Original Research Article

Geographical environment and dynamics of farming systems in the commune of Korsimoro: An integrated approach to optimizing farming practices

ABSTRACT

Korsimoro, located in the Sudano-Sahelian region of north-central Burkina Faso, is heavily dependent on agriculture, making it particularly vulnerable to climate change. This study examines the interaction between biophysical factors and agricultural practices in Korsimoro. Using a multidisciplinary approach, we carried out a geospatial analysis using t maps from various sources (BUNASOLS, IGB). A detailed soil evaluation was carried out to assess the agronomic potential of the different soil types. Historical rainfall data was analyzed to understand the climatic variability of the region.

The results reveal that the leached tropical ferruginous indurated soils (FLIPP), which occupy almost half of Korsimoro, have low agronomic potential due to their shallow depth and limited water retention capacity. These soil characteristics, combined with the decline in vegetation cover due to deforestation and overgrazing, make the region highly vulnerable to soil degradation. In addition, the region experiences high variability in rainfall, which poses a major threat to agricultural productivity.

As a result, the low agronomic potential of the soil and the increasing variability of the climate have a direct impact on farming practices in Korsimoro. Farmers in the region are facing difficulties in maintaining crop yields and ensuring food security.

To improve the resilience of farming systems in Korsimoro, we recommend the following:

- Site-specific soil management practices: Given the heterogeneity of soil types, adapted soil management practices, such as conservation tillage and organic fertilization, should be encouraged to improve soil fertility and water retention.

Improved water management: Investments in water harvesting, irrigation and water efficiency technologies are essential to mitigate the effects of drought and ensure a stable water supply for agriculture.

- Agroforestry: Integrating trees into farming systems can help to improve soil structure, reduce erosion and enhance biodiversity.
- Climate-smart farming: Adopting climate-smart farming practices, such as drought-resistant crop varieties, can help farmers adapt to changing climatic conditions.
- Capacity building: Providing farmers with training and extension services on sustainable farming practices is essential to ensure the long-term success of these interventions.

By implementing these recommendations, Korsimoro can improve agricultural productivity, enhance food security and contribute to more sustainable land management practices.

- *Keywords: Korsimoro, Agriculture, biophysics, climate variability,farming systems,*climatic conditions.

1. INTRODUCTION

The commune of Korsimoro, located in the Centre-North region of Burkina Faso, is a rural area typical of semi-arid environments, where agriculture is both the main economic activity and the mainstay of local communities' livelihoods. The specific biophysical features of this region, such as the diversity of soils, the varied vegetation, and the relief, as well as the particularities of the hydrography and climate, play a determining role in agricultural practices and crop productivity. According to [1], local conditions and biophysical elements, such as rainfall and temperature, are essential for adapting farming practices to climate change, thereby helping to improve food security for the people of Burkina Faso. However, these conditions are becoming increasingly fragile as a result of climatic variations, continuing demographic growth, and the intensification of farming activities.

Faced with these dynamics, it is crucial to develop an in-depth understanding of the complex interactions between these biophysical characteristics and the various factors influencing agricultural production. Such an understanding is essential for designing effective and relevant adaptation strategies. As [2] point out, farmers, particularly those in vulnerable regions, are often the most sensitive to the effects of climate change.

2. MATERIAL AND METHODS

2.1. Study area

The commune of Korsimoro, located in the Centre-Nord region of Burkina Faso, was chosen for this research because of its agricultural importance and unique environmental characteristics. This region, with a semi-arid climate, has a great diversity of soils, varied vegetation, contrasting relief, and hydrographic particularities. These elements have direct influence on agricultural practices and crop productivity in the area.

2.2. Data and sources

The data used for this study come from a variety of reliable sources. The soil information was collected from the National Soil Bureau (BUNASOLS), which provides detailed analyses ofsoil types and their distribution within the municipality of Korsimoro. The maps used in this study were obtained from the Geographical Institute of Burkina Faso (IGB) and the National Topographic Data Database (BNDT). They made it possible to map the geographical characteristics of the municipality. In addition, socio-economic data was collected from the municipality's technical services, and supplemented by field surveys conducted among local populations as well as the results of the 2019 General Population and Housing Census (RGPH).

