

Original Research Article

Predictive modelling of land use in 2050 in the commune of Korsimoro in north-central Burkina Faso.

In the context of the commune of Korsimoro, in Burkina Faso, this study looked at the evolution of land use between 1991 and 2021, with projections to 2050. Using satellite data and geospatial processing methods, an analysis of past and projected trends in future land use scenarios was conducted. The results revealed a significant increase in anthropogenic activities in recent decades, with a 25.69% per cent increase in land dedicated to agriculture and an the expansion of urban areas. However, an optimistic outlook for 2050 suggests a regression in anthropogenic activities and an increase in natural areas, with an increase of 5.67% per cent increase for wooded savannahs and 78.37% per cent increase for shrub and grassy savannahs, respectively. These findings underscore the importance of rethinking land management policies in order to promote more sustainable development. Sustainable agricultural practices, integrated urban planning and the protection of natural ecosystems appear to be promising avenues for reconciling human needs with environmental preservation of the environment.

Keywords : Land occupation ; trend projection ; optimistic projection ; Municipality of Korsimoro

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ABSTRACT

1. INTRODUCTION

At the heart of north-central Burkina Faso lies the commune of Korsimoro, a dynamic territory where issues related to land use are of paramount importance for local and regional development. This commune, largely dominated by rain-fed agriculture, is distinguished by its landscapes marked by a mosaic of agricultural activities and a strong human presence.

In a global context marked by increasing urbanization and unprecedented environmental pressures, the effective management of land use in Korsimoro is of utmost paramount importance to ensure harmonious and sustainable development. This municipality, subject to constantly changing demographic trends and increasing economic pressures, offers a privileged field of observation to study the dynamics of land use and to anticipate their future developments.

From this perspective, this article proposes a prospective analysis of the evolution of land use in the municipality of Korsimoro, adopting both an optimistic and a trending approaches. Based on historical data, dating back to 1991, and population projections, we seek to identify the main trends and determining factors that will shape the land landscape of the municipality in the coming years.

The use of Landsat satellite data, coupled with GIS (Geographic Information System) tools such as QGIS, is an essential component of this analysis. These technologies make it possible to map and quantify changes in land use over time, identifying occupancy units such as housing, agricultural land, vegetation and other types of land cover (Dovonou [et al.](#), 2017; Faloulou [et al.](#), 2018).

Over the past three decades, the municipality of Korsimoro has witnessed a significant transformation of its territory, marked by a growing phenomenon of anthropization. From 1991 to 2021, urban sprawl, intensive agriculture, and other human activities [have](#) put constant pressure on the land, leading to rapid and sometimes irreversible changes in the natural landscape. This anthropization has been fuelled by a combination of factors, including population growth, rapid urbanization, unsustainable agricultural practices, and often poorly coordinated development policies.

By providing a forward-looking view of the changes to come, this study provides local decision-makers and development actors with valuable tools and information to guide their actions and policies in terms of spatial planning (Al Karkouri and al., 2017). By better understanding the possible trajectories of land use in Korsimoro, contributes to a more resilient, sustainable and inclusive planning, capable of meeting the present and future needs of the local population while preserving the natural resources and environmental heritage of the municipality.

2. MATERIALS AND METHODS

The methodological approach adopted is based on an analytical and diachronic cartographic approach based on the use of remote sensing and geographic information systems. Four Landsat satellite imagery ~~was were used in the study~~. These are the 1991 TM and 2001, and 2011 ETM+ ~~images that were displayed in a 432 color composition~~ and the 2021 OLI images ~~in a 543 color composition~~. The resolution of each image is 30 m. The adopted projection ~~was~~ WGS 1984, UTM-Zone 30 N. The final validation of the different land-use maps was ~~performed done~~ using a pixel confusion matrix and data from field visits. This method ~~has been used~~ by many authors, ~~in particular by~~ [Djaouga \[et al.\]\(#\)](#), (2022) ~~and~~, [Arouna](#), (2017).

