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**Research Article**

# Soil Degradation and Prospects for Their Restoration in Ba-Illi (Chari-Baguirmi) in the Sahelo-Sudanian Zone of Chad

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**Abstract**

A study conducted in the sub-prefecture of Bâ-Illi, located in southern Chad, aimed to assess the state of agricultural soil degradation and explore prospects for its restoration. A survey was carried out among producers and other stakeholders involved in agricultural activities. The study reveals that the primary method of land acquisition is inheritance, followed by leasing. Producers are aware that declining field yields result from soil degradation caused by inadequate farming techniques. They employ a variety of techniques, ranging from no-till farming and mulching to half-moon planting.

## Introduction

Soil degradation is a global environmental problem affecting arable land worldwide (Honvou *et al*., 2022); in sub-Saharan Africa, it is rapidly increasing and poses a serious threat to the agricultural sector (Bruinsma, 2017; Altieri, 2018). To propose solutions for improving agricultural production, it is essential to understand the extent of soil degradation (Nezomba *et al*., 2017). Arid and semi-arid zones appear highly vulnerable to climate variability and change because they are characterized by factors conducive to soil degradation (Taylor *et al*., 2017). Soil loss is a global risk and a serious threat to any ecosystem, affecting agriculture and even forests. Thus, all inhabitants of the earth are affected by the threats to the health of the world's soils (Pimentel, 2006; Lemenih *et al*., 2014; Gilbey *et al*., 2019). The primary function of soils remains agricultural production for the food supply of humanity (Millogo, 2002). The loss of arable land appears

by far to be the most fundamental problem for the future of humanity (Gonne, 2004). Soil fertility is a potential for plant production, the assessment of which is linked to knowledge of its various components, primarily its physical, chemical, and biological components (Issiné, 2023). The role of soils in adapting to climate change and mitigating its negative effects can no longer be ignored, as regional climate projections show that significant warming and decreased rainfall are expected in the coming years (Bucchignani *et al*., 2018). Cultivating soils leads to a rapid decline in organic matter and a collapse in fertility (Mulaji, 2011). Data on the functioning of these ecosystems, the types of degradation, and the potential recovery of affected soils are scarce, poorly disseminated, and underutilized. Soil degradation is the primary factor limiting the average annual increase in food production in Africa to 2%. When soils are degraded and can no longer perform functions such as agricultural production and water retention, users have no choice but to migrate to more productive soils or rely on subsistence farming (FAO, 2019). Food crises and shortages can also lead to conflicts resulting in migration (FAO, 2019). Sahelian agriculture faces several challenges related to population growth, agricultural pressure, and soil fertility (Bakary, 2001). This pressure primarily leads to a loss of vegetation cover caused by deforestation, thereby increasing the soil's exposure to wind and rain. The sub-prefecture of Ba-illi, like other sub-prefectures in Chad, is also facing the problems of agricultural land degradation. This sub-prefecture is characterized by an imbalance between land use practices, with poorly adapted agricultural techniques, and population growth. This results in poverty, hunger, and biodiversity loss. Therefore, the restoration of degraded land is increasingly becoming a key requirement in a context where food security is seen as one of the main objectives for a country's sustainable development.

## Methods and Materials

### *Presentation of the Study Area*

The study took place in the sub-prefecture of Bâ-illi, located in the Chari-Baguirmi Province of southern Chad. The study area is bordered to the north by the Chari River, to the south by the Gam canton (Tandjilé) and the Gourgara canton, to the east by the Gourgara canton, and to the west by the Mitau canton (Mayo-Lémié). It lies at an altitude of 350 meters, at 10°30'0'' North latitude and 16°30'0'' East longitude. Generally, the terrain is flat; the climate is Sahelian-Sudanian, characterized by two distinct seasons: a rainy season from May to October and a dry season from November to April. The maximum temperature is 45°C between March and April and 22 to 23°C in December. The average rainfall is 600 to 1000 mm. The vegetation is dominated by *Anogeissus leocarpa*, *Anona senegalensis*, *Piliostigma* spp., *Diospiros mespiliformis*, and *Combretum* spp.