2.3. Methodology

The applied methodology combines spatial analysis, field data collection, and secondary data exploitation. The objective is to understand how biophysical characteristics influence agricultural production in the commune of Korsimoro. The information provided by BUNASOLS was analysed to identify the different types of soils and their suitability for various crops, resulting in a detailed soil map of the study area. Maps from the IGB and the BNDT were used to represent geographical features, such as relief, hydrography and vegetation cover, thus facilitating the analysis of agricultural areas and ecological potentials. At the same time, socio-economic surveys were conducted to obtain information on farmers' agricultural practices, risk perceptions and coping strategies. These surveys, combined with data provided by the municipality's technical services and the RGPH 2019, were analysed to identify trends and make recommendations adapted to local realities. All of these analyses have made it possible to identify the vulnerable areas and the most resilient agricultural practices, thus providing avenues for sustainable management of natural resources and improvement of agricultural resilience in the commune of Korsimoro.

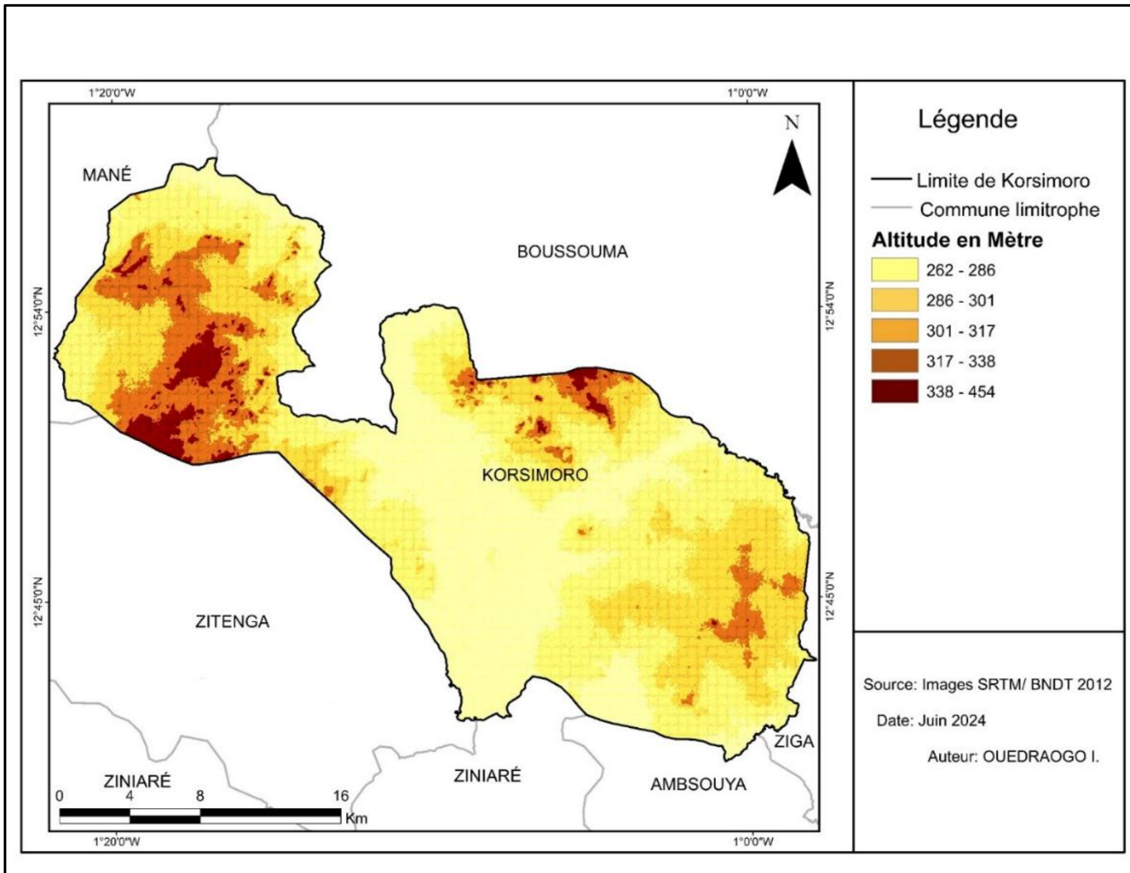
3. RESULTS AND DISCUSSION

3.1. Biophysical Characteristicsof the Municipality of Korsimoro

This part concerns the characteristics of the relief of vegetation, soils, hydrography, and climate