The areas of the different land cover classes were calculated using the Arc Gis 10.1 software. This made it possible to ~~conduct carry out~~ a diachronic study of the situations of the reference years ~~in order~~ to highlight the dynamics of land use in the study area. ~~The image processing consisted in of~~ defining the nomenclature of the different types of land cover based on the ~~LCCS (Land Cover Classification System (LCCS))~~ model. Maximum likelihood-based classification was applied to each of the 1991 images, 2001, 2011 and 2021 and allowed ~~the~~ identification of the different classes of land use. ~~The satellite images have been subjected to undergone~~ various treatments. After ~~the~~ mosaicking ~~of the~~ individual strips, the first step was to improve the quality of the images, i.e. to improve their contrasts and colour composition. Then, they underwent geometric corrections which consisted of realigning the image on a geographical reference frame. The area of interest was extracted from the boundaries of the study area.

Colour composition is a qualitative combination of three spectral bands of an image for a good interpretation of the image. The 1991 TM and 2001, 2011 ETM+

images were displayed in a 432 colour composition and the 2021 OLI images in a 543 colour composition. This choice was guided by the need to provide as much information as possible. The images of the different dates were displayed simultaneously on the computer screen in different views. Thus, the object classes were chosen considering their evolution over time.

A temporal analysis was then performed to assess the trends in land cover over the study period. This analysis was used to calculate the rates of change for each land cover unit, and to identify spatial conversion trends. Simultaneously, scenarios for the evolution of land cover in 2050 were developed, taking into account the different variables likely to influence these changes. These scenarios were developed in collaboration with local experts and stakeholders to ensure their relevance and realism. Finally, the results obtained were validated using field data and interviews with local stakeholders, in order to verify the robustness of our forecasts for 2050 and to identify any gaps or uncertainties in the analysis.

3. RESULTS

1.1 Summary of land use from 1991 to 2021

From 1991 to 2021, over a 31-year period, land tenure units have fluctuated several times. These changes are summarized in Table 1 and Figure 1.

Table 1 : ~~2001 and 2021~~ Spaceview of Korsimoro for 2001 and 2021

Unit	Area in 1991 (in %)	Area in 2021 (in %)	Evolution of spaces (in %)
Field/Agricultural Area	10,51%	13,09%	2,59%
Gallery Forest	2,72%	1,10%	-1,62%
Habitat	0,78%	2,26%	1,48%
Body of water	0,45%	0,32%	-0,13%
Wooded savannah	3,00%	4,35%	1,35%
Shrub/grassy savannah	81,47%	77,31%	-4,16%
BareFloor	1,08%	1,58%	0,50%

Source : Landsat Image Processing 1991, 2021

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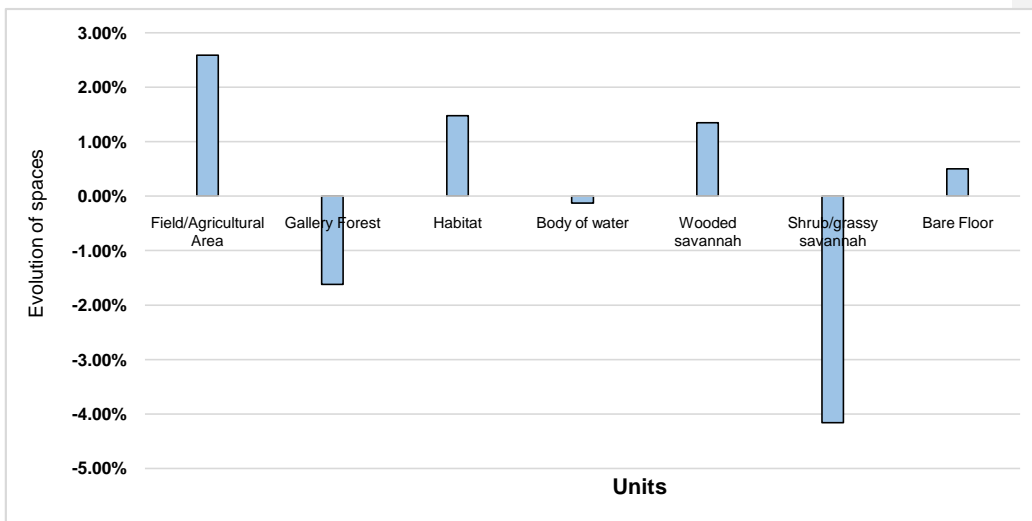
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Source : Landsat 2001 Image Processing; 2021

Figure 1: Evolution of occupancy units from 2001 to 2021

The general observation, based on the analysis of the data from the two extreme dates, allows us to make the following observations :

- An increase in the surface area of bare soil, wooded savannahs, habitats and especially fields and agricultural areas ;
- A regression in the areas of shrub and grassy savannahs, water bodies and gallery forests.

