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Socio-economic Factors Influencing the Adoption of Zaï and Stone Barriers in North-Central Burkina Faso: A Case Study of Korsimoro

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Authors' contributions

This work was carried out in collaboration among all authors. Author IO designed the study, performed the statistical analysis, and wrote the protocol and the first draft of the manuscript. Authors JB and NGZ managed the study analyses. All authors read and approved the final manuscript.

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ABSTRACT

This study analyses the socio-economic factors influencing the adoption of two sustainable farming techniques, zaï and stone barriers, in the commune of Korsimoro, Burkina Faso. Using a Multinomial Probit econometric model, the results show that 98.31% of farmers adopt stone barriers, while 62.92% opt for zaï.

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Several key factors were identified, such as access to agricultural training, subsidies, credit, membership of producer organisations, household size, age and literacy level. Agricultural training, in particular, is a determining factor in the adoption of zaï, while household size and animal ownership significantly influence the adoption of stone barriers.
These data highlight the importance of integrating sustainable agricultural practices into public policies in order to improve productivity, strengthen resilience in the face of climate change and preserve natural resources. The findings of this study offer valuable insights for policymakers and development practitioners in sub-Saharan Africa, highlighting the need for targeted support to maximise the impact of sustainable agricultural techniques in the region.

Keywords: Agricultural technique; Korsimoro; socio-economic factor; stone barriers; zaï.

1. INTRODUCTION

Sub-Saharan Africa faces deep-rooted challenges, including chronic food insecurity, widespread poverty and accelerated ecosystem degradation. As AGRA [1] points out, the future of agriculture in this region lies in the sustainable management of natural resources, which is essential to guarantee the continuity of agricultural production for future generations. In this context, it is becoming imperative to promote environmentally-friendly farming practices to increase food production, improve living conditions for rural communities and preserve ecosystems.

The study carried out in Korsimoro, a commune in Burkina Faso, focuses on the socio-economic factors influencing the adoption of two traditional but effective farming techniques: zaï and stone barriers. These methods, which are well rooted in local practices, have demonstrated their ability to improve soil fertility and boost crop resilience in the face of growing climatic challenges. According to Sanon [2], the adoption of these practices is closely linked to farmers' knowledge, resources and ability to adapt.

The aim of this research is to understand how factors such as access to training, availability of resources and farmers' ability to adapt influence their decision to adopt these sustainable practices. The study hypothesises that these elements play a key role in farmers' choice to use these techniques to maximise their yield while ensuring the sustainability of their land.

By identifying and analysing these determinants, the study aims to provide concrete guidance for policy-makers, development practitioners and agricultural extension services. Integrating these practices into public policy is crucial not only for improving the productivity and resilience of farming systems in Burkina Faso, but also for promoting sustainable agriculture throughout the sub-Saharan region. The results obtained offer valuable insights for guiding development efforts and ensuring that agriculture in this region can meet present and future needs, while preserving the natural resources that are essential to its sustainability.

2. MATERIALS AND METHODS

2.1 Study Area

The commune of Korsimoro is located 70 km from Ouagadougou in the province of Sanmatenga, in the Centre-Nord region (Map 1). The municipality of Korsimoro has an area of 667 km^2. It is bordered to the north by Boussouma, to the east by Ziga, to the west by Mané and Zitenga and the south by Absouya and Ziniaré. The agglomeration of Korsimoro is connected to the main centres of its environment by the following national and departmental roads: Korsimoro-Ouagadougou: 70km, Korsimoro-Kaya: 30km, Korsimoro-Boulsa: 60 km and Korsimoro-Ziga: 40 km.

2.2 Methodological Approach

For the demographic sampling in this study, the technique used is that of Cochran et al*.,* [3] readapted by Rea L.M. et al*.*, [4]. This sampling technique has also been used by Joski et al*.*, [5], in their work on the analysis of the effects of the adoption of improved maize varieties on food security at the household level in northern Benin. Kay et al, [6], also used this sampling technique to analyse the socioeconomic dynamics of the adoption of cashew nut cultivation in rural Côte d'Ivoire.

