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An Interdisciplinary Approach to Understand the Resilience of Agrosystems in the Sahel and West Africa

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Abstract: Sub-Saharan African farmers have long been portrayed with very negative representations, at least since the beginning of coordinated European colonialism in the late 19th century. In the Sahel-Sudan area, agrosystems have been described as overgrazed, forests as endangered, and soils as overexploited, with local and traditional "archaic" practices. Against this background, the objective of this article is to focus on these agrosystems' resilience, for which several criteria have been monitored. The approach used in this research was to synthesize observations from a large amount of material gathered over multiple years by the authors, drawing on our long-term commitment to, and inter-disciplinary study of, the evolution of surface hydrology, ecosystems, and agrosystems of West Africa. The positive trends in rainfall and streamflows, reinforced by farmer's practices, confirm the overall regreening and reforestation of the Sahel-Sudan strip, especially in areas with high population densities, including the mangrove areas. The intensification of agricultural systems and the recovery of the water-holding capacity of soils and catchments explain the recorded general increase in terms of food self-sufficiency in the Sahel, as well as in crops yields and food production. Finally, we compare the neo-Malthusian discourse to the actual resilience of these agrosystems. The article concludes with a recommendation calling for the empowerment of smallholder farmers to take greater advantage of the current wet period. Overall, the speed of change in knowledge and know-how transfer and implementation, and the farmers' ability to adapt to ecological and economic crises, must be highlighted. Far from being resistant to change, West African agriculturalists innovate, experiment, borrow, transform, and choose according to their situation, projects, and social issues.

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1. Introduction: Departing from a Very Afro-Pessimistic Narrative

The concept of an agrosystem, or social–ecological system, refers to a dynamic and holistic apprehension of the relations between human societies and their environments. Those systems adapt—or not—to environmental or social disturbances, to their frequency and intensity. They cope—or not—with cumulative pressures or sudden events to recover a functional state, possibly to take advantage of the circumstances. The analysis of the resilience of such socio-ecological systems considers the transitions between different functional states, which are more or less desired and looked for by a given human group at a given time.

Desertification is a good example of the mutual relationships between mesological and social dynamics, which are neither synchronous nor uniform in space [1,2]. During the wet period in the Sahel that preceded 1967, the strong land pressure of still extensive agriculture (to meet the needs of both a growing local population and colonial markets overseas) disrupted the conservation practices for tree cover and soils' organic and mineral fertility. Sociosystems have marked ecosystems. The great drought of the 1970s–1980s led to even more degradation of soil and vegetation that was already fragilized by unsustainable practices. In turn, these physicochemical and biological dynamics influenced the local population's livelihoods. Both ecosystems and sociosystems were affected. Soil degradation became a factor as well as evidence of desertification. Soils lost their structural characteristics and their water, carbon, and nutrients holding capacities.

Nevertheless, on the margin of international conservation programs, many rural Sahelian communities have been able to adapt to the multi-decade dry period. They combined the indispensable increase in food production with the necessary sustaining of ecosystems. They succeeded by implementing a mix of practices that they had inherited and borrowed, which were very often re-interpreted, or at times, completely innovated. This included modifications of cultivated species or varieties; changes in technical practices and usage of space; diversification of economies and income sources; new patterns of mobility, etc. [3]. In many places, new knowledge and know-how have produced regreening dynamics that largely draw from agroforestry, after the lack of rainfall led to significant losses in biomass [3–12].

However, in sub-Saharan Africa, the inhabitants of the Sahel-Sudan areas have long been portrayed with very negative representations. The persistence of droughts and agrosystem degradation have been partly attributed to human activities, thereby 'justifying' the European colonial enterprise with a semi-scientific discourse. Lands have been purposefully described as overgrazed, soils as overexploited with local and traditional "archaic" practices, and forests as endangered. In 1945, French colonial official Périé [13] in Maradi (located in today's independent state of Niger) contributed to the discourse on local populations' supposed incompetence, short-termism, and sheer danger to their environment: "*In sedentary areas, deforestation is almost total, nothing can resist to the farmer's unconsciousness and vandalism*".

The whole Sahel-Sudan area is still commonly presented in the media as undifferentiated places that suffer from cumulated ecological and social disasters: overpopulation, desertification, aridification, bad governance and high levels of poverty and inequality, political instability, as well as administrative, educational, and public health misfortunes, among other crippling issues. In a large number of reports from development multilateral and regional organizations, think tanks, NGOs, and even in a number of scientific publications [14], the pan-Sahelian drought is expected to continue; deserts to advance; forests to disappear; crop yields per hectare to fall; and food dependence to rise; and, at last, people's migrations to massively increase [10,15].

The Sahel-Sudan area has undeniably been featuring extreme meteorological events and vulnerabilities for over a half century. After the protracted regional severe droughts of the 1970s and 1980s, there has been a return to pre-drought rainfall amounts, but with increased devastating heavy rainfall events since the late 1990s and early 2000s [16–19]. It is also undeniable that some Sahelian agrosystems have experienced erosion that is difficult to remedy. However, as explained by [15], the catastrophic "desertification narrative" has iteratively been shaping the ideas, discourse, and international development agenda for this sub-region since the 19th century; it still influences decision making for the allocation of international development resources [20], "regardless of the fact that the majority of literature in environmental science does not support its underlying rationales" ([15], p. 117).

Vegetation has adapted and has so far withstood the impacts of climate and anthropogenic changes; the observed regreening is general, and accompanies the sharp increase in cultivated areas. Figure 1 shows the net primary productivity of the West African sub-region in 2023 and its meridian spatial distribution.