3.1.1. Relief

The relief of the municipality of Korsimoro, characterized by a chain of lateritic hills with peaks up to 454 meters, directly influences the agricultural land use. [3] observed that in areas with moderate relief, such as Korsimoro, extensive production systems predominate. This situation is reflected in the distribution of agricultural land: 81.3% of the plots are on plateaus or plains, 5.8% in the lowlands, and 12.9% on slopes. According to [4], moderate relief, combined with a high land use rate, favors cultivation strategies adapted to local conditions, in particular, to minimize the risk of erosion (Map 1 and Table 1).



Map 1: Map of the altitudes of the municipality of Korsimoro

Table 1*: Topography of agricultural plots*

Location of the plots	Percentage
Plain/Plateau	81,3
Depression	5,8
Side	12,9
Total	**100**

Source: EPA/DGESS/MAAH, (2020)

3.1.2. Soils and Agricultural Potential

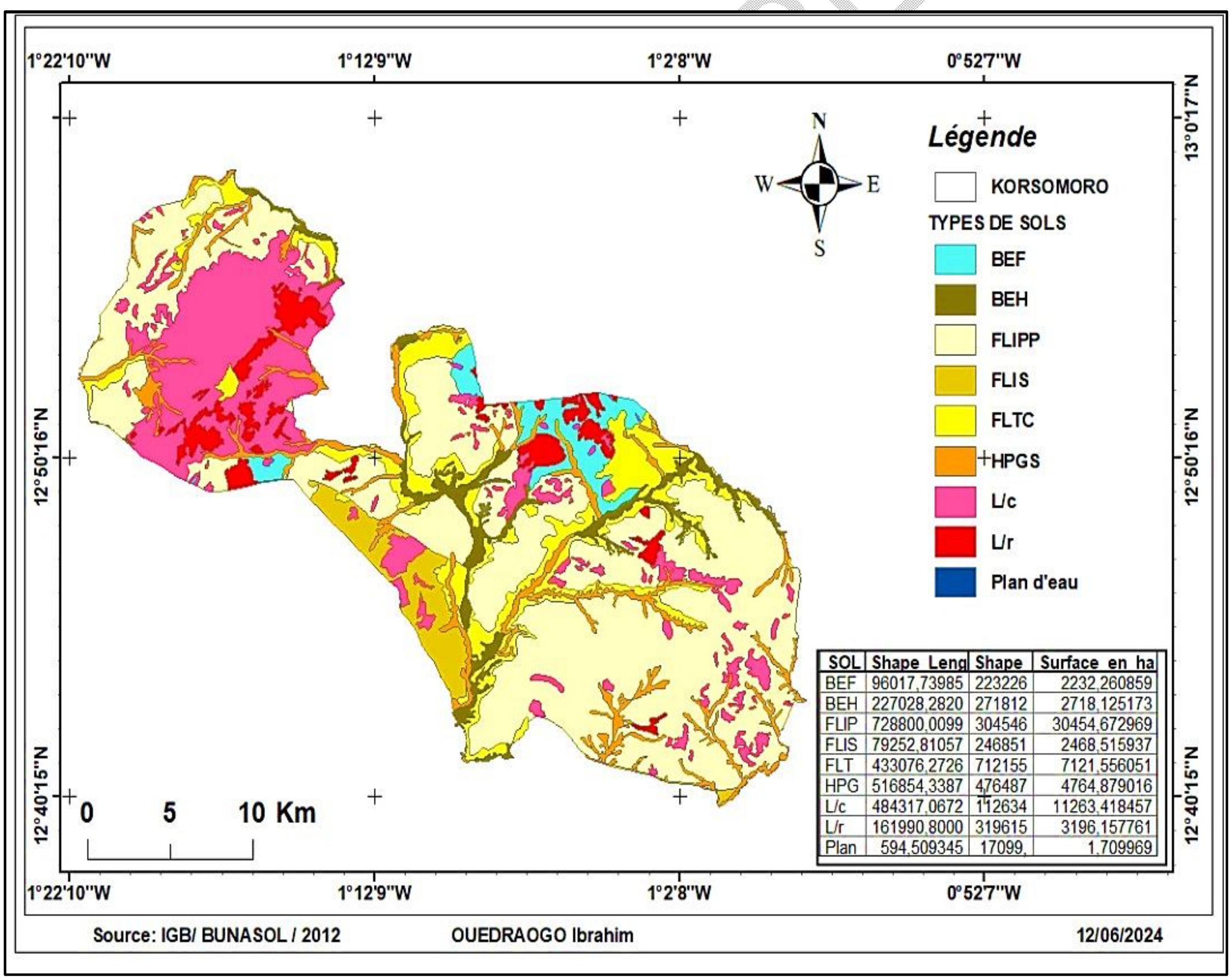
The soil study conducted in 1998 by the National Soil Office (BUNASOLS) revealed a diverse range of soil types within the municipality of Korsimoro, identifying eight distinct categories. Among these, the most prevalent are the shallow indurated leached tropical ferruginous soils (FLIPP), which cover 47.42% of the total area. These FLIPP soils, while widespread, have a low water retention capacity ranging from 49 to 58.8 mm and a limited effective depth of just 40 to 60 cm. This shallow depth and reduced water-holding capability significantly constrain their agronomic potential, rendering them only moderately suitable for cereal crops such as millet, sorghum, and maize. As highlighted by [1], FLIPP soils are particularly susceptible to erosion due to their thin layer of fertile material and low reserves of usable water. This vulnerability not only impacts the yield but also necessitates careful management practices to prevent further degradation.