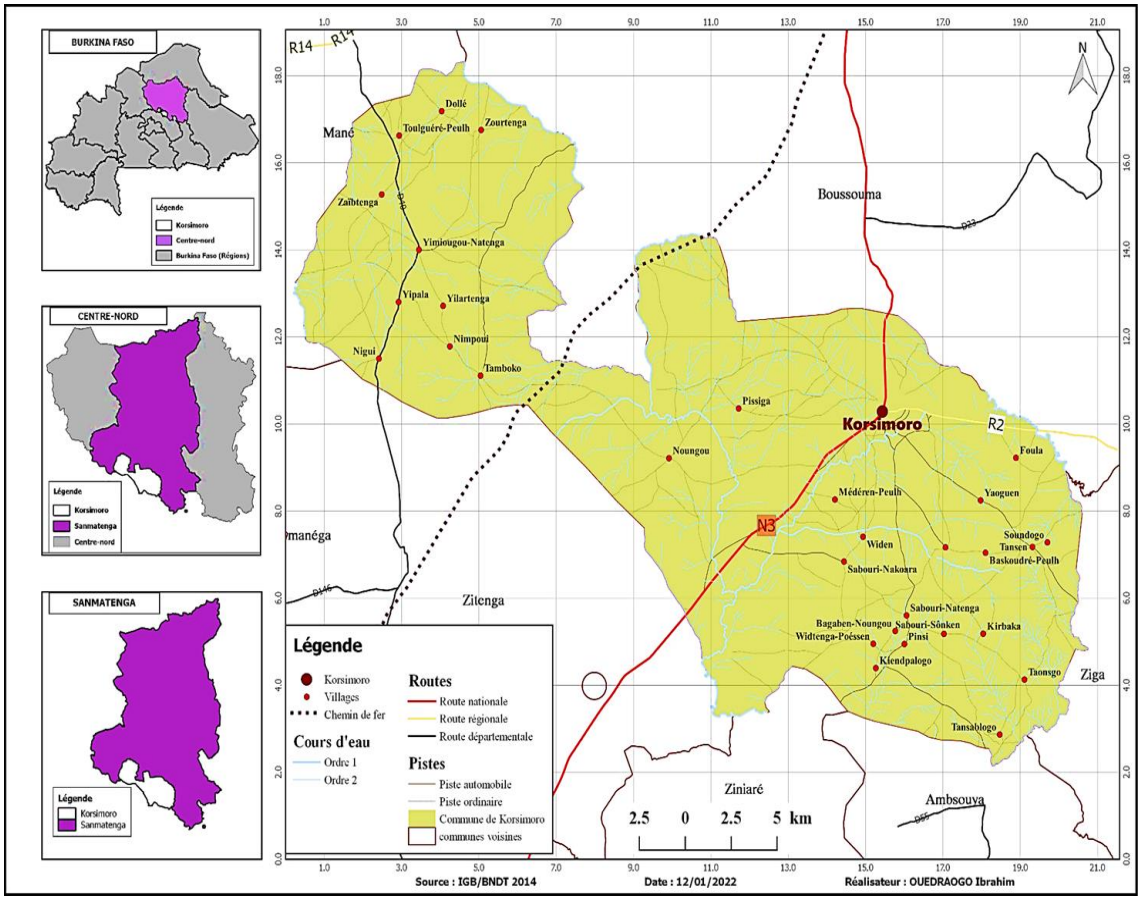
It is carried out by determining the sample size by the following formula:

$$\mathbf{n} = \frac{t_p^2 \times P(1-P) \times N}{t_p^2 \times P(1-P) + (N-1) \times y^2}$$

With:

- **n**: sample size that represents the number of households to be surveyed per village (study site);
- N: the size of the target population which is represented by the number of households,
- **P** (constant): 0.5;
- tp: Confidence interval which is defined in Table 1. For this study, tp = 1.96, i.e. a 95% confidence interval.
- y: margin of sampling error which is 5%.

This method resulted in a fairly representative sample, which is summarized in Table 2.