1.2. Trend to 2050

Based on data on the evolution of land cover by the different occupancy units, from 1991, 2001, 2011 and 2021, a trend shows land use in 2050. This form of occupation shows an increase in the spaces occupied by anthropogenic activities, particularly fields and agricultural areas (25.69%), habitats and bare soil. However, the natural areas are declining (Map 1, Figure 2).

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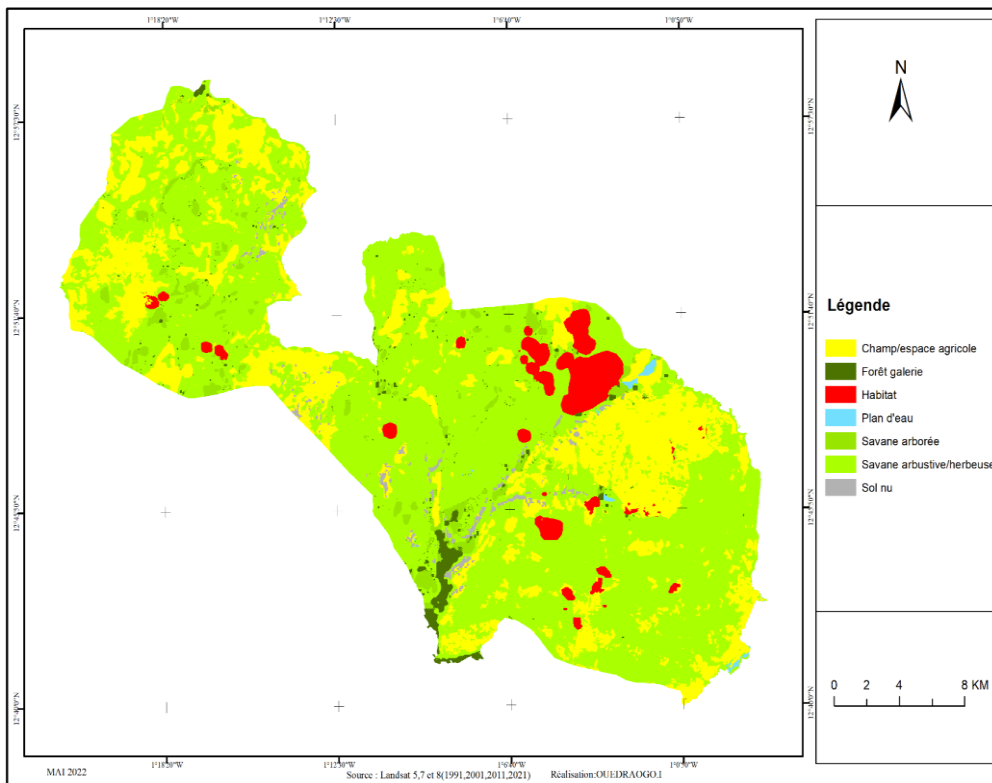
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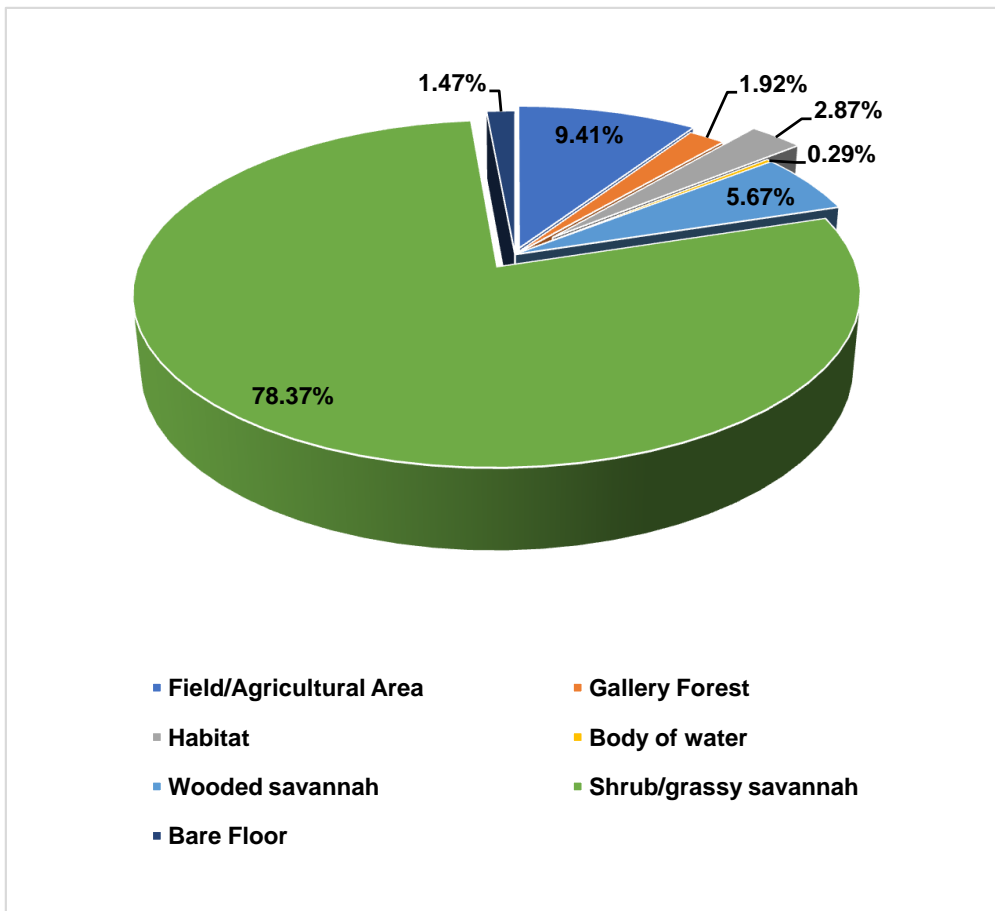
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Map1: Trend to 2050