Beyond FLIPP soils, several other soil types have been identified in Korsimoro, each with unique characteristics and agricultural suitability (Map 2) :

- **Lithosols on cuirass (LC) :** Accounting for 17.53% of the area, these soils are gravelly and stony, making them largely unsuitable for agricultural production. Their low water retention capacity, combined with a high gravel content, means that they can barely support plant life. Farmers in these areas often face significant challenges in cultivating crops, and these soils are often left uncultivated or used for non-agricultural purposes.
- **Lithosols on rock (LR) :** Covering 4.97% of the municipality, these soils are characterised by an extremely shallow depth, often less than 10 cm. This minimal depth severely restricts their agricultural use, limiting them to sparse vegetation and occasionally used for grazing rather than cropping. The rocky nature also poses challenges for any form of tillage or soil preparation, further diminishing their suitability for traditional agriculture.
- **Tropical ferruginous soils leached with spots and concretions (FLTC) :** Representing 11.08% of the area, these soils are moderately suitable for certain cereal crops like sorghum, maize, and upland rice. However, they are only marginally suitable for millet cultivation due to their specific texture and structure, which affects water infiltration and nutrient availability. These soils require careful management and appropriate crop selection to maximise productivity.
- **Tropical ferruginous soils with shallow indurated leaching (FLIS):** Making up 3.84% of the region's soils, these are deemed poorly to moderately suitable for cereal crops. They are, however, unsuitable for upland rice and vegetable cultivation, primarily because of their poor nutrient profile and limited moisture retention. Farmers in these areas often resort to hardy, drought-resistant crops to ensure some level of agricultural output.
- **Brown eutrophic ferruginised soils (BEF) :** Covering 3.47% of the total area, these soils are moderately suitable for cereals but poorly suited for vegetable crops. The moderate fertility levels mean they can support cereals like millet and sorghum under certain conditions but often require soil amendments or fertilisers to improve yields.
- **Hydromorphic eutrophic brown soils (HEBs) :** Occupying 4.23% of the municipality, these soils are highly valued for their high water-holding capacity. This characteristic makes them ideal for crops that require more consistent moisture levels, such as rice, maize, vegetables, and tubers. Farmers often prioritise these soils for more water-intensive crops, leveraging their natural properties to maximise production.

- **Hydromorphic soils with low humus and pseudo surface gley (HPGS):** Comprising 7.41% of Korsimoro's soils, these are moderately suitable for rainfed crops such as sorghum, maize, and upland rice, but less so for millet. The limited humus content affects the soil's overall fertility, requiring additional inputs to sustain crop growth. However, their unique water-retaining capabilities make them useful in areas where rainfall is unpredictable.