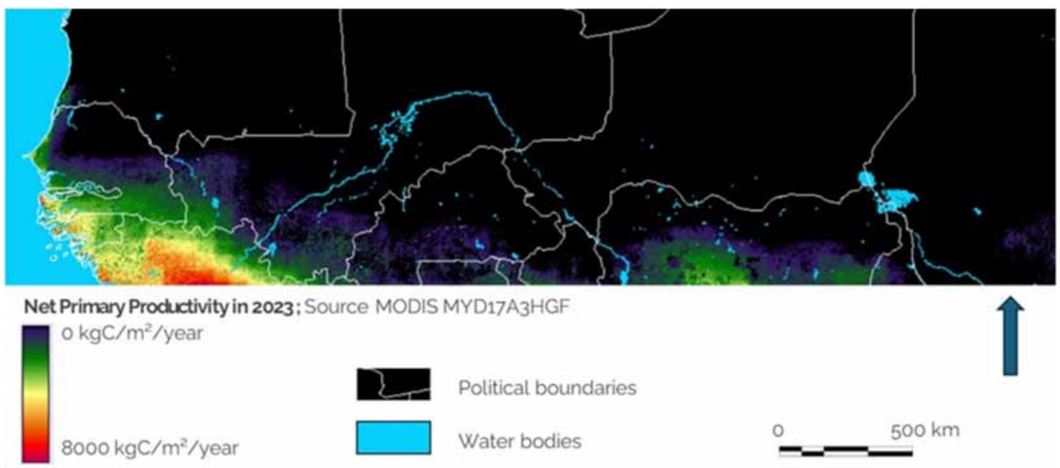


Figure 1. Net primary productivity of West Africa (MODIS data, 2024).

Resilience dynamics, we articulate in this article, illustrate the way many local farmers and herders have been able to cope with disturbances, the way they have been perceiving or anticipating environmental risks, and how they have been adapting to their changing frequency and intensity. To do so, the following section brings a transdisciplinary perspective with positive trends in rainfall and stream flows across the Sahel and West Africa (section 3.1), and the transformation of agricultural knowledge and know-how. Section 3.2 confirms the overall regreening of the Sahel with the return of tree cover (3.2.1) and the extension of mangrove areas (3.2.2). Section 3.3 underlines the recovery of the water-holding capacity of soils and catchments. Section 3.4 highlights the general increase in food self-sufficiency in the Sahel, as well as in crop yields and overall food production. Finally, in Section 4, there is a discussion about the "desertification narrative", the more general Afro-pessimistic discourse, and the social–ecological resilience of the agrosystems of the Sahelo-Sudan area, and even of West Africa.

2. Methodology

This paper is based on a large amount of material gathered over multiple years by the authors, drawing on to their long-term commitment to, and inter-disciplinary study of, the evolution of surface hydrology, ecosystems, and agrosystems of West Africa. More specifically, Section 3.1. draws on climatic and hydrological data assessment and treatment material that was gathered via the National Hydrological Services of six West African countries (Senegal, Gambia, Mali, Guinea, Burkina Faso, and Niger); Section 3.2

relies upon aerial pictures and landscape observation, and more generally on the synthesis of abundant documentation on [Section 3.2.1] Sahelo-Sudanian land use, land change monitoring, and [Section 3.2.2] a West African mangrove survey; Section 3.3 is based on evolutions of the depletion coefficient and runoff coefficient for the main West African rivers, used as indicators of basins' water-holding capacity; Section 3.4 rests on the rich FAOSTAT3 database, which is open access.

The fourth and final section provides a synthesis of previous sections, and features insights of a study on land use changes in the Fouta Djallon range known as the "West African natural water tower". It provides a transdisciplinary analysis of the intensification of agricultural systems, the general increase in terms of food self-sufficiency, and the actual resilience of these agrosystems across West Africa's Sahelo-Sudanian region.

In the entirety of this article, the statistical processing was carried out in Excel© (2016) including XLSTAT©(2024 1.1); the figures are also from Excel for some, and from Power Point©(2016) for others.

3. Results

This section gathers the authors' observations on the evolution of the surface hydrology, ecosystems, and agrosystems of West Africa.

3.1. Positive Trends in Rainfall and Streamflow

After the 1950–1967 humid period and the long 1968–1993 West African drought, rainfall and then streamflows have been reaching and exceeding their long-term average values.

3.1.1. Rainfall Recovery

It is well established that the extreme period of the "great drought", which characterized the third part of 20th century, is marked by a sharp decline in rainfall until the mid-1980s. Since then, yearly rainfall has been increasing [17]. As the drought had begun in 1968, only people who were more than 10 years old in 1950—and thus more than 80 years old in 2020—could potentially remember that rainfall was significantly heavier between 1950 and 1967 (Figure 1). However, they can attest to the relative youth of many settlements created when the rains were good and land reserves were still plentiful. Oral memories of these elders have partly been building the social perceptions of a pre-drought generous, abundant, and regenerative nature, which has long vanished.

Figure 2 shows that the rainy 1950–1967 period (unfortunately, this is too often considered as the baseline period, but is qualified here as hyper rainy) was followed by the long and hyper-dry 1968–1993 period that lasted until 1998 in Senegambia, in the western side of West Africa. Elsewhere in the Sahel, since 1994, the yearly rainfall amounts have been around or above the long-term average (1920–2020), with large interannual variability, as was also observed during the 1900–1950 period. The same increasing trend is observed over two windows, the Senegambia and the middle Niger basin [21], and over the whole of West Africa [22]. This is confirmed by [23,24] and partially by the article of Nicholson (2013) [25], which show an increase in rainfall since the 1990s in the eastern and central Sahel. However, Nicholson et al. (2018) [26] are more nuanced: "*From 1994 onwards the inter-annual variability was strong and only a few years were as wet as the 1950s, but these wet conditions did not persist from year to year. This suggests that the rainfall regime in the Sahel has not fully recovered to its pre-drought conditions (…). The frequent shift between anomalously wet and anomalously dry years since 1994 appears to signal an increase in inter-annual variability*". Figure 2 shows that, before the anomalous wet period (1950–1967), the interannual variability was relatively high with some alternation of wet and dry years, such as the current period.

