Open Journal of Applied Sciences, 2025, 15(12), 3828-3842
https://www.scirp.org/journal/ojapps
ISSN Online: 2165-3925
ISSN Print: 2165-3917

Mapping Land Use and the Impacts of Hydro-Agricultural Developments in the Kabaline Sub-Watershed, Lower Casamance (Senegal)

Hyacinthe Sambou[1], Fode Amata Drame[1], Cheikh Sadibou Faye[2]

[1]Institute of Environmental Sciences, Cheikh Anta Diop University, Dakar, Senegal
[2]Civil Engineering Department, Thiès Polytechnic School (EPT), Thiès, Senegal
Email: hyacinthe.sambou@ucad.edu.sn, csfaye@ept.edu.sn

How to cite this paper: Sambou, H., Drame, F.A. and Faye, C.S. (2025) Mapping Land Use and the Impacts of Hydro-Agricultural Developments in the Kabaline Sub-Watershed, Lower Casamance (Senegal). *Open Journal of Applied Sciences*, **15**, 3828-3842.
https://doi.org/10.4236/ojapps.2025.1512248

Received: November 1, 2025
Accepted: December 5, 2025
Published: December 8, 2025

Abstract

In Lower Casamance, rice cultivation is developing in lowlands and valleys. It is mainly rain-fed. Rice plays a major role in dietary habits. It is a symbol in cultural activities. However, rice cultivation faces many constraints, such as rainfall deficits, but above all, soil salinization and acidification. This study focuses on analyzing changes in land use and the impacts caused by hydro-agricultural developments in the Kabaline sub-watershed. The methodology used is based on diachronic mapping through the processing of Landsat satellite images from 1984, 2006, and 2024, combined with field surveys. The results of satellite image processing showed a significant increase in the area of dense dry forests between 1984 and 2024. In contrast, a sharp decline in the area of wooded savannas and plateau fields was observed. Furthermore, the creation of change maps revealed that between 1984 and 2024, 768.59 hectares of wooded savannahs became dense dry forests. However, 101.76 hectares of plateau fields and 74.45 hectares of dense dry forests became wooded savannas between 1984 and 2024. Lowland fields increased in size between 2000 and 2024. This trend is the result of hydro-agricultural developments carried out in the sub-watershed since 1992. These results show that state authorities must encourage this type of development and involve local communities more closely in the management and conservation of these structures in order to intensify rice cultivation, which is the primary objective of these developments.

Keywords

Impacts, Hydro-Agricultural Developments, Cartography, Sub-Watershed, Lower Casamance

1. Introduction

Earth observation from space is becoming an increasingly indispensable tool in the development of a multitude of scientific disciplines. This technique makes it possible to track the dynamic changes and transformations undergone by the Earth through diachronic analyses [1] [2]. Indeed, thanks to new information and communication technologies, the last two decades have seen an unprecedented boom in scientific work in Earth monitoring.

Lower Casamance, located in southern Senegal in the Ziguinchor region, covers an area of 7339 km^2 (**Figure 1**). In terms of climate, it belongs to the South Sudanese coastal domain [3]. It is considered one of the rainiest regions in the country with very rich agricultural land. In addition, Lower Casamance is crisscrossed by numerous rivers and valleys (the Casamance River and its tributaries) with a concentration of surface and underground water flows, thus favoring the cultivation of these depressions. It has long been self-sufficient in rice. However, for several decades, the region has been subject to soil salinization and acidification, exacerbated by climate variability, marked since 1968 by a significant decrease in rainfall and a change in the water regime, as well as a reduction in the flow of the Casamance River and its tributaries [4] [5]. Some of its valleys are also marked by a profound invasion of seawater inland due to the low slopes. According to the National Institute of Pedology [6], 73% of Senegal's saline soils are located in the alluvial valleys of the Casamance and Senegal rivers. However, the Diola society of Casamance, the main player in lowland rice cultivation, demonstrates remarkable expertise in the development of rice fields compared to other rice-growing societies [7] [8]. This has affected agricultural activities, which are the main sources of income and food for the population. To address this phenomenon, water management is seen as a strategy for securing rice production, resulting in the development of small, traditionally designed hydro-agricultural structures. Numerous small anti-salt structures have been installed throughout the Ziguinchor region. The purpose of these hydraulic structures is to recover and make profitable some of these valleys affected by salinization and rainfall deficit in order to intensify rice production. The salinization of lowlands and valleys and the construction of small anti-salt structures in Lower Casamance have attracted the interest of many researchers since the 1960s, including [9]-[14]. However, given the extent of salinization and acidification of agricultural land, the impact of small, traditionally designed hydro-agricultural structures appeared to be limited.

This led to the construction of more modernized anti-salt micro-dams in the area starting in the 1990s, in the hope of substantially slowing down the salinization of rice-growing land. However, the proliferation of these types of structures has led to changes in ecosystems, which in turn have led to changes in land use around the structures. Numerous studies have been conducted in the area to explain the phenomenon of salinization and identify the different types of saline soils [15]-[17] and the dynamics of agricultural landscapes on agricultural activities [18] [19]. There has been little research into changes in land occupation and use around anti-salt structures in the area. Today, the planning and monitoring of rice-growing areas is a constant concern for those involved in water resource management and for producers for whom rice plays a major role in their diet and in certain cultural rituals. In order to understand the dynamics of land use change around anti-salt structures and analyze their impact on rice farming, we undertook this study in Lower Casamance, an area characterized by a predominance of rice cultivation (more than 80%). Rice farming, the main activity in the area, is influenced by climatic hazards that cause significant changes. Space-based remote sensing offers opportunities for continuous observation of the Earth's surface. Thanks to remote sensing, it is possible to create databases that provide information on the state of natural ecosystems and their evolution. In Sudanian regions undergoing rapid socio-environmental change [20] [21], monitoring land use is essential for establishing a diagnosis and better understanding the causes of vegetation change and its consequences.