These data illustrate that while FLIPP soils are the most common in the region, their agronomic potential is restricted due to their physical and chemical properties. In contrast, less common soil types, such as hydromorphic and brown eutrophic soils, provide better growing conditions for certain crops, particularly those requiring more moisture and nutrients. This diversity of soil types necessitates a strategic approach to agriculture in Korsimoro, where farmers must carefully select crops based on the specific properties of the soil available to them, as noted in [5]. Understanding these variances not only aids in optimising agricultural practices but also highlights the importance of targeted soil management and conservation efforts to sustain and improve productivity in the region.



SOL	Shape Leng	Shape	Surface en ha
BEF	96017,73985	223226	2232,260859
BEH	227028,2820	271812	2718,125173
FLIP	728800,0099	304546	30454,672969
FLIS	79252,81057	246851	2468,515937
FLT	433076,2726	712155	7121,556051
HPG	516854,3387	476487	4764,879016
L/c	484317,0672	112634	11263,418457
L/r	161990,8000	319615	3196,157761
Plan	594,509345	17099,	1,709969

Map 2: Soil types in Korsimoro

3.1.3. Vegetation

The vegetation of Korsimoro, typical of the Sudano-Sahelian zone, is dominated by shrub savannah (mainly on the plateaus and plains, which represent 81.3% of agricultural land) and grassy savannah on the slopes of hills and armored mounds. [6] described this vegetation as representative of the central regions of Burkina Faso, where the shrub savannah is composed of species such as Combretum micranthum and Anogeissus leiocarpus. However, deforestation and overgrazing have led to a significant degradation of vegetation cover, reducing the availability of natural pastures, which affects the local population, 90% of whom depend on agriculture and livestock. [7] have pointed out that this degradation has direct consequences on the ability of land to support agricultural and pastoral activities.

To counter this degradation, reforestation initiatives have been undertaken, particularly with exotic species such as *Eucalyptus camaldulensis*. [8] note that while these efforts may have immediate benefits, they also pose long-term ecological challenges, such as competition for water with local crops.

3.1.4. Hydrography

The river network in Korsimoro is primarily made up of non-perennial rivers, which are illustrated in Map 3. These rivers tend to dry up swiftly after rainfall events, largely due to high rates of infiltration into the soil and substantial evaporation. Evaporation levels in the region are notably high, averaging around 2,133 mm per year between 1998 and 2020. This high rate of evaporation presents a significant challenge for water resource management, particularly during the dry season when water availability is crucial for agricultural activities. The rapid loss of water not only reduces the volume available for crop irrigation but also affects the overall sustainability of farming practices in the region.