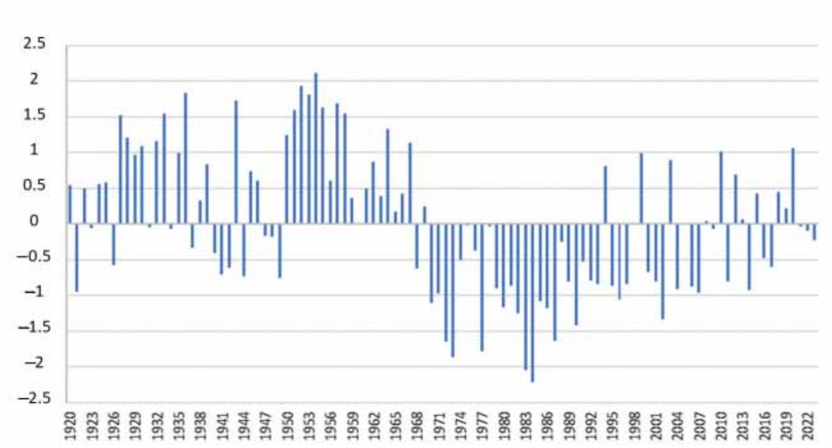


Figure 2. Standard precipitation index from 1920 to 2020 in the whole West African Sahel.

This more positive ongoing trend in rainfall should logically benefit agrosystems, but its benefits should be moderated by three elements [27]:

- The rainfall seasonal cycle evolution (start, end, dry spells, wind, etc.), [28–31];
- The statistically significant increase in the number of extreme rainfall events observed since the mid-2000s [23,32];
- The increased evapotranspiration, due to rising temperatures, that will "consume" a non-negligible share of the expected increase in rainfall [33].

3.1.2. Streamflows

In the mid 1990s (about ten years after the change in rainfall), and in a more gradual manner, a re-increase in (post drought) discharges from rivers can be observed. First, natural reservoirs had to be filled again, as they had gradually emptied during the protracted drought, sustaining low water flows for years. Major river flows have partially recovered during the 2010s towards their mean discharges of before the 1950–1967 wetter period (Figure 3) [16].

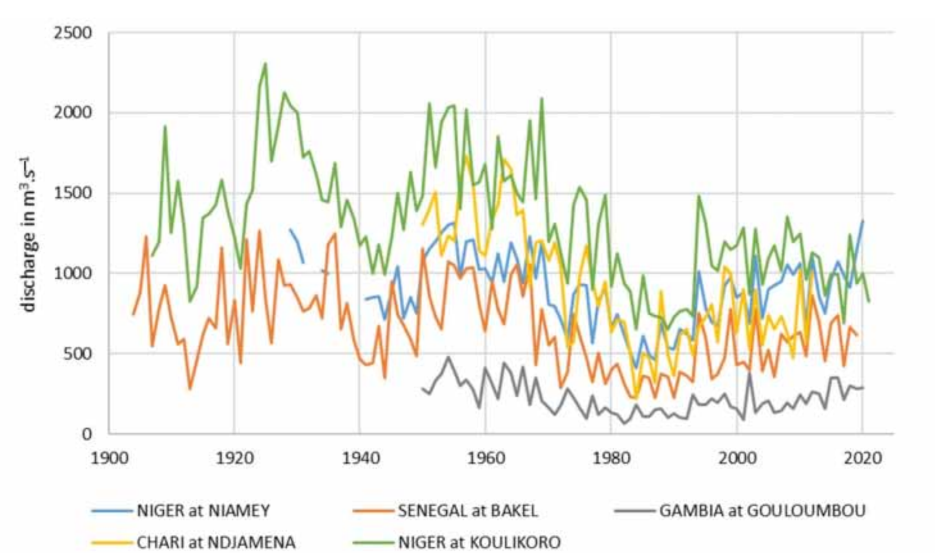


Figure 3. Sahelian major rivers discharge evolution ([16], actualized).

Another kind of Afro-pessimistic paradigm is the one of water scarcity and overexploitation. Due to low water consumption rates per capita, the water balance in West Africa is far from being as stressed as Europe's water balance, for example. It remains markedly lower than in northern countries [34].

3.2. A Proven Regreening

Since the beginning of the 1990s, indexes from satellite data have shown a gradual regreening of the Sahel, following the return to "mean" rainfall conditions (Figure 2). Indeed, the "relative increase in annual rainfall levels since the very end of the 1990s, which reached the 1900–2015 average value, appears to be the main factor explaining the observed, widespread regreening trend over the Sahel, and mostly in rural areas. Almost all remote-based vegetation maps demonstrate a dominant increase in NDVI signal since the early 1980s" [35–41]. Most of the regreening is more likely due to herbaceous recovery, although there is also evidence of "significant natural increase in tree cover over the last 15 years" [42].

These maps (Figure 4) show that there is not exactly overlap of each regreening or deforestation area, which suggests that the magnitude of regreening can be in some cases a consequence of management practices of the agro-pastoralists, and in other cases, a consequence of rainfall recovery, or to the contrary, the persistence of aridity.