It is a suitable tool for understanding spatio-temporal changes in land use [22]. The availability of Landsat satellite images provides an opportunity to characterize the evolution of the soil in this sub-watershed. However, the heavy reliance on spectral characteristics is one of the main reasons for the unreliability of the classified map [23]. To overcome this constraint specific to remote sensing, we used field data to improve the accuracy of classification and the reliability of land cover maps obtained from Landsat data from 1984, 2000, and 2025. This topic has become essential in most cartographic inventories and environmental monitoring [24]. Unable to study changes in land use and occupation around saltwater barriers across all production systems in Lower Casamance, this study focuses on analyzing changes in occupation and the impacts caused by hydro-agricultural developments. It centers on the Kabaline sub-watershed.

2. Materials and Methods

2.1. Presentation of the Study Area

The Kabaline sub-basin is located in the Tendouck district, Bignona department. It is situated between the municipalities of Balingor and Diégoune, between 16˚22'00" and 16˚25'30" west longitude and 12˚45'30" and 12˚48'30" north latitude (**Figure 1**). The flat terrain consists of vast plains and large valleys suitable for agriculture and livestock farming. The geomorphology is characterized by plateau soils, ferralitic and ferruginous soils, rich hydromorphic soils near estuaries and along watercourses, clayey lowland soils used for rice cultivation, and poor halomorphic soils characterized by high salinity, which are unsuitable for agricultural activities [25]. Climate According to [3], it belongs to the South Sudanese coastal climate zone. Its location in this zone gives it particular characteristics. It is the rainiest area in Senegal [26]. Average annual rainfall is 1500 mm. The high rainfall is one of the main features that makes this region suitable for agriculture, particularly flooded rice cultivation. Temperatures vary between 38˚C and 22˚C. The forest area consists of dense, open forests and gallery forests located mainly in the southern part, wooded and tree-covered savannas, mangroves, and palm groves that colonize the riverine and maritime zone. Most dense dry forests are traditionally protected sites because they are sacred places, which gives them special protected status. There are also rattan groves [27].

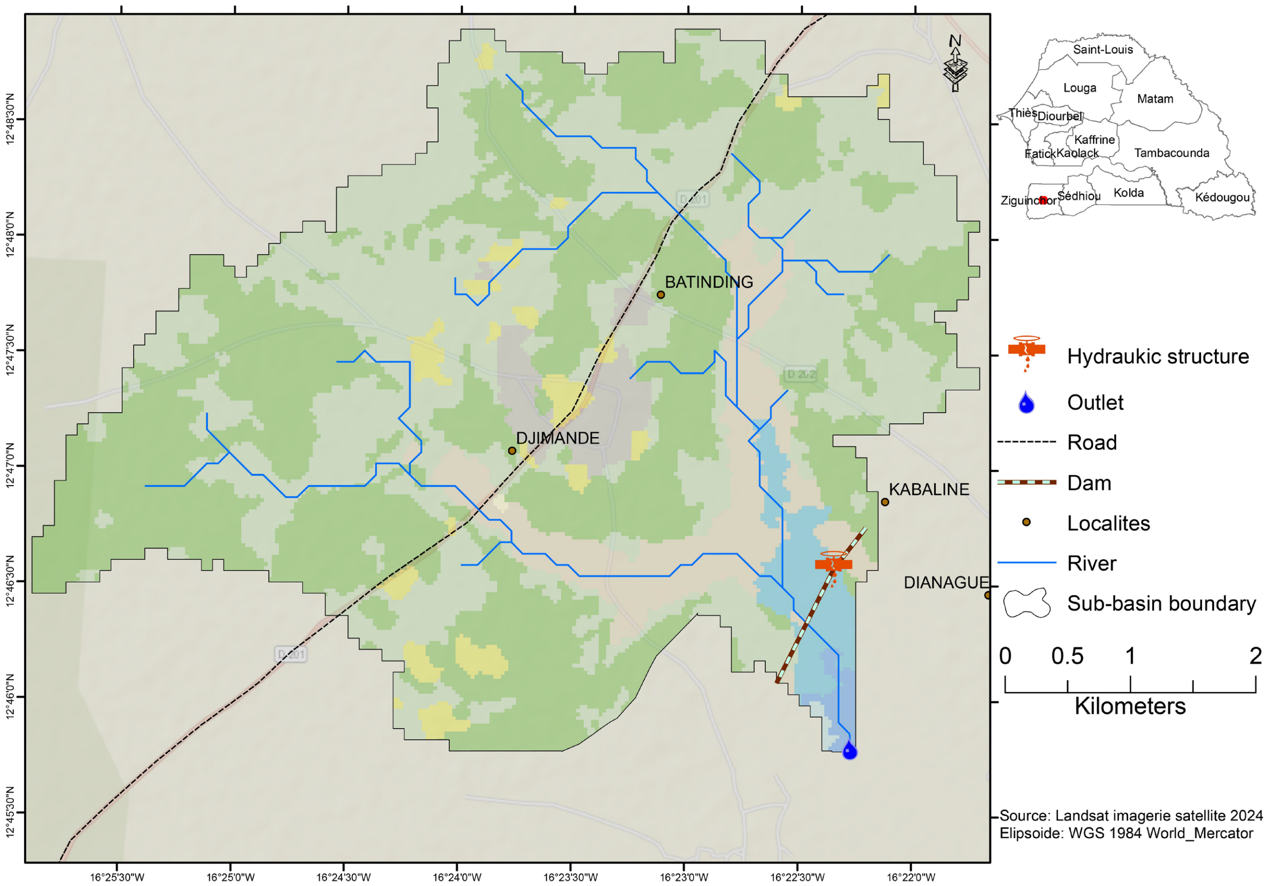

Figure 1. Map of the study area location.