### *Methods*

The method used was based on a survey. It consisted of determining a sample chosen for various reasons; the main reason for selecting respondents was to choose individuals with a good understanding of agricultural soil degradation. The sample size was 120 people distributed across 6 villages (Table 1).

## Results and Discussion

### *Modes of Access to Agricultural Land*

The survey results show that 92.7% of the individuals included in this study are married for labor reasons. Many of these producers stopped their education at the primary level, a significant number did not attend school at all, a few reaches higher education, and very few have received vocational training. This finding aligns with the work of Issiné (2015), who demonstrated that in Mayo-Lemié, producers are generally less educated. Access to land occurs through inheritance, rental, donation, loan, purchase, or pledge. Inheritance accounts for 65% of cases, while rental of agricultural land represents 20%; purchase and pledge are less common (Fig. 1). Rental and sale prices vary from one village to another, ranging from 5,000 to 10,000 francs per hectare for rental and from 150,000 to 350,000 francs per hectare for sale. These results are comparable to those obtained by Morembaye (2019), who studied rural mobility and the sustainability of agropastoral systems in Logone Occidental (southern Chad).

### *Use of Fertilizers and Other Products*

In the Bâ-Illi Sub-Prefecture, mineral and organic fertilizers are used by farmers to increase yields. Some use only mineral fertilizers, others only organic fertilizers, and some use both. Fig. 2 shows the proportions of the different types of fertilizers used. Some farmers also use chemical and biological pesticides to treat their fields. The use of chemical pesticides is more frequent than biological pesticides; similarly, the use of mineral fertilizers exceeds that of organic fertilizers. The number of farms using both mineral and organic fertilizers is also minimal.

**Table 1:** Distribution of respondents by village

| | Villages | | | | | |
|---|---|---|---|---|---|---|
| | Ba-illi | Djanta | Mirou | Délkodjo | Landjiwa | Lac-gabri |
| Number of respondents | 30 | 25 | 20 | 20 | 15 | 10 |