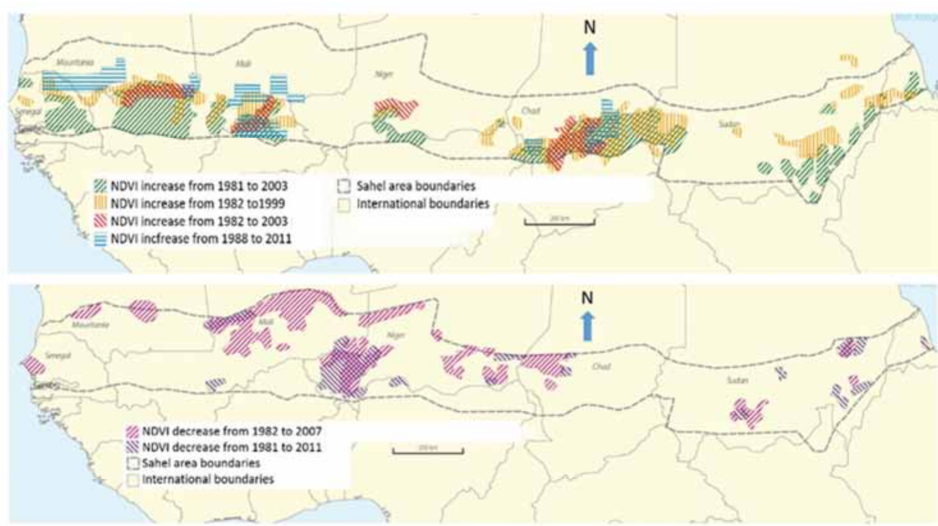


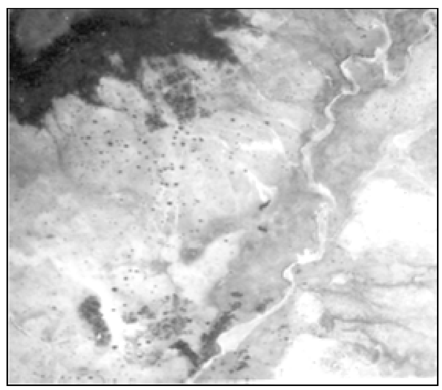
Figure 4. The Sahel's regreening [16] according to [35,37,38]: areas of NDVI increases and decreases for different periods and different sources.

3.2.1. The Return of Trees in the Sahel-Sudan Areas

In 1998, Fairhead and Leach [43] underlined the mismatch between the discourse of massive deforestation in West Africa and the situations observed on the ground. They also highlighted that the deforestation rates exaggeration often justified draconian environmental policies, which further impoverished the people living in this already disadvantaged region. André and Pestaña [44] also pointed to the pessimistic discourse of postcolonial observers. Investigations in the literature [35,37,45] using remote sensing confirmed a reforestation trend that had already begun emerging since the 1990s and 2000s. This process emphasizes a deep transformation of social representations and knowledge about trees. Their role in biodiversity and fertility conservation is clearly expressed, such as in anti-erosive action [46].

Some forms of agroforestry have always existed before and during colonial times. For example, the southern part of what became the Senegalese groundnut belt is now inhabited by more than 300 inhabit/km^2 [47]; the southern Hausa region in Niger has a local population density that has reached 200–250 inhabit/km^2 [48]. In the Maradi region of Niger, the international NGO Sudan Interior Mission improved, by the early 1980s, the old and well-known practice of integrating trees into the cropping system. It consists either of preserving tree stumps and clump shoots, or in planting young trees so that farmers could select the species, their location, and density. In such a process of resilience induced by new knowledge and practices, new actors are involved in new tasks: village tree nurseries have been created everywhere, and have often been managed by women.

Landscapes have profoundly been transformed in the areas of high rural population density that were heavily deforested by agricultural expansion and droughts. As shown in Figures 5 and 6, since the hyper-dry 1968–1993 period, the areas occupied by tiger bush and most of the forest gallery located on the collective highlands and lowlands have decreased in sheer size. Despite the growth of settlements, many trees have been purposefully spared or planted in crop fields making up agroforestry parks. Elsewhere, orchards, little woodlands producing firewood and timbers, and hedges, have developed in the appropriate fields.



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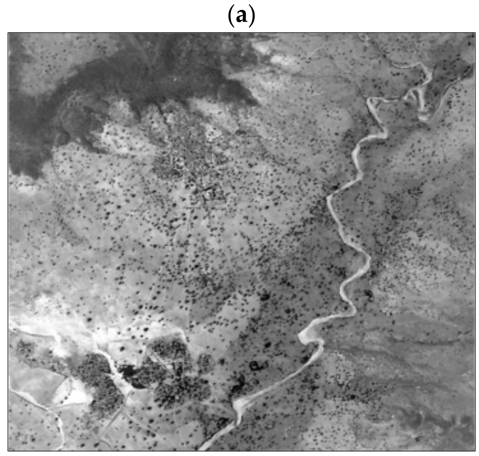
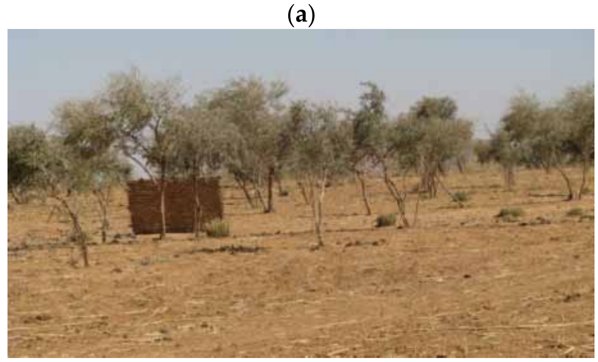


(**b**)

Figure 5. Change in tree cover density and distribution in Galma, Niger (400 mm rainfall) between 1975 (**a**) and (**b**) 2003 [8].

(a)



(b)

Figure 6. Diversified old agroforestry park with (**a**) *Combretaceaes*, *Ficus*, *Bauhinia*, *Cassia*, *Tamarindus*, *Piliostigma*, and *Lannea* in the Maradi area (2002); (**b**) about ten years agroforestry park, consisting mainly of *Guiera* and some *Bauhinia* (2008). (Niger) (ph. A. Luxereau).