This expansion of agricultural land implies the deforestation of natural vegetation formations such as gallery forests, dense forests and wooded and shrub savannahs by producers in search of fertile land, probably because of the decline in crop yields, but also because of the constant increase in the population whose basic needs must be met or incomes improved. Unfortunately, the cultivation technique seems to have remained traditional without a remarkable improvement. It is characterized by slash-and-burn cultivation, without the use of a minimum amount of chemical or organic fertilizer to preserve soil fertility. Agricultural activities are one of the main causes of the downward trend of natural vegetation formations and their degradation.

The simulation indicateds a profound landscape change. However, this future development did not considertake into account changes in the population, changes in land-use practices in particular, and the implementation of a possible development project.



Source : Landsat Image Processing 1991, 2001, 2011, 2021

Figure 2: Proportion of spaces with trend occupancy by 2050

According to Malthus' theory, this pessimistic scenario predicts the evolution of space. As human populations increase, the continued and irreversible pressure on the environment will lead to the depletion of the natural resources on which humans depend. Expanding the field will not be conducive to plant formation. This would result in a degraded savannah, reddish-brown formations, or even an occupation of fringe areas constituting rocky outcrops or armoured spaces. The loss of pasture land to agricultural land will lead to the scarcity or disappearance of fodder resources.

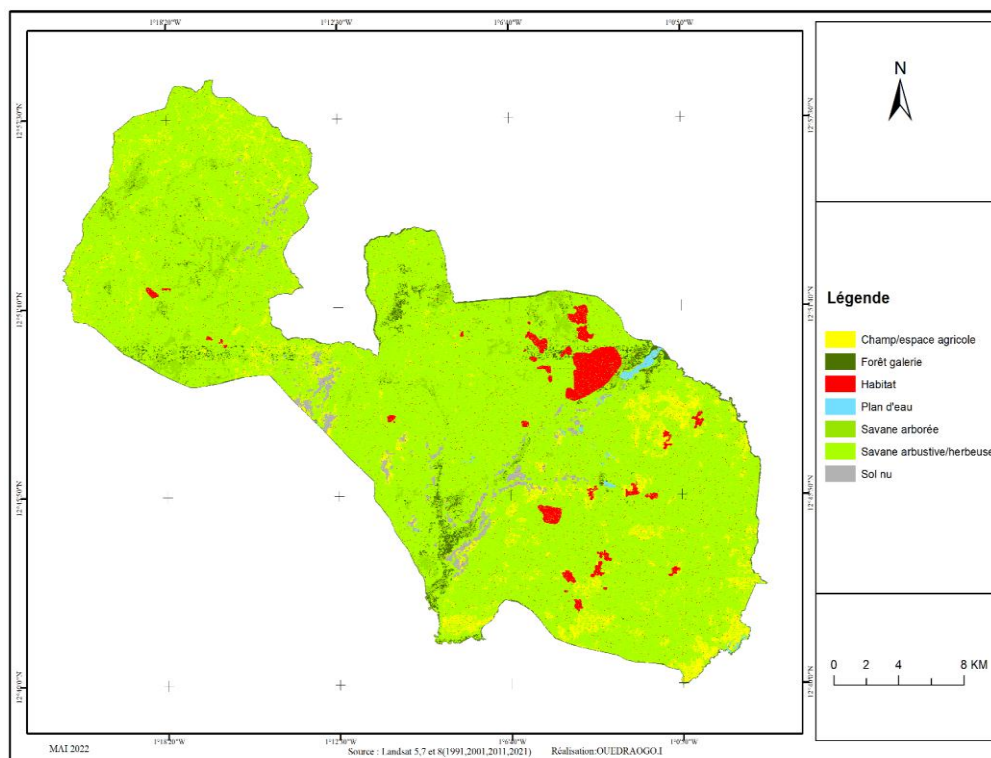
1.3. 1.3 Optimistic outlook for 2050

An optimistic forecast of land use by 2050 based on data of 1991, 2001, 2011 and 2021, shows a regression in the spaces occupied by

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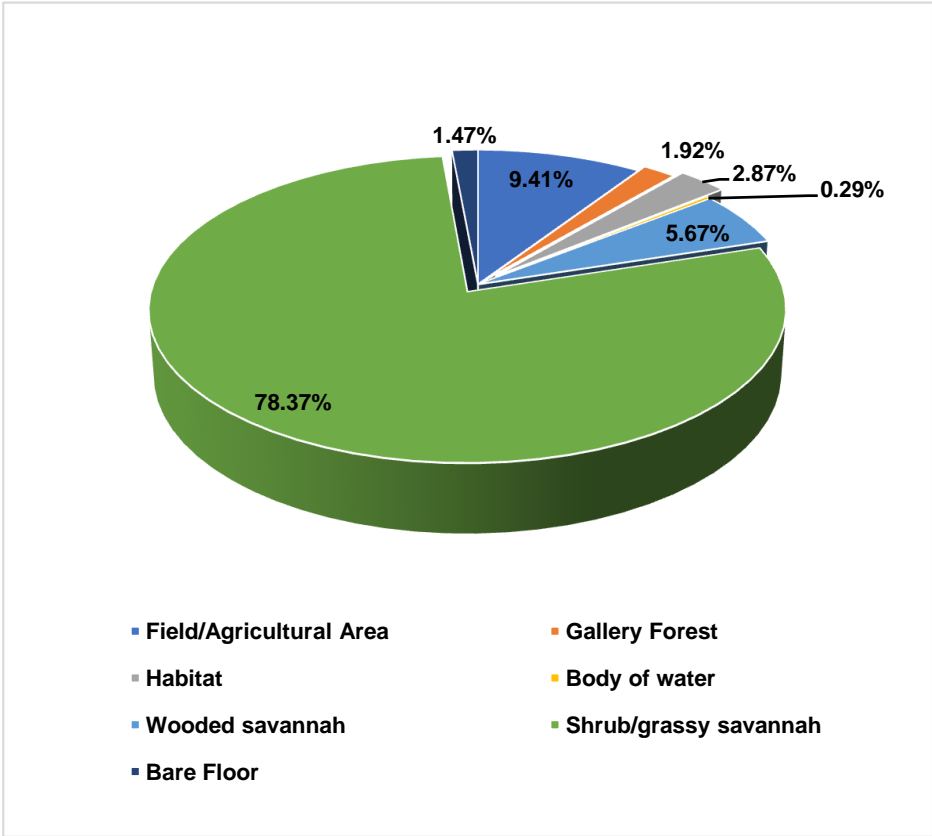
anthropogenic activities and an increase in natural areas of 5.67 per cent % for wooded savannahs and 78.37 per cent% for shrub and grassy savannahs. This dynamic of optimistic land use dynamics is only possible if there is a break in with the current trend (Map 2, Figure 3).