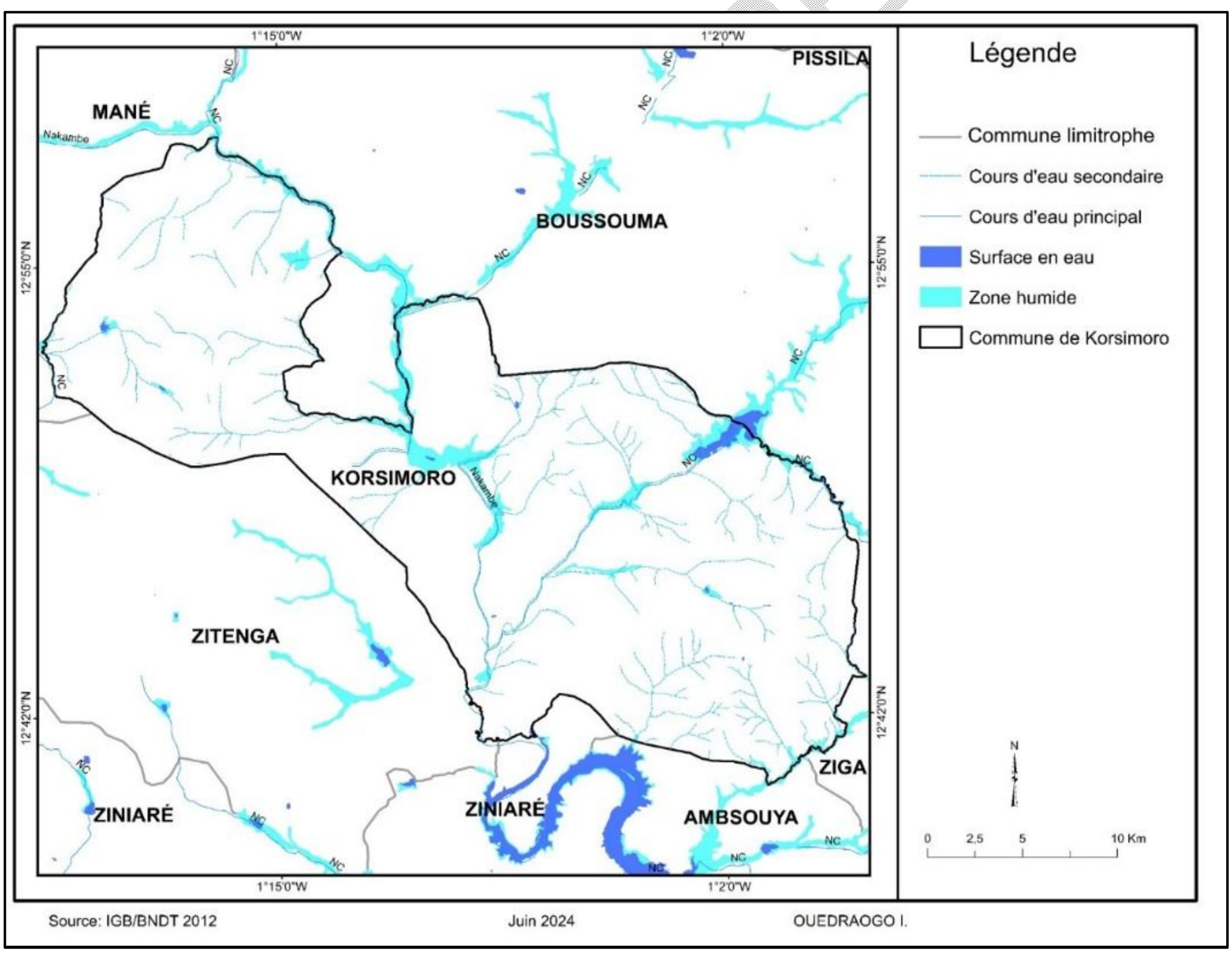
As noted by [9], this phenomenon is characteristic of Sudano-Sahelian regions, where water resources are often insufficient to sustain agricultural activities throughout the year. In these areas, the climate's variability exacerbates the challenges, with prolonged dry spells leading to reduced water availability and increased pressure on existing water resources. Farmers in Korsimoro, like many in similar climatic zones, often find themselves at the mercy of these environmental conditions, which dictate the timing and success of their planting seasons.

The absence of reliable water sources means that during the dry season, many rivers shrink to small streams or disappear entirely, leaving behind dry riverbeds that are of little use for irrigation. This scarcity of water during crucial growing periods limits the types of crops that can be grown and reduces overall agricultural productivity. Farmers are forced to rely on a narrow range of drought-resistant crops or to adopt practices that require minimal water, often at the expense of crop diversity and yields.

To address these challenges, [10] suggests that the construction of water reservoirs could provide a viable solution. Building reservoirs would enable the collection and storage of water during the rainy season, which could then be used to support irrigation during dry spells. Such infrastructure could significantly improve water management strategies in Korsimoro, helping to mitigate the impacts of prolonged periods of drought and offering a more stable water supply throughout the year. This approach would not only benefit agriculture but could also support other water-dependent activities, such as livestock rearing and small-scale industries.

Moreover, the creation of water reservoirs could have additional benefits, such as reducing soil erosion and improving groundwater recharge. By capturing and storing rainwater, reservoirs can help maintain soil moisture levels, reduce surface runoff, and prevent the loss of fertile topsoil. Enhanced groundwater recharge could also lead to improved water quality and availability for domestic use, further supporting the resilience of local communities in the face of climate variability.