Reforestation via agroforestry is well advanced in Niger. However, it is also taking place in many other areas like the Yatenga plateau in Burkina Faso, the Gondo plain in Mali, or the northern part of the groundnut zone in Senegal. The evidence that trees have been an important component of agrosystems in these regions has been underlined by many authors [49–52].

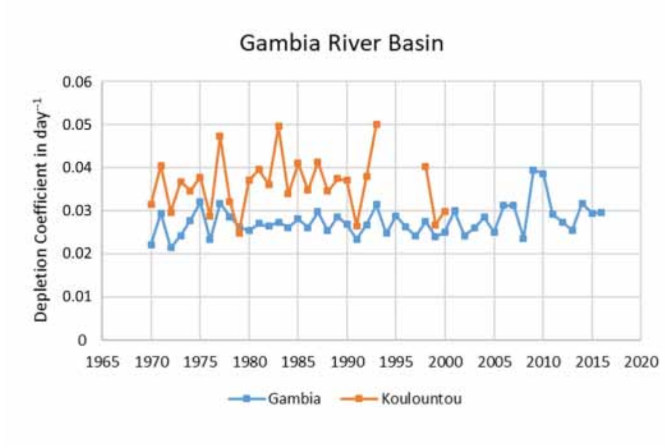
3.2.2. An Exception to a Worldwide Trend: The Return of the Mangrove

A kind of vegetation has long been erroneously considered as dying in West Africa is the mangrove. However, as shown by growing literature [53], it is doing well, and even increasing [54,55].

The West African mangrove had certainly suffered from the salinization of the *bolongs* (Mandinka name of the mangrove's rivers) during the great drought. However, since 1992, many projects have been witnessing its revival, particularly since the 2000s, as supported by the increase in literature [54–56]. In Senegambia, it increased by 55% between 1988 and 2018 : 115% in the Saloum river delta [53-56], + 31% in Gambia River estuary [54, 55], and +39% in Lower Casamance River estuary [53-55, 57]").

3.3. A Recovery of the Water-Holding Capacity of Soils and Catchments

One of the problems posed by the above-mentioned return of the rains in the Sahel has been that the soil's structure and its hydrodynamic behavior had been modified during the 1968–1993 drought, and that these have not always recovered their previous physical properties. In order to estimate the evolution of the natural basin's water-holding capacity, an analysis of the depletion coefficients was carried out on 16 main rivers that have their source in the Fouta Djallon massif [17]. Contrary to what a previous study completed in the upper Niger basin suggested [16], the results below (Figure 7) show that a majority of catchments have seen their depletion coefficient decrease (assuming they had increased during the drought) with the return of the rains. Most of the river basins that provide fresh water to the Sahel have experienced improvements in soil water-holding capacity, with the only exceptions being two tributaries to the Upper Niger River (the Milo and the Niandan Rivers) and the opposite Atlantic hillslope of the Fouta Djallon, the Konkouré River, and two of its main tributaries. In other words, the natural water storage conditions have been reinstalled in most of the cases where they had been degraded during the great drought.



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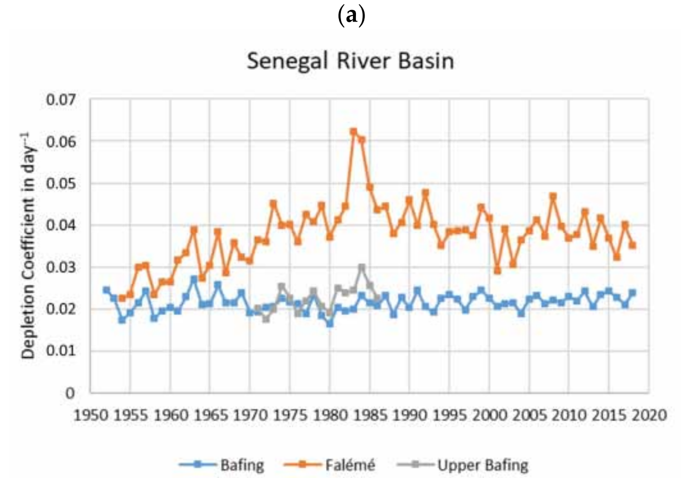

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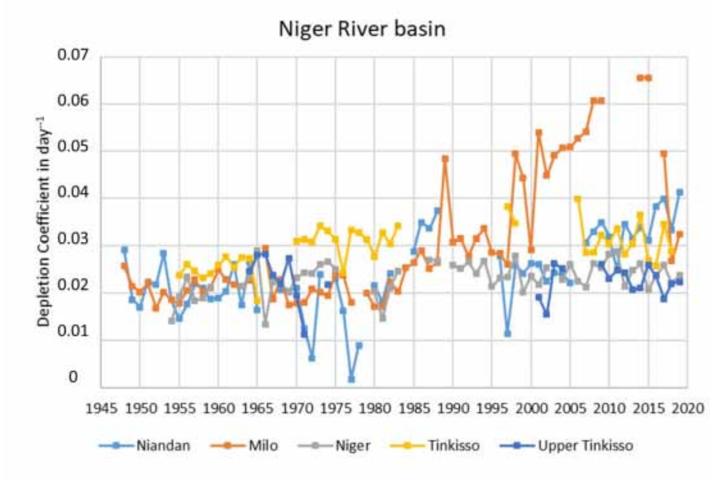

(**c**)

Figure 7. Evolution of depletion coefficients of rivers in Gambia (a), the Senegal (b), and the Niger River Basin (c) since the 1950s [17].