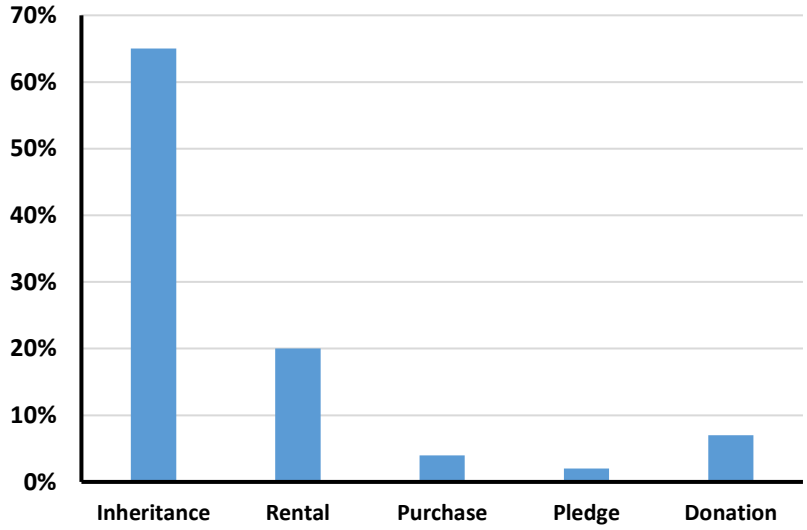


**Fig. 1:** Modes d'accès à la terre agricole

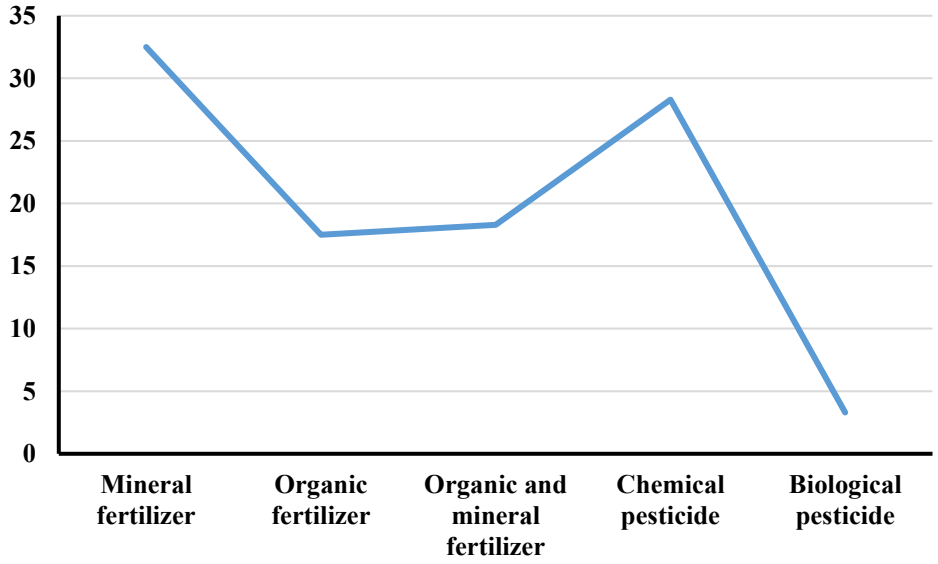


**Fig. 2:** Use of fertilizers and other products

***Producers' Perceptions of Soil Degradation***

Soil degradation leads to changes in physical properties in the first case and causes a decline in biodiversity as well as a considerable decrease in the soil's living biomass in the second case. It can have natural or human causes. All those surveyed cited humans as the primary cause of soil degradation. On the list of human causes, agricultural practices occupy a very prominent place. This type of degradation leads to a decrease in soil organic matter content, as confirmed by laboratory analysis of soil samples. These results are consistent with those obtained by Passinring (2016), who studied climate change and landscape transformations in the Léré lake basin and the Mayo Dallah watershed (southwest Chad). Some farmers believe that cotton production, with its continuous use of mineral fertilizers, is also a contributing factor to soil degradation. Overgrazing and transhumance were also mentioned by some respondents. Specifically, the analysis of the results revealed that 90% of farmers across all six villages in the study area perceive land degradation at the level of their agricultural plots. These results are corroborated by those of other authors who have reported a perception of land degradation (Traore, 2015). However, at the village level, the differences observed between villages are small and not statistically significant at the level of individual agricultural plots. These results are similar to those of Kinané *et al*. (2021), who reported that 98% of non-native farmers and 95% of indigenous farmers in northern Burkina Faso perceived land degradation. These findings also corroborate those of Assogba *et al*. (2017), who found that 60% of agricultural soils in Benin are vulnerable to erosion. Furthermore, similar results were obtained in the eastern and northern regions of Ghana, where 96% and 87% of farmers, respectively, perceived erosion as a threat to their land (Brhane *et al*., 2021).

***Soil Restoration Practices***

The results revealed adoption rates of sustainable land management practices across the six villages ranging from 0% to 65%. Among commonly known sustainable land management practices, no-till farming and mulching are most prevalent in the study area. The mulching adoption rate is 57%, a result similar to those obtained in eastern Burkina Faso by Labiyi *et al*. (2019). The half-moon technique is also used by a few farmers. The very low adoption rate of half-moon planting is explained by rainfall levels that allow most cultivated varieties to complete their cycles without too much difficulty. In the six villages, 8% of producers produce and use compost; this rate is lower than that found by Tesfaye (2017) working in the Central region of Ethiopia. Cover cropping, direct seeding, organic matter mulching, and agroecology can be used to improve soil fertility (Tejada and Gonzalez, 2006). Indeed, if the soil surface is covered, it is protected from raindrops and strong dry-season winds, and the activity of soil organisms can intensify (Tesfaye, 2017); the addition of locally available high-CEC materials, such as clay, also significantly improves soil fertility (Ismail and Ozawa, 2007). Cover cropping (CCP) is a new approach to agriculture that is based on no-till farming.

