drought. During the drought, even the small basins under tree cover had not retained water long enough to grow rice, therefore these basins were dedicated to millet and peanut, which led to an opening in the tree cover of the agroforest, as seen in the remote sensing imagery and studied during the

interviews carried out in 2005. Other crops, mainly millet and peanut, also suffered from the drought and the peanut stock price rate to fall. Therefore, the people of Bani chose to expand peanut growth during the 1980s and 1990s. Places previously dedicated to rice and other crops that required more water than peanut were the first targets to reduce tree cover in the agroforests. In 2017, the agroforests regained some density and were associated with important cashew nut orchards, as mapped in the land cover change between 2000 and 2015.

- 28 Regarding mangrove regeneration, this was explained by a replantation program. During the beginning of the interview, people began to repeat the narrative of the awareness programs; then, as the interviews continued, the discourse about mangroves changed to more personal opinions. First, the replantation program was realized without the cooperation of the fishermen, the pathway from the village to the channel was blocked, and the saltpan that the fishermen used to spread the fishing net was replanted as well. During that time, control of mangrove cutting activities continued to strengthen, as people continued to believe that they had the right to remove dead mangrove branches.
- 29 The link between rice and trees remained unchanged, with the drought having reduced both and the rainfall recovery also enabling the regeneration of both.

Brefet

- 30 When faced with the same impact from the drought and the low peanut stock price rates, the people of Brefet decided to target the intensification of a few select fields. Less fertile plots were abandoned to fallow and both manpower and cow manure were dedicated to the best plots. In the meantime, the women of Brefet benefitted from a dam building and invested large efforts into lowland cultivation on the border of the mangroves with great success. In Mandinka culture, husbands and wives keep their economies separate. During this period, where interest in highland crops dwindled, a new form of forest governance was developed, labelled community forestry, with two simple rules. A committee of old men, who decide which trees are cut and sold, and a committee of young men, who carry out serious surveys in the forest, combating cows trespassing in areas where important species were regenerating, fires, and illegal cutting. The young men even started to uproot *Azadirachta indica*, an Asian species correctly perceived as an invasive species (while still being recommended by Senegalese forestry agents). The community forest received enough income to collectively purchase a sawmill, solar streetlamps, and a hostel for ecotourism. This remarkably well-managed forest brought sustainable development to the Brefet community.
- 31 In the interviews carried out between 2006 and 2017, it appeared that the forest maintained good management, which continuously strengthened the local economy and territorial resilience. Nevertheless, the dam protecting the rice paddies from sea water began to leak because residents had insufficient resources to repair it. Women obtained the right to cultivate rice under the forest, which led to the development of an important clearing (leaving palm trees *Borassus flabellifer* and a few other trees) in a section of the community forest (Figures 10 and 11). In addition, before our 2017 enquiry, an important fire had occurred. It had been the first since the beginning of the forestry management program. These two small changes in the margins of this strong

and efficient community forest management program might have signaled a weakness. The mangrove is not included in the community forestry management. Mangrove cutting depends on an authorization given by the village chief. Rare clearings have been observed, mostly small size clearing few meters after the first line of *Rhizophoras*.

Figure 10: Conversion from forest to agroforest in Brefet (shown in red in Figure 11) (Andrieu, 2018).

Figure 11: Landcover change between 1979 and 2015 around Brefet.

Kamobeul

- 32 Since the 1980s, the rice plots of Kamobeul have experienced regular abandonment periods. During the interviews, abandonment was always initially explained by rainfall conditions (drought) and salinity increases (due to drought and dam neglect), but when the interviews proceeded deeper, the main reason was always revealed to be a lack of manpower. Young people who left Kamobeul to live in towns and students that did not

stop studying long enough to fully participate in rice cultivation were frequently cited. Most of the abandoned plots were those on the highest ground, those closest to the forest and far away from the mangroves, except some that were very close to the mangroves, which were abandoned when a dam broke. This led, in the last decade, to an increase in fallows and open-wooded landscapes around the dense palm tree forests (Figures 12 and 13).

- 33 The dynamics in the mangroves are similar to those of Diamniadio and Bani. The mangroves experienced important spontaneous diebacks during the drought and spontaneous regenerations after the rainfall recovery, accelerated by replantation programs, which are more important in this part of Casamance than in the Saloum Delta.

Figure 12: Land cover change between 1979 and 2015 around Kamobeul.

Figure 13: Fallows over past rice plots in Kamobeul (shown in green in Figure 12) (Andrieu, 2018).

- 34 As the rice crop decreased proportionally with the manpower, the rice nurseries shifted from agroforests to gardens. Until the early 2000s, the first stage of rice

cultivation was realized within the palm tree agroforest in a burning crops–fallow shift, which enabled tree selection (every burning and crop preparation phase consisted of cutting all the trees except palm trees (*Elæis guineensis*) and some other important trees (for fruit or medicine). Among the main changes between 2006 and 2017, was the almost complete abandonment of this practice in favor of fenced garden nurseries, with each family managing them close to their homes. The process of the palm tree forest becoming wilder was described as a consequence of this change and of the decline in palm wine extraction (also described as a consequence of younger people no longer living in the village or no longer being interested in such activities).