Map 1. Location of the municipality of Korsimoro

Table 1. TP values associated with confidence intervals

Confidence Interval	PQ
90 %	1,65
95 %	1,96
99 %	2,69

Source : Rea L.M. et al.*, (1997)*

Table 2. Selected demographic sample by site

Walking through the Villages	Number of Households	Ménages Selected
Baskoudré-mossi	98	49
Katenga	68	41
Tamsin	97	49
Soundogo	64	39
Total	**327**	**178**

Source: RGPH (2019), OUEDRAOGO I

Table 3. Evaluation grid of the determinants of adoption of ICA techniques

Variables	Definition
Dependent variable	
Technology/Practice (Y)	Technical package. Takes the value 1 if the technical package is adopted and 0 otherwise.
Explanatory Variables	
Age	The CCB Age
Literate	1 = yes oui, 0 yes not
Household size	Number of people
Formation	1 = have received training, 0 if this is not the case
Credit or grant	1 = have received a grant or credit, 0 if no
Member of an organization	Member of a producer organization (1= yes, 0= no)
Pet ownership	1 = yes oui, 0 yes not

Source: Adapted from MAAHA, (2019); Seydou Zakari, (2017)

In the case of this study, the technologies or practices to which the respondents were subjected are those known as techniques/technologies disseminated, [1] which are mainly those that are popularized by the agricultural advisory services of the municipality of Korsimoro. The agricultural extension approaches and tools used by agricultural advisory services are part of the dynamic of increasing agricultural productivity through the improvement of the technical skills of producers. This study focused mainly on stone barriers and zaï.

The practice of a technique can conventionally be modelled as a choice between two alternatives: to practice or not to practice. When considering the adoption or choice of different technologies, the household's goal is to increase its production or maximize its profit by choosing among alternatives. The idea is that the head of the household chooses a vector (J, K, L, M, N, etc.) of technologies to maximize its utility.

A head of household who strives to meet the needs of his or her members and to choose from a set of options or technologies (e.g., improved variety, zaï, FMN, etc.). If "i" is the number of heads of households prefer to choose J, if the perceived benefit of J is greater than the utility of K, then we can write:

$$Uij\ (\beta jXj + \varepsilon i) > Uik\ (\beta kXk + \varepsilon i),\ k \neq J$$

Where Uij and Uik are the perceived utility of the head of household i in the choice of technologies J and K, respectively; Xi is a vector of explanatory variables (e.g., level of education of the head of household, size of the household, land, etc.) that influence the choice of options; βj and βk are parameters to be estimated, εj and εk are the error terms.

We can link the fact that a household adopts technology for its utility maximization and not adopt it as a discrete choice. The result Y is then a dichotomous dependent variable taking the value 1 when the head of household is practising and 0 otherwise (Table 3).

The probability that household i will use technology j, among the set of options, could be defined as follows:

$$P= (Y=1/X) = P\ (Uij > Uik/X) = P\ (\beta'jXi + \varepsilon j - \beta'kXi - \varepsilon k > 0/X)= P([\beta'j-\beta'k]\ Xi + \varepsilon j-\varepsilon k > 0/X) =P\ (\beta^*Xi + \varepsilon^* > 0/X) = F\ (\beta^*Xi)$$

When ε* is a random perturbation term, β* is a vector of unknown parameters that can be interpreted as the net influence of the vector of the explanatory variables that determine the adoption and F (β*Xi) is the cumulative distribution of ε* to evaluate a β*Xi.

We can then estimate the Probit model based on the assumed distribution that the random term follows, and we can estimate several qualitative choice models such as linear, logit, or probit Probit. In this study, there are several technologies that the head of household practices. Therefore, a multinomial Probit is appropriate for estimating how the socioeconomic and demographic characteristics of respondents determine a household's decision to practice or not to practice a technology/practice [7,8].

[1] *It is a set of knowledge, processes and tools that implement proven scientific discoveries and applications in the agricultural field and provided to producers with the aim of improving their production system.*

3. RESULTS AND DISCUSSION

3.1 Determinants of Adoption of Agricultural Practices

Barriers such as limited access to education, technological resources and communication infrastructure were highlighted by CHAKER, [9]. However, a study by Orozco et al. [10], noted that despite these challenges, governmental and non-governmental initiatives to raise awareness and train farmers have contributed to increasing knowledge in some regions. Knowledge of smart technologies is closely linked to agricultural yields. Research conducted by Ouedraogo et al. [11], showed a positive correlation between the use of smart technologies and improved agricultural productivity in Burkina Faso.

3.2 The Determinants of Adoption of Agricultural Technologies and Practices

The practices and technologies used to evaluate the level of practice made it possible to take stock of the practices adopted by the agricultural populations in the commune of Korsimoro. Thus, 98.31% of the sample use stone barriers, and 62.92% practice zaï.

3.2.1 Determinants of Zaï adoption

The results of the econometric analysis for the adoption of the technical package (Zaï) are reported in Table 4. These results reveal that access to agricultural training is a very significant factor that increases the probability of adoption of zaï by producers.