However, constructing such reservoirs requires careful planning and consideration of environmental, social, and economic factors. It is crucial to ensure that these structures are designed in a way that maximises their benefits while minimising potential negative impacts, such as displacement of communities, loss of agricultural land, or ecological disturbances. Engaging local communities in the planning and decision-making processes is essential to ensure that the constructed reservoirs meet their needs and are maintained effectively.



Map 3: Hydrography of the municipality of Korsimoro

3.1.5. Generality of the climate

The climate in Korsimoro, characterized by its Sudano-Sahelian type, presents a unique set of challenges for local agriculture. This region experiences a prolonged dry season that stretches from October to May, during which the landscape often becomes parched and barren, and water sources dwindle. In contrast, the rainy season is comparatively brief, lasting from June to September, providing a narrow window of opportunity for farmers to cultivate their crops. This seasonal pattern creates a delicate balance, with agricultural success hinging on the timing and amount of rainfall received during these critical months.

Precipitation levels in Korsimoro are notably unpredictable, with annual rainfall varying significantly over the years. For instance, in 1991, the region received just 509.6 mm of rain, which was considerably lower than the average needed to sustain most rainfed crops. In stark contrast, 2020 saw a much higher total of 858 mm. Such fluctuations in precipitation from year to year are not just minor inconveniences; they can spell the difference between a bountiful harvest and a season of hardship. As noted by [11], this inter-annual variability in rainfall poses a significant threat to agricultural stability, particularly in years when precipitation falls below the average. During these dry spells, farmers often find themselves grappling with severe water shortages, which can lead to reduced crop yields or even total crop failure in the worst cases.

Adding to these challenges is the issue of high temperatures, particularly during the transitional period just before the onset of the rainy season. Research highlighted by [12] indicates that temperatures in Korsimoro frequently surpass 34°C in April. These elevated temperatures, when combined with erratic rainfall patterns, can create an environment that is exceedingly tough for rainfed agriculture. Crops such as millet, sorghum, and maize, which are the staples for many households, are especially vulnerable. These crops rely heavily on consistent rainfall not only for initial growth but also for reaching full maturity. When rains are late, insufficient, or abruptly interrupted, the plants can suffer from stress, leading to lower yields or, in some cases, complete crop loss.

Furthermore, the local farmers have adapted various traditional techniques to cope with these climate challenges, such as practicing crop rotation and using organic mulches to conserve soil moisture. However, these strategies can only mitigate the effects to a certain extent. When faced with consecutive years of poor rainfall or extreme heat, even the most resilient farming systems can be overwhelmed. Thus, the need for more robust, climate-adaptive agricultural practices becomes increasingly urgent as climate variability continues to affect Korsimoro and similar regions.

3.2. Dynamics of Agricultural Systems in the Municipality of Korsimoro

3.2.1. Rainfed Crops

Rainfed crops, such as sorghum, millet, and maize, are the cornerstone of Korsimoro's agricultural system. These crops, deeply embedded in local farming practices, are highly dependent on rainfall, which can vary significantly from year to year, exposing farmers to considerable risks. For example, a year with insufficient rainfall can lead to reduced harvests or even total crop failure, severely impacting household food security.

As highlighted by [1], effective water management practices are essential for maintaining productivity in Sahelian regions, where rainfall is often unpredictable and unevenly distributed. Key strategies include improving soil structure and employing conservation techniques to enhance water retention. Among these, the *zaï* technique is widely adopted in Burkina Faso. This traditional method involves digging small pits in the soil where seeds and manure are placed, helping to capture and retain rainwater while also improving soil fertility. Although a time-honoured practice, *zaï* has proven highly effective in arid zones, enabling farmers to better withstand periods of drought and optimise the use of scarce water resources.

Table 2 presents the main agricultural crops in tonnes over a five-year period, showing notable fluctuations in yields from year to year. For instance, sorghum production peaked at 8,642 tonnes in 2018-2019, a significant increase compared to the 1,506 tonnes harvested in the following year. This dramatic variation underscores the challenges faced by farmers in Korsimoro, who must continuously adapt their practices to survive in an unpredictable climate. The yields of mill

et and maize also display similar variations, highlighting the importance of robust adaptive strategies. Rice, though less widely cultivated than other cereals, shows relative stability in production, likely due to its more consistent water requirements and the presence of irrigated areas.