3.4. A Restoration of Food Self-Sufficiency Levels

Many droughts are remembered in the Sahel-Sudan strip for the famines they generated [58]. However, this region, characterized by the highest population growth in the world, has regained overall self-sufficiency. Figures contradict the Malthusian logic that asserts that human population growth that is faster than the means of subsistence in agrarian societies leads to famine and/or resource-based conflicts [59]. Overall agricultural production has increased, and food insecurity has been declining to varying degrees depending on the agricultural and political contexts over the past two decades. These societies have apparently developed more sustainable and labor-intensive agrosystems. This is in line with the theses developed by [60] about agrarian societies.

Since 1986, we observe a growth—although uneven—of all food crops across West Africa: cereals, roots and tubers, pulses, and vegetables. For example, from 1980 to 2006, cereals production from West African countries (CEDEAO) has risen from 16 to almost 50 million tons, while roots and tubers have risen from 27 to 124 million tons. As shown on Figure 8, the Sahel sub-region as a whole became increasingly more self-sufficient for cereal in the last 20 years. The inland Sahelian area (Mali, Burkina Faso, Niger), known for featuring highly food-insecure areas, covers its cereal needs overall, even if it does not prevent food shortages than affect either some areas or specific populations (children, nomadic herders, etc.).

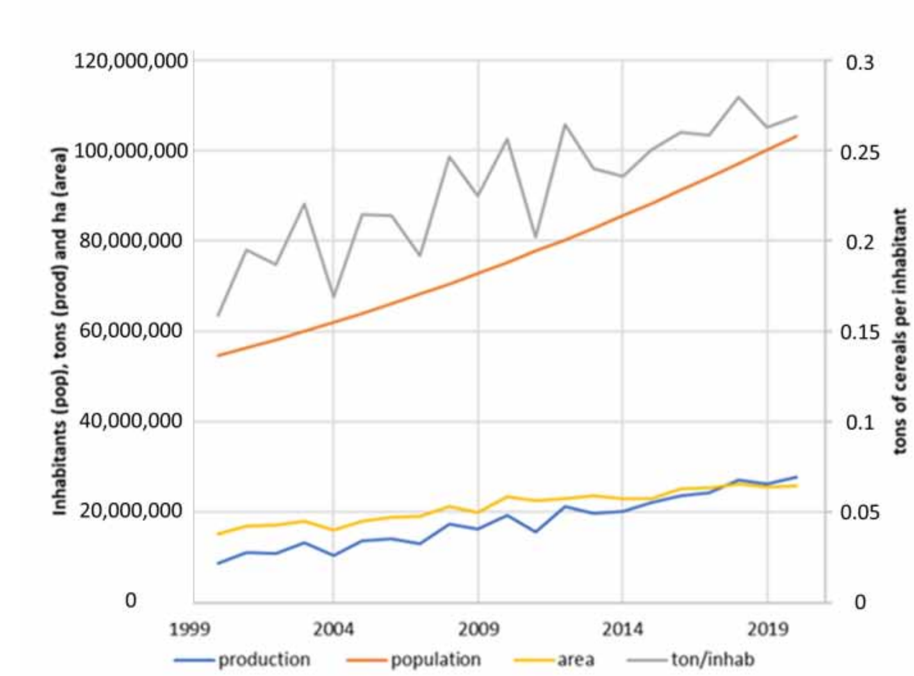

Figure 8. Evolution of cereal self-sufficiency in the Sahelian countries (Senegal, Mauritania, Mali, Burkina Faso, Niger, and Chad, pooled), showing an increasing self-sufficiency rate [61].

Figure 8 shows that production has tripled while population doubled; thus, the available food per inhabitant increased significantly. Table 1 shows that crop yields increased by 32% for roots and 50% for cereals on average, with cultivated areas rising by 60%.

Table 1. Evolution of main crop yields produced in West African Sahel from 2000 to 2020 (mean values of Senegal, Mauritania, Mali, Burkina Faso, and Niger) [61].

Crop	Evolution of Crop Yield 2000–2020 (%)	Crop	Evolution of Crop Yield 2000–2020 (%)
cassava	+33	pearl millet	+27
groundnuts	+31	rice	+36
maize	+52	sorghum	+60

As shown previously, a sharp increase in sawn areas (grazing areas, lands considered marginal, land reclaimed through reforestation) is observed. According to [62–65], this is the main reason for the overall growth in agricultural production. Comparatively, growth in yields (kg/ha), which is still positive, has remained relatively weak and unequal, depending on the crops grown.

Diversification of species and varieties (use of ssp-called “improved varieties” and also reintroduction of old varieties, such as the pearl millet *sanyo* in Senegal), the intensification of practices, the abandonment of cultures originating from the colonial system, have all contributed to the rise in crop yields. In parallel, new agricultural productions or trade, for instance, have contributed to maintaining the livelihood of populations.

A PCA was conducted to synthesize this information and determine the relationships between variables and observations. Table 2 contains the observations based on the PCA. All of the variables have been increasing, at least since 1990. Figures 9 and 10 show the distribution of variables and observations for the first two components, which explain more than 95% of the variance. In Figure 9, we can see that all the variables are grouped together because of their very similar behavior; the same is true, in Figure 10, for the years of observation. Only 1990 stands out from the fact that the inertial effects of the drought are still being felt 5 years after the end of its severe phase: flows and mangroves were slow to recover when the rainfall rose.

Table 2. Evolution of data used in this research.