- 35 The set of results on these four case studies revealed that they had very few dynamics in common (Table 1). No major general trend could easily be described from the remote sensing data, nor from the enquiries.

Table 1. Synthesis of the changes, and drivers by period.

		Rice			Trees	
		What	Why		What	Why
Diamniadio	1979 to 2000	Regression	Drought	D	Progression	Rice regression
				M	Regression	Drought
	2000 to 2016	Recovery	Rainfall recovery	D	Progression	New specie on the island
				M	Progression	Rainfall recovery and replantation
Bani	1979 to 2000	Regression	Drought	D	Regression	Agroforest degradation
				M	Regression	Drought
	2000 to 2016	Recovery	Rainfall recovery	D	Progression	Agroforest restoration
				M	Progression	Rainfall recovery and replantation
Brefet	1979 to 2000	Increase	Women investment	D	Progression	Forestry management
				M	Stability	Forestry management
	2000 to 2016	Change location	Dam break	D	Stability	Forestry management
				M	Stability	Forestry management
Kamobeul	1979 to 2000	Regression	Drought	D	Progression	Fallows of rice paddies
				M	Regression	Drought
	2000 to 2016	Regression	Loss in manpower	D	Stability	Forestry management

				M	Progression	Rainfall recovery and replantation
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D: dryland vegetation; M: mangroves

- 36 The rice cultivations between the four villages differ considerably (even if they are sometimes separated by only a few kilometers), as well as the spontaneous vegetation. Table 1 provides a summary of the changes and identified drivers.
- 37 Unlike Kamobeul, which faced significant decreases in rice cultivation, the other three villages were resilient in terms of agriculture. Diamniadio and Bani experienced rice cultivation regressions during the drought, but they have recovered since. In addition, Brefet illustrated its resilience by shifting from lowland to plateau rice cultivation in response to the building of the dam and its subsequent degradation.
- 38 Regarding the links between rice and mangrove, this paper considered them much less important than previous rural state-of-the-art studies (Pelissier, 1966, Cormier-Salem, 1999). First, in Diamniadio, Bani, and Brefet, the rice was not cultivated in a possible mangrove area; only Kamobeul exhibited this configuration. In the Saloum, the rainfall is probably not sufficient and in The Gambia the lowlands at the transition between mangrove and dryland seem to satisfy the needs. Then, regarding Kamobeul, the changes in both mangroves (decreasing in the 1980s and 1990s, and then recovering) and rice cultivation (decreasing continuously) did not reveal direct links. Rice abandonment is often cited as a factor of the recent improvements in mangroves, but none have been observed (Andrieu *et al.*, 2019).
- 39 Instead, links between rice and dryland tree cover are much stronger in these case studies. However, the link is different in each of these four case studies. The Diamniadio system is exclusive (it is either rice or wooded vegetation), the savanna first increased and then regressed. Bani exhibited the opposite: when rice cultivation is strong, agroforests become denser. When rice is abandoned, agroforests become clearer, because when rice is not cultivated, peanut and millet are cultivated and, similar to rice in Diamniadio, here, these crops are not under tree cover. Brefet illustrates an intermediate case because the lowland investment in rice paddies has led to some clearing of the transitional vegetation between the mangroves and dryland (but not strictly deforestation), while later investment in the dryland forest also led to clearing (but not deforestation). Rice dynamics leads to light changes in landscapes but is not a driver of strong changes. The Gambian case study is peculiar because community forest management is different from all other landscape and vegetation management styles used throughout the whole studied coast. Kamobeul, until the early 2000s, had an exclusive relationship (lowland rice is grown in a completely open landscape, in areas that were mangroves or forests in the past, and which can be regenerated after abandonment) with rice agroforestry (the creation of rice nurseries under palm trees within agroforests). However, the second configuration almost completely disappeared, reducing the rice–forest relationship to a simple, exclusive kind, like Diamniadio.
- 40 However, if the separate dynamics are very different from one village to the other as are the relationship between trees and rice, 2 strong trends are common to the 4 villages: most of the changes provoked by the drought have known a recovery. No major deforestation is observed.