***Assessment of Soil Degradation Indicators***

Soil degradation is a current phenomenon affecting more than half of Chad's territory. Bâ-illi, located in a buffer zone between the Sahelian and Sudanian boundaries, is not spared from this desertification phenomenon. Thus, much of the soil in the Bâ-illi sub-prefecture is degraded due to overexploitation or the use of poor agricultural practices by local farmers. During the survey, farmers perceived soil degradation differently.

***Overall Approach to Soil Restoration***

According to all the producers surveyed, soil restoration is of great importance. 34.2% say that soil restoration increases agricultural production, 30% acknowledge that restoring soil improves its fertility, and others state that this practice maintains fertility, combats all kinds of erosion, and facilitates tillage (Fig. 3). Indeed, the restoration of degraded soils can aim for three objectives: rebuilding the potential for water and soil production, improving their resilience to future risks, and increasing their sustainability. Some producers point to farming practices, crop rotation, crop rotation and intercropping to restore soils; a low use of fallow land is justified by the increase in the number of producers in the locality so it is difficult to leave plots fallow for long periods, even one to two years of fallow land is considered impossible. These farming practices have the advantage of increasing the amount of organic matter and reducing soil erosion. According to Gustavo (2022), monoculture is one of the causes of declining agricultural productivity; thus, for many authors (Kaho, 2011), fallow land can be considered to compensate for the ever-decreasing production because it promotes the production of organic matter, which has the advantage of increasing soil fertility on the one hand and limiting erosion on the other. Belonging to an organization (group) facilitates access to information and best practices that boost productivity (Issoufou *et al*., 2017).

## Conclusion

The study on soil degradation and restoration prospects in the sub-prefecture of Bâ-Illi showed that the main causes of soil degradation are population pressure and poor agricultural practices. Access to land is obtained through inheritance, rental, donation, loan, purchase, or pledge. Inheritance is the most common form of land acquisition, followed by rental. All farmers know that declining yields are due to land degradation. To improve the situation, they use all types of fertilizers and pesticides. In addition to fertilizers and pesticides, farmers practice no-till farming, mulching, and even half-moon planting to restore degraded land. It is urgent to train farmers in the area in appropriate farming practices to minimize this problem.

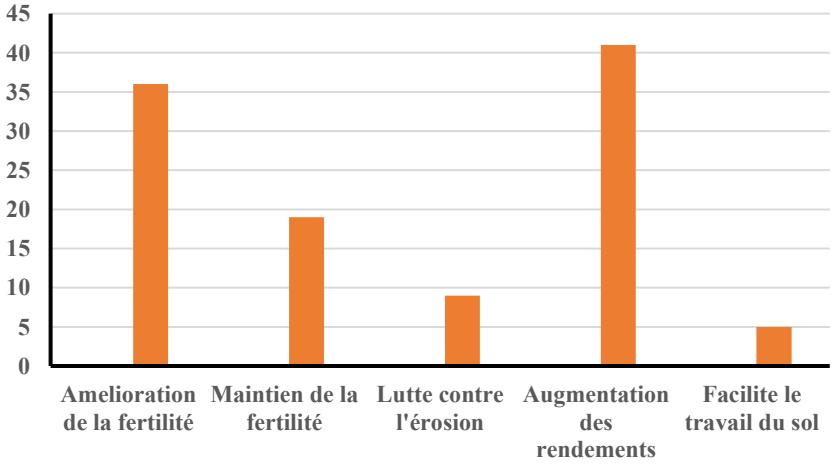


**Fig. 3:** Soil restoration design

## Authors' Contribution

All authors contributed equally at all stages of research and manuscript preparation. Final form of manuscript was approved by all.

## Conflict of Interest

Authors declare no conflict of interest with the present publication.

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