2.2. Satellite Data Collection

This study required the use of three (03) satellite images from Landsat Thematic Mapper (TM) sensors for the 1984 image, Enhanced Thematic Mapper Plus (ETM+) for the 2000 image, and Operational Land Imager (OLI) for the 2025 image. The year 1984 was characterized by a rainfall deficit in the study area (a continuation of the drought period of the 1970s). It was also a year in which the fight against salinization of rice fields was mainly carried out using traditional anti-salt structures. The year 2000 marked the end of the drought. It also marked the advent of more or less modernized anti-salt structures. Then, in 2025, rainfall gradually returned to normal levels. Similarly, this year was chosen not only because it was when the field missions took place, but also to allow sufficient time to assess the long-term effects of developments that began in the 1990s. All images used in this study were taken during the dry season in December for all satellite images from 1984, 2000, and 2025. The dry season was chosen because cloud cover is lowest during this period. Furthermore, as the study took into account the inventory of herbaceous plant species in rice fields, December appears to be the most appropriate month. In addition, using images from the same season in a study of changes helps to reduce seasonal effects [28].

2.3. Mapping of Land Use Units

Mapping the spatiotemporal dynamics of land use in the Kabaline sub-watershed in Lower Casamance began with the development of land use maps. The sub-watershed is entirely covered by the Landsat 205-51 scene. For each image, color composites were created by combining the OLI 6/5/4 and TM/ETM+ 5/4/3 bands, corresponding respectively to the mid-infrared, near-infrared, and red spectral bands after extraction of the study area from the scene. Based on the color compositions, 180 points were selected from the images according to their spectral signature, and their geographical coordinates were recorded. In addition, three field missions were conducted (prospecting mission, classification verification mission, and classification validation mission). The first consisted of visually checking the land use classes in the field. This task was carried out after acquiring satellite data in order to determine the units corresponding to the areas identified on the color compositions. These different land use units were referenced and described in the field based on physical criteria such as stratification, land use types, structure, and plant species.

During field missions, the first task was to visually verify land cover classes in the field. Thus, based on the reflectance of the different strata that make up the satellite images, a supervised classification using the maximum likelihood algorithm was performed according to the different strata [29]. The classification quality was estimated using a confusion matrix [30] [31]. The overall accuracies obtained were 88%, 89%, and 93% for the 1984, 2000, and 2024 satellite images, respectively. However, slight confusion was noted between hillside fields and ponds on the one hand, and mudflats and ponds on the other.

2.4. Analysis of the Dynamics of Changes in Land Use in Different Areas from 1984 to 2024

The analysis of the spatio-temporal dynamics of land cover units in the study area focused on the quantitative distribution of land cover units for each year (1984, 2000, and 2024) and their evolution during the study period. The spatio-temporal evolution of each land cover unit was assessed by determining the areas of different land cover types on the images processed for the dates on which they were taken [32]. Thus, histograms were created based on the surface areas of land use units. For the statistical analysis of land use dynamics, the rate of stability, regression, or progression of landscape units was first calculated from one year to the next. This calculation was performed using the formula applied by [33] to measure changes in area between two given dates. The variable considered here is area (A). Thus, for S_1 and S_2, corresponding respectively to the area of a land use unit in 1984, 2006, and 2024, the rates of change in area are calculated using the following formula:

$$Tv(\%) = \frac{S_2}{S_1} - 1 * 100$$

$S_2 - S_1$ = negative, we conclude that there has been a decline in vegetation cover from year 1 to year 2.

$S_2 - S_1$ = positive, we conclude that there has been an increase in vegetation cover from year 1 to year 2.

$S_2 - S_1$ = zero, we conclude that vegetation cover has remained stable from year 1 to year 2.

3. Results—Spatio-Temporal Dynamics of Land Use Units in the Kabaline Sub-Watershed between 1984 and 2024

3.1. Land Use Status in 1984

In 1984, land use mapping showed a predominance of vegetation cover, consisting mainly of dense dry forest and wooded savanna (Figure 2). At that time, dense forest covered 10.5% of the 287.5 ha sub-watershed. As for the wooded savanna, it covered 1580.7 hectares, representing 57.5% of the entire sub-watershed. In 1984, agricultural areas consisted of plateau rice fields and slopes covering a total area of 811 hectares, with 297 hectares and 514 hectares, respectively. Tans, water, and mudflats were the least represented land use types in 1984. These types covered 1 hectare, 2.1 hectares, and 17.7 hectares, respectively.

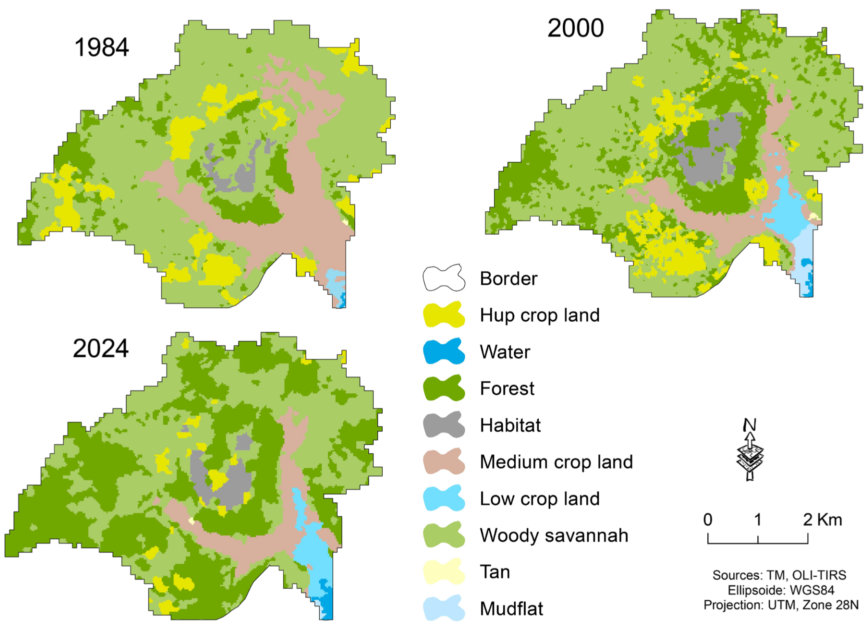

Figure 2. Spatial evolution of land use units in the Kabaline sub-watershed between 1984 and 2024.