The adoption of Zai is influenced by various socio-economic determinants. According to Kaboré et al. [12], local economic conditions, such as farmers' income levels, play a crucial role in decision-making about the adoption of this agricultural practice. In addition, the TRAORÉ et al. [13], highlight access to resources, including the availability of materials needed for the construction of zaï, as a key factor. On the other hand, the studies of Zongo et al., [14], emphasize the importance of social factors such as community networks and interpersonal influences in the dissemination of this technique. Regional disparities, studied by Kinane et al., [15], show that the geography and diversity of local ecosystems also impact the adoption of Zaï. In short, the adoption of Zai is influenced by socioeconomic variables, such as income, access to resources, social factors, and geographical particularities, as highlighted by various authors.

3.2.2 Determinants of the adoption of stone bunds

The objective of the stone barrier technique is to increase soil infiltration and water stock, and to recover and restore the fertility of crusted soils for agronomic and agroforestry use. The econometric analysis shows that producer training, animal ownership and household size are significant factors in the probability of adopting the technique (Table 5).

The adoption of stone barriers in sub-Saharan Africa is shaped by various socioeconomic determinants. The research of Kouma et al. [16], emphasize that the level of education of farmers is a key factor positively influencing the adoption of stone barriers, highlighting the importance of technical understanding in this process. The work of Raven et al. [17], highlight access to resources, including the availability of stones and other necessary materials, as a crucial determinant in farmers' decision-making. Hardware feasibility appears to play a significant role in the adoption of this practice. As far as economic factors are concerned, the studies of Ngondjeb et al. [18], indicate that the level of knowledge of the impact of erosion on farm units and their impact on agricultural yields are incentives for farmers, thus influencing their adoption.

Table 4. Estimation result of the Zaï

Variable	Marginal Effects dF/dx	Err Standard	Z-Value	Pr(>|z|)
Age	-0. 10036	0. 5179	-1. 938	0.05263
Household size	0.10262	0. 07731	1. 327	0. 18436
Subsides	-0. 60957	0. 86349	-0. 706	0. 48023
Ownership of an animal	-1. 08320	1.00008	-1. 083	0. 27876
Literacy	0. 52629	0. 35729	1. 473	0. 14075
Organization	0. 69576	1. 00031	0. 696	0. 48671
Formation	2. 07759	0. 77344	2. 686	0.00723**

*Legend: * 1% significance, ** 5% significance, *** 10% significance (*) dF/dx corresponds to the discrete change of the dummy variable from 0 to 1 z and P>|z| correspond to the test of the underlying coefficient equal to 0*

Table 5. Stone barrier estimation results

Variable	Marginal Effects dF/dx	Err standard	Z-Value	Pr(>|z|)
Age	0. 26345	0. 06454	4. 082	4. 4658
Household size	- 0.28434	0. 09404	- 3. 024	0. 0025**
Subsides	0. 00353	0. 92768	0. 004	0.9970
Ownership of an animal	- 17. 62541	1042. 52156	- 0. 017	0.001865**
Literacy	0. 98465	0. 41585	2. 368	0.0179
Organization	15. 68993	1042. 52156	0. 015	0.9880
Formation	- 0. 48240	0. 84741	- 0. 569	0.001692**

*Legend: * 1% significance, ** 5% significance, *** 10% significance.*
(*) dF/dx corresponds to the discrete change of the dummy variable from 0 to 1
z and P>|z| correspond to the test of the underlying coefficient equal to 0

4. CONCLUSION

Sub-Saharan Africa faces significant challenges in food security, poverty, and environmental degradation. Promoting sustainable agriculture is crucial for ensuring food production, improving rural livelihoods, and preserving natural resources. This study, conducted in Korsimoro, Burkina Faso, explores the socio-economic factors influencing the adoption of sustainable farming techniques, focusing on zaï and stone barriers. It identifies farmers' knowledge, resources, and capacities as key determinants. The findings are essential for policymakers, development practitioners, and agricultural extension services, particularly in Burkina Faso and similar regions, to enhance productivity, resilience, and resource conservation through sustainable agricultural practices.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The authors hereby declare that no generative artificial intelligence technology, such as large language models (chatgpt, copilot, etc.) and text-to-image generators, was used during the writing or editing of the manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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