Map2:Optimisticoutlook for 2050

The optimistic simulation is based on the likely awareness of the dire situation and the implementation of environmental restoration projects. This forecast is optimistic insofar as it would be the result of a rational exploitation of natural resources and an efficient implementation of a land use plan that considerstakes into account not only the needs of people, but also the environment.

The second scenario, on the other hand, calls for human ingenuity to cope with the constraints of natural resource degradation in a context of population growth. This is an optimistic Boserupian scenario. In this context, the abuse and destruction of forest resources, crops and residential occupation to the detriment of natural areas will lead actors to become aware of the need to protect the environment. The Ppastoral areas are dedicated to grazing animals. In addition, other spaces have been allocated for hunting activities and can be used as grazing areas for animals. The aim is to protect ecosystems from risks and threats, particularly those associated with agricultural activities. In this scenario, land use and the protection of certain areas will be fully respected in the future.



Source : Landsat Image Processing 1991, 2001, 2011, 2021

4. DISCUSSION

The analysis of the evolution of land cover in the municipality of Korsimoro, based on data collected between 1991 and 2021, made it possible to project land cover trends up to 2050. The results indicated a trend marked by a significant increase in the areas occupied by anthropogenic activities, in particular fields and agricultural areas, as well as urban habitats, to the detriment of natural areas. Similar ~~These different~~ results ~~were~~ corroborated by ~~these~~ Arouna et al., (2016); Traore and Koura, (2019) and Mounir and al., (2022).

Observing ~~these~~ trends revealed a major change in the land landscape of the municipality. ~~In fact,~~ the data shows a 25.69% per cent increase in the area devoted to agricultural activities, suggesting an intensification of land use to meet the population's growing needs for food and agricultural resources. This expansion of agricultural activities is often associated with intensive practices such as

Figure 3: Proportions of Optimistic Occupancy Spaces by 2050

deforestation and the conversion of natural land to arable land, thus leading to a regression of natural areas, as evidenced by the work of ~~the~~ Kamagaté et al. (2019) and Zongo ~~et al.~~ (2014).

At the same time, ~~the~~ study showed ~~an~~ increase in housing and bare soil, which testifies to increasing urbanization and ~~an~~ expansion of human infrastructure in the municipality. This rapid urbanization may be the result of factors such as population growth, ~~the~~ attraction of economic opportunities, and increased demand for housing and infrastructure. Similar results ~~were reported~~ ~~are found~~ by Said and Ouilji (2022).

However, this shift towards land use dominated by anthropogenic activities raises major concerns ~~regarding in terms of~~ environmental and biodiversity preservation. ~~The r~~Regression of natural areas can have harmful consequences on local ecosystems, air and water quality, as well as on resilience to climate change. In the face of these challenges, it is imperative to adopt land management policies and strategies ~~to that~~ promote sustainable and balanced use of natural resources. This could involve measures such as the promotion of sustainable agricultural practices, ~~the~~ preservation of green spaces and integrated urban planning to limit excessive urban sprawl (Thierry ~~et al.~~, 2018; ~~(Honvou~~ ~~et al.~~, 2022; ~~(MOUSSA dit~~ Kalamou ~~et al.~~, 2018).

In contrast, the analysis of the evolution of land use in the municipality of Korsimoro, ~~considering taking into account~~ an optimistic forecast for 2050, reveals contrasting trends compared to the current situation. This optimistic projection, based on data from 1991, 2001, 2011 and 2021, highlights ~~at the~~ potential reversal of land use trends, with a regression in the spaces occupied by anthropogenic activities and an increase in natural areas (Thierry ~~et al.~~, 2018; ~~(Corgne,~~ 2004; ~~(Kinane~~ ~~et al.~~, 2008).