3.2. Land Use Status in 2006

In 2000, the area covered by wooded savannahs declined from 57.50% in 1984 to 50.60% in 2000 (Table 1) in the Kabaline sub-basin. At the same time, there has been an increase in the area of dense dry forests. From 10.50% in 1984, their area increased to 24% in 2000. In contrast, there has been a decline in the area of rice fields. Thus, plateau rice fields and hillside rice fields declined from 10.8% to 9.00% and from 18.1% to 8.1%, respectively, between 1984 and 2000. The construction of the anti-salt micro-dam in 2000 contributed significantly to the emergence of low-lying rice fields covering an area of 62.8 hectares (Figure 2). Similarly, in 2000, there was more than a twofold increase in built-up land and mudflats.

Table 1. Changes in land use units in the Kabaline sub-watershed between 1984 and 2024.

Land Use Units	1984		2000		2024	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Habitat	49.4	1.8	101.6	3.7	83.42	3.03
Water	2.1	0	8.3	0.3	80.27	2.92
Hup Crop Land	297	10.8	248.6	9	16.80	0.61
Forest	287.5	10.5	659.1	24	1188.15	43.21
Medium Crop Land	514	18.1	233.6	8.5	227.57	8.28
Low Crop Land	0	0	62.8	2.3	82.70	3.01
Woody Savannah	1580.7	57.5	1392.8	50.6	1065.94	38.77
Tan	1	0	2	0.1	1.17	0.04
Mudflat	17.7	0.7	40.6	1.5	3.44	0.13
Total	2749.4	100	2749.4	100	2749.47	100.00

3.3. Land Use Status in 2024

In 2024, the Kabaline sub-watershed is dominated by vegetation formations. Dense dry forests have increased significantly. Their area has grown from 659.1 hectares in 2000 to 1188.15 hectares in 2024, occupying 43.21% of the sub-watershed. However, a decline in the area of wooded savannas has been noted. From 1392.8 hectares in 2000, their area decreased to 1065.94 hectares in 2024. One of the most notable changes in 2024 is in the land use category of lowland rice fields. Their area decreased from 0.00% in 1984 to 3.01% in 2024. As for plateau rice fields, their area has decreased significantly from 9.00% in 2000 to 0.61% in 2024 (Table 1). Mudflats have virtually disappeared in 20224, leaving only a few entities. In summary, from 1984 to 2024, land use dynamics in the Kabaline sub-watershed reveal a steady increase in dense dry forests and a decline in wooded savannas and agricultural areas, except for lowland farming areas.

The changes that have occurred in the different types of land use are illustrated by the transition matrices (Table 2 and Figure 3). Figure 3 shows that conversions are mainly located in the central part of the sub-watershed, while changes are more localized in the western part. Between 1984 and 2024, the type of land cover that remained most stable was waterways, at 100%. Meanwhile, wooded savanna was one of the land cover types that underwent the most change.

Table 2. Transition matrix for land use units between 1984 and 2024.

1984-2024 (ha)	LUC 1984								Total 2024(f)	Gain
LUC 2024	HCL	WA	FO	HB	MCL	WS	TA	MU		
HCL	178.71	0.0	0.72	1.8	44.34	54.68	0.0	0.0	**280.25**	101.54
WA	0.0	2.09	0.0	0.0	3.91	0.0	0.0	10.81	**16.81**	14.72
FO	6.53	0.0	209.1	0.33	0.36	768.59	0.0	0.0	**984.91**	775.81
HB	0.63	0.0	3.06	45.92	0.0	40.81	0.0	0.0	**90.42**	44.5
MCL	0.0	0.0	0.18	0.0	379.92	6.84	0.63	0.0	**387.57**	7.65
LCL	0.0	0.0	0.0	0.0	81.76	0.09	0.0	0.0	**81.85**	81.85
WS	101.76	0.0	74.45	1.39	0.0	719.1	0.0	0.0	**896.7**	177.6
TA	0.0	0.0	0.0	0.0	1.17	0.0	0.27	0.0	**1.44**	1.17
MU	0.0	0.0	0.0	0.0	2.39	0.0	0.0	6.91	**9.3**	2.39
Total 1984(i)	**287.63**	**2.09**	**287.51**	**49.44**	**513.85**	**1590.11**	**0.9**	**17.72**	**2749.25**	
Perdue	108.92	0	78.41	3.52	133.93	871.01	0.63	10.81		
Total(f) - Total(i)	−207.36	14.72	900.65	33.97	−286.50	−524.18	0.27	−14.27		
TC%	**−72.09**	**705.93**	**313.27**	**68.71**	**−55.73**	**−32.96**	**30**	**−80.57**		
TE Annual	−1.80	17.65	7.83	1.72	−1.39	−0.82	0.75	−2.01		

HCL = Hup Crop Land; WA = Water; FO = Forest; HB = Habitat; MCL = Medium Crop Land; LCL = Low Crop Land; WS = Woody Savannah; TA = Tan; MU = Mudflat; TE = Annual Expansion Rate.