Year	Rainfall (mm)°	Runoff ($10^6 m^3$)	NDVI	Population (Million)	Mangrove (Area km²)	Grain Production (Million Tons)
1980	750	1645	0;246	35	1800	3.9
1990	802	1344	0.247	49	1660	5.7
2000	846	1823	0.249	65	2110	8.67
2010	867	1890	0.253	89	2270	19.3
2020	873	1814	0.253	121	2560	27.7

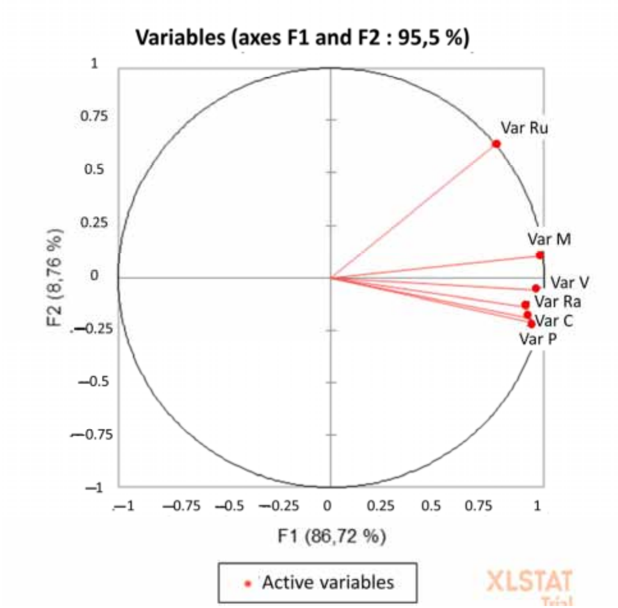

Figure 9. Distribution of variables in their statistical space (Ru = runoff; M = mangrove area; V = NDVI; Ra = rainfall; C = cereal production; P = population).

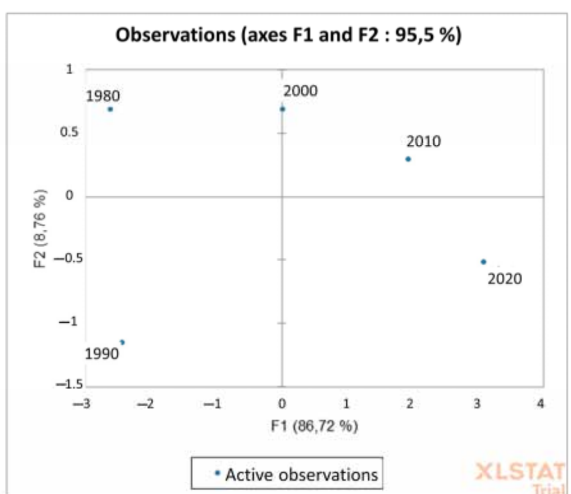

Figure 10. Distribution of samples in their statistical space.

4. Discussion about this Afro-Pessimistic Discourse

The consistently pessimistic and even catastrophist discourse representing poor farming populations (all over the world), as well as the colonial and neo-colonial propaganda [66], are not scientifically supported by many situations of current West African agrosystems, including in the Sahel. We can consider these many agrosystems as testimonies of resilience of both the environments and their agrarian societies.

Against the 'causal link' between overpopulation and environmental degradation highlighted by the Afro-pessimist discourse, the numerous field research studies mentioned in this article, conducted both at regional and village levels [6,11,67–69], show the same process: Already in 2005, it was observed that the increase in rainfall was mixed with human factors to explain the regreening of the Sahel [70]. Agroforestry park density is higher in densely populated areas, for example, up to 120–150 trees/ha in the Maradi and Zinder areas, where 70 to 90% of the land is used and the population density is often greater than 150–180 inh/km^2. Regreening has been confirmed throughout the Sudano-Sahelian strip by more recent studies that have linked this phenomenon to the return of rains and the actions of local actors [47–74]. This process, which is spectacular in the Sahelian areas affected by droughts and land pressure, is documented in many other regions. For example, [75] showed that the most densely occupied area of the Bafing River basin, in Middle Guinea, is also the one where forest vegetation had increased the most between 2000 and 2020 (Figure 11). The mean population density of this Bafing basin is 40 inh/km^2, but it exceeds 100 inh/km^2 in the upper-southern basin, as in the whole Fouta Djallon central plateau it is a part of. The intensity of work (in this case mainly that of women, due to migration) to promote water infiltration is saving and even improving the capacity of the massif to the point of becoming the water tower of West Africa.

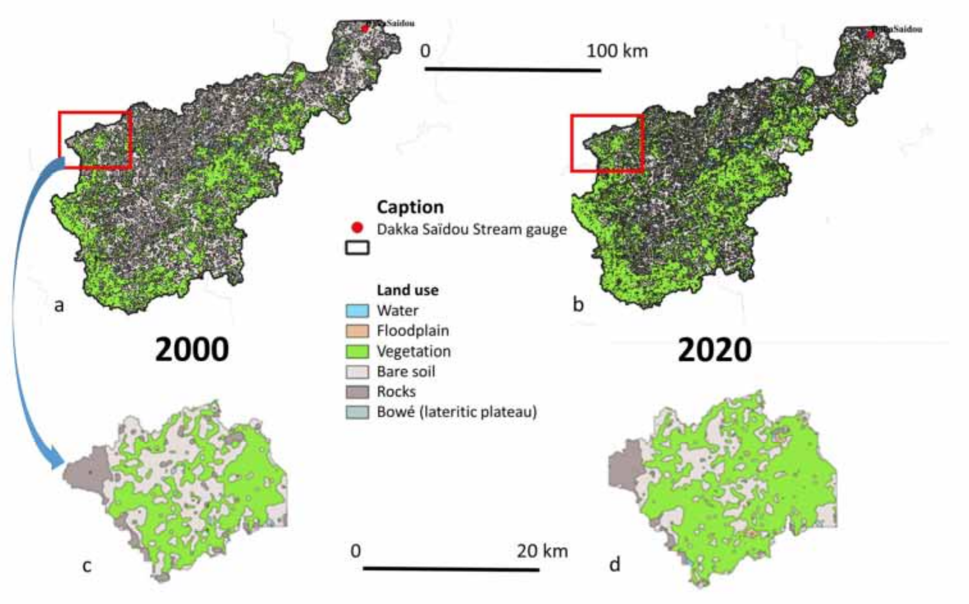

Figure 11. Vegetation evolution in green color, between 2000 (**a** and **c** panels) and 2020 (**b** and **d** panels), in the Bafing basin (**a** and **b** panels) (Guinea, name of the Upper Senegal River basin), and zoom on the area of Labé (**c** and **d** panels) (the major city of the range), the most densely populated area [69] (The grey sector westward is the suburbs of Labé).