Indeed, our results indicate a regression of the spaces occupied by anthropogenic activities, including fields and agricultural areas, in contrast to the trends ~~s~~ observed so far. This dynamic is supported by a significant increase in natural areas, in particular an increase of 5.67% ~~per cent~~ for wooded savannahs and 78.37% ~~per cent~~ for shrub and grassy savannahs.

This optimistic trend highlights the possibility of a break with current land-use patterns, with positive implications for biodiversity conservation and ~~the~~ preservation of local ecosystems. However, it is important to note that achieving this optimistic projection would require significant changes in development policies and land management practices (Rousseau ~~et al.~~, 2007; ~~(Oloukoi,~~ 2013).

To achieve this optimistic momentum of land use, measures such as the promotion of sustainable agricultural practices, ~~the~~ restoration of degraded ecosystems and ~~the~~ establishment of protected areas ~~are would be~~ necessary. In addition, ~~the~~ active involvement of local stakeholders and increased awareness of the importance of nature conservation ~~are would be~~ key to supporting this transition to a more sustainable future (Osseni ~~et al.~~, 2023; ~~(Kabore~~ ~~et al.~~, 2019).

In short, this study highlights the importance of considering alternative scenarios in the analysis of the evolution of land use, highlighting the possibilities and challenges related to an optimistic projection for the future of the municipality of

Korsimoro. These results offer important perspectives to guide land management policies and contribute to a more sustainable development of the region.

5. CONCLUSION AND RECOMMENDATIONS

The analysis of the evolution of land use in the municipality of Korsimoro, integrating both current trends and an optimistic projection towards 2050, reveals valuable lessons for sustainable land management and the preservation of biodiversity. The results highlight the significant impact of human activities on the landscape, with ~~thean~~ expansion of agricultural and urban land at the expense of natural ecosystems. However, an optimistic projection suggests a possible reversal of these trends, with ~~a~~ regression in human activities and an increase in natural areas. The use of predictive methods is essential in this analysis, allowing for the assessment of past trends and ~~the~~ anticipation of future land use scenarios. These methods are crucial for informing land management decisions and ~~for~~ guiding interventions to promote sustainable development.

- **Implement Sustainable Land Use Policies:** Develop and enforce policies that promote sustainable land use practices in ~~the~~ Korsimoro municipality. This ~~includescan include~~ regulations on land conversion, zoning laws to protect natural habitats, and incentives for landowners to adopt conservation measures.
- **Invest in Green Infrastructure:** Invest in green infrastructure projects such as reforestation, green corridors, and wetland restoration to enhance ecosystem services and biodiversity conservation. These projects can also help mitigate the impacts of urbanization and agricultural expansion on natural ecosystems.
- **Promote Agroecology:** Encourage the adoption of agroecological practices among farmers to promote sustainable agriculture while preserving biodiversity. This can include practices such as agroforestry, organic farming, and crop diversification, which can improve soil health, reduce reliance on chemical inputs, and enhance ~~the~~ biodiversity on agricultural lands.
- **Foster Community Engagement:** Engage local communities, stakeholders, and indigenous groups in ~~land-use~~ planning processes to ensure that their perspectives and traditional knowledge are integrated into decision-making. This can help build local support for conservation efforts and foster stewardship of natural resources.
- **Monitor and Evaluate:** Establish a monitoring and evaluation system to track changes in land use over time and assess the effectiveness of interventions aimed at promoting sustainable land management. Regular monitoring can help ~~to~~ identify emerging threats to biodiversity and inform adaptive management strategies.
- ~~Invest in~~ **Education and Awareness:** Educate the public about the importance of biodiversity conservation and sustainable land management through outreach campaigns, environmental education programs, and community workshops. Increasing awareness about the value of natural ecosystems can help garner support for conservation initiatives and foster a culture of environmental stewardship.

- **Collaborate Across Sectors:** Foster collaboration among government agencies, NGOs, academic institutions, and private sector actors to address complex land-use challenges in a coordinated manner. By working together, stakeholders can leverage their expertise and resources to develop holistic solutions that balance socio-economic development with environmental conservation goals.

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