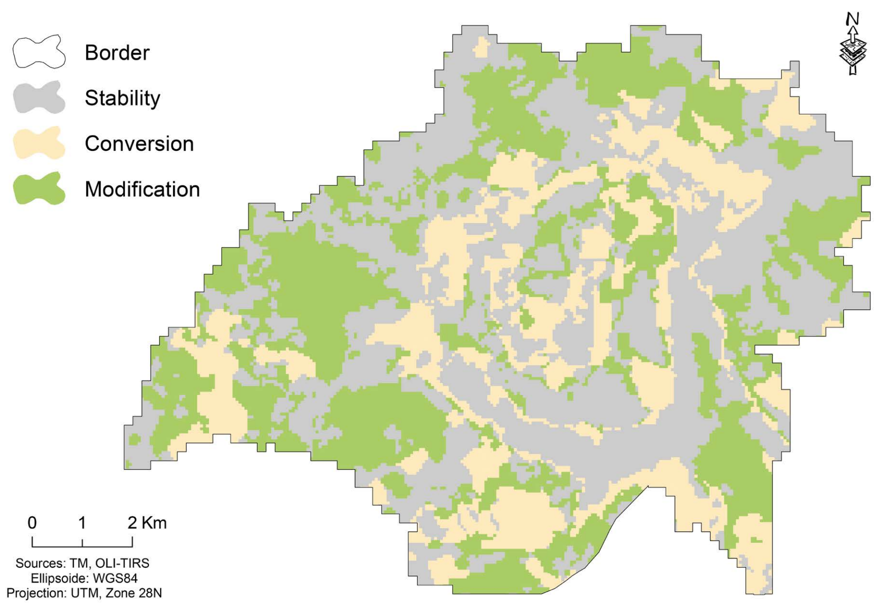

Figure 3. Map of land use changes in the Kabaline sub-watershed between 1984 and 2024.

During this same period, plant formations (dense dry forest and wooded savanna), although remaining the dominant formations in the landscape in 2024, underwent significant changes. Dense dry forests grew by 313.27%, representing an annual expansion rate of 7.83%, despite losing 74.45 hectares of their area to wooded savannah and 0.72 hectares to plateau fields between 1984 and 2024. The expansion of dense dry forests has been at the expense of other land cover types, mainly wooded savannas. Between 1984 and 2024, 768.59 hectares of wooded savannas and 6.53 hectares of plateau fields were converted into dense dry forests (**Table 2**). As for the wooded savanna, it declined by 32.96% between 1984 and 2024 (**Table 2**). This decline has benefited dense dry forests and plateau fields, with 768.59 hectares of land converted to dense dry forests and 54.68 hectares converted to plateau fields. In addition, 40.81 hectares of its area have also been converted into residential areas. Although 101.76 hectares of plateau fields and 74.45 hectares of dense dry forests have been converted and modified into wooded savannas, the overall trend is toward a decline in wooded savannas. Between 1984 and 2024, the areas of plateau fields and slopes declined by 72.09% and 55.73%, respectively. As a result, plateau fields have declined in favor of wooded savanna. During the study period, 101.76 hectares of plateau fields were converted to wooded savanna and 6.53 hectares to dense dry forest. At the same time, hillside fields have declined in favor of lowland fields, with 81.76 hectares of their area converted to lowland fields and 44.34 hectares to plateau fields.

4. Discussion

The high cartographic accuracy achieved in this study can be explained by the good knowledge of the study area, but also by the small number of land cover classes used and the definition of homogeneous plots when selecting training sites [34]. However, the confusion noted between slope fields and tannes and between tannes and mudflats did not significantly affect the reliability of the classification, as it was only around 8.46% and 7.36%. The confusion between sloping fields and tannes could be explained by the fact that fields from which agricultural products are harvested appear as bare areas [29].

The evolution of land use over the last forty years shows significant reforestation overall in the Kabaline sub-watershed in Lower Casamance, with an increase of 313.27% over forty years. This increase in forest areas in the study area has also been observed in central-western Burkina Faso [35], Benin [36], and Brazil [37]. This increase in forest area in the Kabaline sub-watershed could therefore be explained by the fact that dense dry forests have undergone fewer changes and conversions to other types of land use. Thus, several land use units have been converted back to dense dry forests. This is the case for wooded savannas, which have lost 768.59 hectares of their area in forty years to dense dry forests. The same is true for plateau fields, 6.53 hectares of which were converted to dense dry forests in 2024. In addition, this noticeable reforestation in the sub-basin could also be considered a positive impact of the construction of small anti-salt structures, which have helped to retain rainwater and reduce soil salinity. The protection of forest resources based on traditional social rules surrounding the “sacred” could also explain the reforestation of the sub-watershed. In fact, in the study area, the concept of sacredness goes beyond prohibitions based on legal laws. It carries the weight of a strict ban on cutting wood and even gathering it, which all citizens are required to respect, failing which they will face severe penalties. Contrary to our results, studies conducted by [34] [38] [39] and [40] have shown a regressive spatio-temporal dynamic of forest resources in the Sahelian and Sudanian zones of West Africa. Indeed, [34] showed drastic deforestation in the municipalities of Bantè, Glazoué, and Ouèssè in the Sudano-Guinean zone of Benin, while [38] in the Pama partial wildlife reserve and its surroundings (southeastern Burkina Faso) showed that vegetation has declined in favor of bare soil and rocky outcrops, while [39] demonstrated deforestation in favor of savannas in the natural grazing areas of transhumant herds in the municipalities of Banikoara and Karimama in Benin, and [40], whose study in the Agbo 1 classified forest in Côte d'Ivoire revealed a decline in forest cover in favor of agricultural areas.