Very recently, it has been confirmed that regreening is mostly linked both to good rainfall and to the virtuous actions of the populations; however, this is sometimes linked, as in the Fouta Djallon [75], to exodus and rural abandonment; the regreening clearly takes the form of extensions in forest areas, whether this involves continental forests or mangroves [57,76].

In the Sudan-Sahelian countries considered in this article, retrospective analyses show that endogenous innovations are frequent, and mechanisms of diffusion can be powerful, rapid, and diversified [77,78]. The spectacular spread of off-season transplanted sorghum in the great flooded clay plains of the Chadian basin was initiated long before the 20th century by Fulani and Showa Arab herders. It still continues [79], highlighting the adaptability of past and present agrosystems. Farmers have proved that they can quickly evolve their representation of nature, knowledge, and know-how, independently or with the support of agronomic developers. In the case of regreening, different approaches and techniques are often combined: agroforestry parks, zai holes, anti-erosion barriers, etc. These practices are well known, not very expensive but labor intensive, and have efficient impacts: return of the tree cover, improvement in spontaneous biodiversity, better soil fertility, reduction in erosion, softening of the local climate, and higher water tables. On their part, developers sometimes improve local practices.

Alongside the environmental changes, economies and, more generally, social relations, are also changing: diversification of crops, integration of agriculture and livestock, empowerment of village communities and of women, etc. A form of intensive agriculture (both in terms of labor and capital) has been gaining in importance [80]. This phenomenon is observed at the level of individuals and families. It also exists at the level of villages and small regions that can develop products with a strong national and international reputation, even international labels. A comparison may be done with the Kikuyu country of Kenya, where analogous dynamics have been observed for a long time [4].

Still, this analysis should not obscure the fact that these processes are localized; they do not apply to everyone and every place, and they are not always virtuous. Temporal, spatial, and social scales must be taken into account. Even if West Africa is mostly regreening, the re-establishment of woodland by farmers is unequal, either in its composition or in its location [5,52]. Some areas remain under severe constraints, even moving towards forms of desertification; natural forests have decreased significantly. On a social level, the situation still endures that resulted from land pressure, the great drought, punctual famines, and the establishment of a land market. Small farmers who were not self-sufficient or barely self-sufficient, and who sold their land during drought periods, have not benefited from those environmental resilience dynamics [81]. Herders, young people, and women [82] have often been excluded from accessing increasingly scarce agricultural land. On the other hand, the peasants who capitalized on land, savings, means of production, and labor have been able to take full advantage of these differentiated improvements. The unequal distribution of land resources between production units, between men and women, between young people and elders, nomadic breeders and sedentary farmers, still exists and is visible; often, these disparities have increased.

5. Conclusions

This article highlights the environmental and socio-ecological resilience of an African sub-region that was often objectified with a deterministic and dystopian grand narrative, i.e., the Sahel-Sudan strip of West Africa that experienced a high rainfall deficit at the end of the 20th century. After that long dry period, hydrological, ecological, and social systems have been reproduced, yet with significant changes. From an economic point of view, the investments in natural resource management jointly made by farmers and technical services have been positive.

Since the extreme hollow of the "great drought", which occurred in the mid-1980s, yearly rainfall has generally been increasing. Five or ten years after the positive rainfall trend began, in a more gradual manner, a post-drought re-increase in rivers discharges is being observed, as well as a recovery of the water-holding capacity of soils and catchments across the Sahel.

Contrary to widespread ideas, the vegetative cover in the Sahel has been far from systematically declining, despite its demographic growth becoming the highest in the world by the 1980s. On the contrary, field studies show that regreening, which is very often reforestation, is particularly strong in densely populated areas, and is due partly to the rainfall recovery, but also to new farmers' practices that contradict Neo-Malthusian ideas and the more general Afro-pessimist discourse.

Firstly, since 1986, we observe a growth (albeit uneven) of all local food crops production (cereals, roots and tubers, pulses, and vegetables). Production has increased by a factor of three, while the population has doubled. The increasing availability of food per inhabitant has often been less visible than the punctual and localized food shortages, and this has given rise to relief actions by international NGOs. With continued global warming, monsoon rainfall is projected to increase in the Sahel in the mid– to long-term, apart from the far west, which will experience a delayed onset [83,84]. These changes are significant with a global warming of 1.5 °C, which is expected to be reached in early 2030.

Thus, the authors call for the empowerment of smallholder farmers to take greater advantage of the current favorable wet period, and for the international relief and development community to shift their approach towards greater support for local agricultural initiatives [85].

Perhaps the most remarkable aspect highlighted by the above-mentioned data and studies is the speed of change in knowledge and know-how transfer and implementation, and the farmers' ability to adapt to ecological and economic crises. Far from being resistant to change, they have taken potential improvements as opportunities, and added them to their own range of practices. West African agriculturalists innovate, experiment, borrow, transform, and choose according to their situation, projects, and social issues. By emphasizing these facts, and without denying the multidimensional uncertainties to come, the authors refute the performative aspect of a systematically pessimistic and homogenizing discourse that legitimizes power relations.

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