Discussion

- 41 Are these changes important? Do these changes have a negative impact on the anthroposystem and biodiversity? Are these changes examples of the actual degradation of the environment?
- 42 First, remote sensing has revealed a positive amount of forest cover, in terms of both mangroves and dryland, so deforestation should not be considered as a problem here. The positive trends with regard to mangroves are consistent with other studies (Fent *et al.*, 2019; Conchedda *et al.*, 2008; Conchedda *et al.*, 2011; Dieye *et al.*, 2013). About forest cover, this remains the same approximate size, but dryland forest restoration is different to that of mangroves. Woodland dynamics are, of course, more complex than binary changes (gain and loss stability). Here, the neutral budget hides some changes, including the amount of forest lost to allow for the creation of new croplands, later identified as wooded land (if not forest) when cashew orchards became more prevalent. In addition, savannas can become quantitatively degraded (lesser tree cover and lesser species). This has been observed in the classified forest closest to Bani, where illegal cutting was important and *Azadirachta indica* was spreading rapidly, in competition with local species. On the contrary, the excellent management of Brefet is not seen in the remote sensing data.
- 43 Regarding the agroforests in Bani and Brefet, the changes seemed to remain within the metastability range of a resilient system (the Bani agroforest was restored after the rainfall recovery, and Brefet benefited from excellent forest management). Regarding Kamobeul, the management of the agroforests there is currently undergoing a period of change, and a transition is being made that will lead to reduced management. In terms of the environment, this would probably be considered as a positive trend, but, in terms, of the anthroposystem, it constitutes another signal of strong change in the whole system. Moreover, this agroforest was known for providing important resources and ecosystem services, so reducing its management and allowing it to become wilder is probably not such a positive trend for the people of Kamobeul. Of course, some questions remain. Are the differences in these 4 villages due to local situations? Are the differences in these 4 villages due to the agrarian and environmental policy of the country they belong to?
- 44 The approach integrating remote sensing, botany and interviews and trying to avoid the biased states of reference (the drought, the colonial period) and including 4 dates in the landscape dynamics seems efficient in the evaluation of landscape dynamics in terms of resilience vs degradation.
- 45 These changes are important, but most of them remain within the range of metastability. That is why this paper describe the landscape dynamics as processes of resilience. Indeed, the drivers of changes have not provoked structural or permanent changes in the anthroposystems. None of the recent changes since the end of the drought can be associated with a major environmental crisis, a major loss in the forest cover or significant fragmentation. That is the reason why this paper opposes the general narrative about degradation to this observation of resilience. During the interviews, economic difficulties were frequently stated, but the studied changes in agrarian landscapes were not associated with a major decrease in income by the people interviewed, apart from the loss of access to mangrove wood resources.

Conclusions

- 46 This paper, by exploring changes in the relationships between rice and tree cover, in a 4 villages with the synergy of remote sensing, botany and interviews, revealed that the relationships between agriculture and forest can change over the space of a few kilometers and over a period of one decade. The landscape is sometimes built with either rice or trees, and they are also sometimes combined in a sustainable manner.
- 47 Then, when focusing on the changes, this paper revealed that these anthroposystems are strongly resilient during changes in the climate. All four villages have had to change their cultivation and resource management during the droughts, and most of them have also reacted to the rainfall recovery, showing resilience. Here, the agriculture of Kamobeul appears to be different and, thus, maybe less resilient, but the driver of change here is socio-economic, and it is hard to evaluate its resilience to climate change. Its mangrove has also demonstrated resilience.
- 48 The situation in the Saloum, The Gambia and the Casamance, therefore, appears to be inconsistent with the main environmental crisis. The forests are protected well in dedicated areas and are managed well by the population (e.g., in The Gambia). Forests and crops suffered from the severe droughts of the 1970s and 1980s, but they have shown resilience almost everywhere. It is therefore important to change the main narrative of environmental questions for this study, which could be seen as a success stories and not as an example of degradation, as is usually the case.
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ABSTRACTS

We studied, at local scale, how the landscape dynamics of the Saloum and Casamance (Senegal) and The Gambia can reveal environmental crises and the resilience of agrarian. The method is based on remote sensing diachrony in land cover maps, field observations (landscape and botany), and interviews on recent landscape changes and agriculture. The results found that the relationships between agriculture and forest cover were complex and varied in space and time. However, some general trends appear: the period of drought prompted changes but with the rainfall recovery, a regeneration in the mangroves and a restoration in most rice crops happened. The changes stayed within the range of metastability, showing the strong resilience of the ecosystems and of most anthroposystems.

Cet article étudie, à l'échelle locale comment les dynamiques des paysages du Saloum, de la Casamance (Sénégal) et de la Gambie peuvent informer sur les crises environnementales ou, au contraire, la résilience de ces systèmes agraires. La méthode est basée sur la production de cartes d'occupation du sol diachroniques par télédétection diachronique, des observations botaniques et paysagères sur le terrain et des enquêtes sur les changements récents des paysages et de l'agriculture. Les résultats obtenus indiquent que les relations entre agriculture et la couverture forestière ont été complexes et ont varié dans l'espace et dans le temps. Néanmoins certaines tendances générales apparaissent : la période de sécheresse a provoqué des changements mais, avec la reprise des pluies (fin des années 1990) s'observent une régénération des mangroves et une reprise de la riziculture dans la plupart des terroirs. Les changements sont donc restés dans le domaine de la métastabilité, et ont démontré une forte résilience écosystèmes et de la plupart des anthroposystèmes.

INDEX

Mots-clés: dynamiques paysagères, anthroposystèmes, rizière, agroforêts, mangroves, Afrique de l'Ouest, résilience

Keywords: landscape dynamics, anthroposystem, rice, agroforests, mangroves, West Africa, resilience

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