Unlike dense dry forests, wooded savannas are the land cover type that has undergone the most change in the sub-watershed studied. They have experienced a decline in the area. This decline could be the result of several factors. Anthropization is one of the factors behind this phenomenon. Between 1984 and 2024, 40.81 hectares of wooded savannas were converted into residential areas. Similarly, 54.68 hectares of wooded savannas were converted into plateau fields and 6.84 hectares into slope fields in 2024. Land clearing to increase the area of agricultural fields is one of the factors explaining the decline in tree savanna vegetation cover. These results are similar to those of [35]. Indeed, several authors have reported that changes in landscape composition in the Sahelo-Sudanese, Sudanese, Sudano-Guinean, and Guinean zones are the result of rapid and progressive anthropization manifested by unsustainable agro-silvo-pastoral practices [41]-[43]. Furthermore, our results contradict those of [44] and [45], who observed savannization in the Sudanese zone of Côte d'Ivoire. At the same time, the areas of plateaus and slopes also declined between 1984 and 2024, by 72.09% and 55.73% respectively, representing an annual rate of decline of 1.80% and 1.39%. These results corroborate those of [46], who found that in the rural commune of Kaour from 1990 to 2024 (Sédhiou/Casamance region, Senegal), there was a 45.57% decline in agricultural land between 1990 and 2006. There are two possible reasons for the decline in plateau and hillside cultivation. The first is related to the salinization and acidification of agricultural land prior to the construction of anti-salt structures in the sub-watershed. This situation led to the abandonment of agricultural activities in these farming areas, resulting in their savannization and even reforestation. In fact, 101.76 hectares of plateau fields have been converted into wooded savannahs and 6.53 hectares into dense dry forests. The second reason is the change in land use that took place in the hillside fields between 1984 and 2024, with 81.76 hectares of land being converted into lowland fields. These results confirm our hypothesis that the installation of anti-salt structures in the Kabaline sub-watershed has sparked interest among farmers, particularly rice farmers who cultivate rice in low-lying areas, as evidenced by the increase in the area of low-lying crops. However, the 30 m resolution of the Landsat data used may be a limitation in the spatial analysis of rice-growing areas. Rice cultivation in the area is traditional, with ridges measuring a few centimeters in height that are often submerged. Under these conditions, these features are not easily detectable by Landsat images. Looking ahead, the overall impact of anti-salt micro-dams and land use dynamics on rice cultivation in the Kabaline sub-watershed is an urgent need for the region and must be studied and analyzed accurately using appropriate tools and techniques, such as drone images or very high spatial resolution images (like Pléiades).

5. Conclusions

Monitoring land use in the developed sub-watershed is essential for policymakers, development actors, and scientists alike. This detailed study of the sub-watershed developed by anti-salt micro-dams aimed to analyze changes in land use and the impacts of hydro-agricultural developments in the Kabaline sub-watershed. Several lessons can be learned about landscape change. Water retention by the structures has become a reality in the sub-basin. Although water is not available on a permanent basis, it has enabled the resumption of agricultural activities, particularly rice cultivation in the lowlands. Rational management of this water will therefore offer opportunities to intensify and diversify agricultural production. Land use changed considerably between 1984 and 2024. The most striking observation is the decline in agricultural fields on the plateau. On the other hand, the most encouraging observation is the restoration of vegetation cover, particularly dense dry forests. Changes in land use showed significant variations from one class to another. The most significant changes are those observed in shrub savanna formations. More than half of the tree savanna areas have undergone changes, the most significant of which has been to the benefit of dense dry forests. The sub-watershed studied is an area that needs to be well understood in order to better exploit its agricultural potential.

The results obtained in this research, particularly those concerning changes in land use through remote sensing, are of great importance for understanding the most decisive factors. This study is a first step in the process of identifying land use patterns in the sub-basins of Lower Casamance. The practical aspect of this study also opens up prospects for research on the analysis of changes in rice fields, interactions between farmers' organizations, and climate impacts. Several avenues should therefore be explored to better enhance the value of hydro-agricultural structures in the Kabaline sub-basin. Therefore, we strongly recommend that a policy be put in place to preserve land that is not contaminated by salt. In addition, local populations should be involved from the design phase through to project completion, drawing on their knowledge of micro-dam salt management. This approach will make it possible to move beyond a sectoral and vertical approach, empower local populations in the management of structures after projects, and ensure the long-term maintenance and effectiveness of anti-salt structures.

Acknowledgements

This research is the product of the work of three researchers from the Geomatics Research and Teaching Laboratory affiliated with the Institute of Environmental Sciences and the Ecole Polytechnique de Ties (Senegal). We would like to express our sincere gratitude to the anonymous reviewers and the editor-in-chief of the journal for their constructive and valuable comments.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Corgne, S. and Robin, M. (2000) Évolution de l'occupation du sol à la périphérie du Parc National de Taï (Côte d'Ivoire) *Photo-Interprétation*, **38**, 40-48.

[2] Sbai, A., Lasgaa, H. and Sabri, M. (2016) Contribution de la télédétection dans l'étude et l'évolution spatiotemporelle du couvert végétal: Cas du couloir de taourirt-el ayoun et ses bordures montagneuses (maroc oriental). *La 3ème Edition du Colloque International des utilisateurs du SIG*, Oujda, 22-23 Novembre 2016, 245-250.

[3] Sagna, P. (2005) Dynamique du climat et son évolution récente dans la partie ouest de l'afrique occidentale. Thèse de Doctorat, Université Cheikh Anta Diop de Dakar, 786 p.

[4] Dacosta, H. (1989) Précipitation et écoulements sur le bassin de la casamance. Thèse de 3ème cycle, Université Cheikh Anta Diop de Dakar, 278 p.

[5] Albergel, J., Brunet, D., Dubee, G., Montoroi, J. P. and Zante, P. (1991) Gestion d'un barrage anti-sel en Basse-Casamance (Sénégal) In: Kergreis, A. and Claude, J., Eds., *Utilisation Rationnelle de l'eau Des Petits Bassins Versants en Zone Aride*, AUPELF-UREF and John Libbey Eurotext, 275-285.

[6] INP (2013) Atelier de lancement du partenariat sur les sols accra le 04 fevrier 2013. https://www.fao.org/fileadmin/user_upload/GSP/docs/West_africa_partner/Senegal_Ndene.pdf

[7] Dubresson, A., Moreau, S., Raison, J.P. and Steck, J.F. (2011) L'Afrique sub-saharienne. Une géographie du changement. Armand Colin, 109-142.

[8] Marzouk, Y. (1991) Histoire des conceptions hydrauliques étatiques et paysannes en Basse-Casamance, Sénégal, 1960-1990. In: Dupre, G., Ed., *Savoirs Paysans et Développement*, Karthala-ORSTOM, 61-97.