Table 2*: Main agricultural speculations in tonnes*

Speculation	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021
Sorghum	5106	4851.45	8642	1506	5694
Thousand	1491	1309	4335	1130	2541
Maize	345	331	667	628	491
Rice	391.5	394.5	377	365.7	439.8
Cowpeas	2971	2434	3127	1976	2018
Voandzou	255	236	317	204	399
Total	**10559.5**	**9555.95**	**17465**	**5809.7**	**11582.8**

Source: Korsimoro Department of Agriculture (2022)

These figures not only demonstrate the resilience of Korsimoro's farmers but also underscore the ongoing need to develop and adopt climate-smart agricultural practices. The fluctuations in yield from year to year highlight the farmers' ongoing reliance on favourable climatic conditions and water availability. By improving water management practices and investing in conservation techniques like *zaï*, farmers can mitigate the impacts of climate variability and enhance their resilience to an increasingly unpredictable climate.

3.2.2. Cash crops

Cash crops, including sesame, groundnuts, and cowpeas, are also essential in Korsimoro commune. These crops, which are mainly for sale, provide crucial income for local farmers. According to [13], rainfed cropping systems in Sahelian areas benefit greatly from the introduction of cash crops, as they diversify income sources and increase household resilience to climate shocks. The authors also highlighted the importance of integrated soil and water resources management to optimize cash crop yields in a changing climate.

3.2.3. Agricultural Innovations and Practices

In response to climate and environmental challenges, Korsimoro farmers have adopted various innovations to improve the sustainability of their farming systems. The zai technique, mentioned above, as well as stone barriers, are examples of practices that have shown great effectiveness in combating erosion and improving soil productivity. [14] documented the positive impact of these techniques on the management of degraded land in Burkina Faso, showing that these practices can significantly improve agricultural yields even under difficult climatic conditions.

In addition, the adoption of more drought-tolerant crop varieties has allowed farmers to better adapt to fluctuating climatic conditions. [15] studied the effectiveness of improved cereal varieties in the arid regions of the Sahel, finding an increase in yields during periods of drought compared to traditional varieties.

The study reveals that Korsimoro's soils have low agronomic potential, with direct effects on local farming practices and significant socio-economic implications. Due to the low water-holding capacity and limited useful depth of certain soils, such as shallow indurated tropical ferruginous impoverished soils (FLIPP), agricultural productivity is considerably reduced. This forces farmers to adopt drought-resistant crops such as millet and sorghum, limiting agricultural diversification and increasing the economic vulnerability of farming households to climatic fluctuations.To improve soil management and mitigate these challenges, the study recommends specific farming practices adapted to the commune. For example, integrating water management techniques, such as the zaï practice of digging small basins to capture and retain rainwater, can improve soil fertility and agricultural productivity. The adoption of cover crops to reduce erosion and crop rotation to preserve soil nutrients are also recommended.In addition, the construction of dikes and micro-dams to retain water could help improve water availability during periods of drought. These measures, combined with increased farmer awareness of sustainable soil management practices, could strengthen the resilience of local communities in the face of climatic challenges, while optimizing agricultural production in the commune.

4. CONCLUSION

Agriculture in Korsimoro is intimately linked to the biophysical characteristics of the region, such as the relief, soil types, and vegetation of the Sudano-Sahelian zone. These elements directly influence the distribution of agricultural land and crop productivity, especially in a context of high dependence on variable rainfall. The region's soils, although diverse, present agronomic challenges, particularly in terms of water holding capacity and fertility, which sometimes limit the potential of rainfed crops.

Despite these constraints, the farming population of Korsimoro demonstrates a significant capacity to adapt to climatic hazards and environmental challenges. Cash crops, in particular, play a key role in diversifying income sources and strengthening farmers' economic resilience. However, to ensure the sustainability of these agricultural systems, it is crucial to continue to manage and develop natural resources effectively.

In sum, the future of agriculture in Korsimoro will depend on the ability to integrate local biophysical realities into sustainable land and resource management, while strengthening farmers' capacities to adapt to changing conditions. With appropriate support and informed management, the municipality of Korsimoro has the potential to maintain and develop a resilient and sustainable agricultural system.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

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