[9] Aubrun, A. (1987) Les aménagements en Basse Casamance: Exemples dans la vallée de Bignona, Sénégal. *Aménagements Hydro-Agricoles et Systèmes de Production*: *Actes du IIIème Séminaire*, Montpellier, 16-19 Décembre 1986, 283-293.

[10] Marius, C. (1984) Mangroves du Sénégal et de la Gambie: Ecologie-Géologie-Pédochimie Mise en valeur et aménagement. Thèse en ès Sciences Naturelles, ORSTOM, 335 p.

[11] Berton, S. (1988) La maîtrise des crues dans les bas-fonds, petits et micro-barrages en Afrique de l'Ouest. Le point sur, No. 12, GRET, Ministère de la Coopération et Agence de Coopération culturelle et Technique, 360 p.

[12] Brunet, D. (1994) Un aménagement hydraulique simple pour la réhabilitation des sols salés: La riziculture en basse casamance. *Sécheresse*, **5**, 37-44.

[13] Diédhiou, L. (2004) Riz, symboles et développement chez les Diolas de Basse Casamance. Les Presses de l'Université de Laval, 339 p.

[14] Marius, C. (1987) La mise en valeur et l'aménagement des sols de mangroves (Guyane, Indonésie, Sénégal). *Les Aménagements Hydro-Agricoles et Systèmes de Production*: *Actes du IIIème Séminaire*, Montpellie, 16-19 Décembre 1986, 265-274.

[15] Badiane, L.M. (2016b) Gestion hydrologique et spatiale d'un hydrosysteme aménagé: Le marigot de Bignona en Basse-Casamance. Thèse de doctorat, Université Gaston Berger de Saint-Louis (Sénégal).

[16] Diouf, E. (2013) Ouvrages hydrauliques et modèles de gestion de l'eau dans le bassin du fleuve Casamance. Thèse en Cotutelle Internationale, Université Gaston Berger de Saint-Louis (Sénégal) et Université Paris Ouest-Nanterre la Défense (France).

[17] Badiane, A., Sané, B. and Thior, M. (2019) Impacts de la Dynamique des Paysages Agraires sur les Activités Agricoles dans la Commune d'adéane en Basse-Casamance (Sénégal). *European Scientific Journal ESJ*, **15**, 489-506. https://doi.org/10.19044/esj.2019.v15n21p489

[18] Sène, A. (2017) Dynamiques de l'agriculture péri-urbaine de la commune de Ziguinchor: Cas du maraîchage des quartiers de Kadialang Est et Ouest. *Regards Croisés sur les Enjeux et Perspectives Environnementaux de la Recomposition des Espaces Urbain et Périurbain Face aux Changements Climatiques*, *Colloque UASZ*, Ziguinchor, 9 February 2017, 17 p.

[19] Rachdi, B., Hakdaoui, M., Badri, W., Fougrach, H., El Aboudi, A. and Hsaine, M. (2016) Etude Diachronique des Changements Spatio-Temporels du Couvert Végétal par Télédétection Spatiale: Cas de la Province de Benslimane (Maroc Central). *European Journal of Scientific Research*, **143**, 176-185.

[20] Fayama, T., Dabiré, D. and Ba, A. (2020) Chapitre 22. Perceptions du changement climatique et stratégies paysannes d'adaptation. In: Sultan, B., Bossa, A.Y., Salack, S. and Sanon, M., Eds., *Risques Climatiques et Agriculture en Afrique de l'Ouest*, IRD Éditions, 289-296. https://doi.org/10.4000/books.irdeditions.36509

[21] Lambin, E. (1988) Apport de la télédétection satellitaire pour l'étude des systèmes agraire et la gestion des terroirs en Afrique occidentale. Exemple au Burkina Faso. Thèse de doctorat, Université Catholique de Louvain, 239 p.

[22] Manandhar, R., Odeh, I.O.A. and Ancev, T. (2009) Improving the Accuracy of Land Use and Land Cover Classification of Landsat Data Using Post-Classification Enhancement. *Remote Sensing*, **1**, 330-344. https://doi.org/10.3390/rs1030330

[23] Ouattara, T., Dubois, J.M. and Gwyn J. (2006) Méthodes de cartographie de l'occupation des terres en milieu aride à l'aide de données multi-sources et de l'indice de végétation TSAVI. *Télédétection*, **6**, 291-304.

[24] SDADT (2016) Schéma départemental d'aménagement et de développement territorial de bignona. 122 p.

[25] Sané, T. (2017) Vulnérabilité et adaptabilité des systèmes agraire à la variabilité climatique et aux changements sociaux en Basse Casamance (SUD-OUEST du Sénégal. Thèse de doctorat de Géographie et Environnement, Université Cheikh Anta Diop de Dakar and Université Sorbone, 377 p.

[26] Mané, A. (2007) L'importance de la route dans le développement socioéconomique d'une région: Exemple de la départementale 200 ou boucle du Blouf. Université Cheikh Anta Diop de Dakar, 97 p.

[27] Kan, K. (2021) Dynamiques du paysage d'une zone de contact forêt-savane et migration agricole pour la culture cacaoyère à l 'ouest de la Côte d'ivoire. Thèse de Doctorat, Université Jean Lorougnon Guédé, Daloa, 135.

[28] Salomon, W., Sikuzani, Y.U., Kouakou, A.T.M., Barima, Y.S.S., Theodat, J.M. and

Bogaert, J. (2021) Cartographie et quantification de la perte du couvert forestier dans les parcs nationaux du Sud de la République d'Haïti de 1985 à 2018: Rôle des activités agricoles locales. *International Journal of Biological and Chemical Sciences*, **15**, 477-496. https://doi.org/10.4314/ijbcs.v15i2.9

[29] Abdel Kawy, W.A. and Belal, A.A. (2011) GIS to Assess the Environmental Sensitivity for Desertification in Soil Adjacent to ElManzala Lake, East of Nile Delta, Egypt. *American-Eurasian Journal of Agriculture and Environmental Sciences*, **10**, 844-856.

[30] Szwald, J. (2005) Dynamique des formations agroforestières en Côte d'Ivoire (depuis les années 1980 aux années 2000): Suivi par télédétection et développement d'une approche cartographique. Thèse de Doctorat, Université de Lille 1, 304.

[31] Kpedenou, K.D., Boukpessi, T. and Tchamie, T.T.K. (2016) Quantification des changements de l'occupation du sol dans la préfecture de yoto (sud-est togo) à l'aide de l'imagerie satellitaire landsat. *Revue des Sciences de l'Environnement*, **13**, 137-156. https://hal.archives-ouvertes.fr/hal-01409418

[32] Oloukoi, V., Mama, J. and Agbo, F.B. (2006) Modélisation de la dynamique de l'occupation des terres dans le épartement des Collines au Bénin. *Télédétection*, **6**, 305-323. https://www.academia.edu/download/31950941/20070711045420.pdf

[33] Mama, A., Bamba, I., Sinsin, B., Bogaert, J. and De Cannière, C. (2014) Déforestation, savanisation et développement agricole des paysages de savanes-forêts dans la zone soudano-guinéenne du Bénin. *Bois & Forets des Tropiques*, **322**, 66-75. https://doi.org/10.19182/bft2014.322.a31237

[34] Tiamiyu, K., Yaméogo, J., Sanou, K. and Yanogo, P.I. (2023) Dynamique des forêts communautaires dans la région du centre-ouest du Burkina Faso: Cas de la commune rurale de siglé. *International Journal of Biological and Chemical Sciences*, **17**, 63-76. https://doi.org/10.4314/ijbcs.v17i1.5

[35] Gbedahi, O.L.C., Biaou, S.S.H., Mama, A., Gouwakinnou, G.N. and Yorou, N.S. (2019) Dynamique du couvert végétal à Bassila au nord Bénin pendant et après la mise en œuvre d'un projet d'aménagement forestier. *International Journal of Biological and Chemical Sciences*, **13**, 311-324. https://doi.org/10.4314/ijbcs.v13i1.25

[36] Melo, F.P.L., Pinto, S.R.R., Brancalion, P.H.S., Castro, P.S., Rodrigues, R.R., Aronson, J., *et al.* (2013) Priority Setting for Scaling-Up Tropical Forest Restoration Projects: Early Lessons from the Atlantic Forest Restoration Pact. *Environmental Science & Policy*, **33**, 395-404. https://doi.org/10.1016/j.envsci.2013.07.013

[37] Soulama, S., Kadeba, A., Nacoulma, B., Traore, S., Bachmann, Y. and Thiombiano, A. (2015) Impact des activités anthropiques sur la dynamique de la végétation de la réserve partielle de faune de Pama et de ses périphéries (sud-est du Burkina Faso) dans un contexte de variabilité climatique. *Journal of Applied Biosciences*, **87**, 8047-8064. https://doi.org/10.4314/jab.v87i1.6

[38] Issiaka, N.T., Arouna, O. and Imorou, I.T. (2016) Cartographie de la dynamique spatio-temporelle des parcours naturels des troupeaux transhumants dans les communes de banikoara et de karimama au benin (Afrique De L'ouest) *European Scientific Journal, ESJ*, **12**, 1857-1881. https://doi.org/10.19044/esj.2016.v12n32p251

[39] N'guessan, A.E., Akpa. Y.L., Yao, N.O. and Kassi, J.N. (2019) Cartographie de la dynamique du couvert végétal de la forêt classée d'Agbo 1 Cote d'Ivoire. *Agronomie Africaine*, **31**, 87-99.

[40] Alohou, E.C., Ouinsavi, C. and Sokpon, N. (2016) Facteurs déterminants de la fragmentation du bloc foret classée forets sacrées au Sud-Bénin. *Journal of Applied Biosciences*, **101**, 9618-9633.

[41] Alongo, S., Visser, M., Drout, T., Kombele, F., Colinet, G. and Bogaert, J. (2013) Effets

de la fragmentation des forets par l'agriculture itinérante sur la dégradation de quelques propriétés physiques d'un Ferralsol échantillonné à Yagambi, R.D. Congo. *Tropicultura*, **31**, 36-43. http://hdl.handle.net/2268/160233

[42] Salamatou, A.I., Abdoulaye, D., Boubacar, M.M., Abou Soufianou, S., Ali, M. and Mahamane, S. (2015) Dynamics of a Third World City: Case of Niamey, Niger. *Journal of Geography and Regional Planning*, **8**, 120-130. https://doi.org/10.5897/jgrp2015.0491

[43] Coulibaly, L., Kouassi, K.H., Soro, G.E. and Savane, I. (2016) Analyse du Processus de Savanisation du Nord de la Côte d'Ivoire par Télédétection: Cas du Département de Ferkessédougou. *International Journal of Innovation and Applied Studies*, **17**, 136-143. http://www.ijias.issr-journals.org/

[44] Timite, N., Koua, K.A.N., Kouakou, A.T.M. and Barima, Y.S.S. (2023) Dynamiques spatio-temporelles des parcs agroforestiers dans la zone soudanienne de la Côte d'Ivoire de 1990 à 2020 dans un contexte d'expansion de l'anacarde. *International Journal of Biological and Chemical Sciences*, **17**, 484-504. https://doi.org/10.4314/ijbcs.v17i2.16

[45] Drame, F.A., Sambou, H. and Ndiaye, S. (2025) Analysis of Land Use Changes in the Commune of Kaour from 1990 to 2024 (Sedhiou Region/Senegal). *Journal of Applied Biosciences*, **211**, 22300-22318.

[46] Sambou, H. (2014) Remote Sensing Mapping of the Rice Field and Vegetal Cover and the Impacts of Soil Factors on Herbaceous in the Sub-Watershed of Boutolate (Lower Casamance, Senegal). *American Journal of Environmental Protection*, **3**, 73-82. https://doi.org/10.11648/j.ajep.20140302.16