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Research Article

Cartographic Analysis of the Spatial Changes in the Tourist Resort of Saly (Senegal) Between 1988 and 2024

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Abstract

The creation of the seaside resort of Saly in Senegal in 1984 marked the beginning of a transition from a village to an urban center. However, the development of a designated area is often marked by a context of urban transformation and expansion, giving rise to various territorial and societal challenges. Hence, the objective of this study is to assess the spatial dynamics of the Saly tourist resort between 1988 and 2024. The methodological approach was based on the analysis of satellite imagery and the application of remote sensing techniques, notably the NDBI index and the calculation of the average annual growth rate of spatial units. The results revealed that from 1988 to 2002), the built-up area increased significantly (from 38 to 534 ha), while agricultural land (from 963 to 613 ha), bare land (from 315 to 78 ha), and beaches (from 67 to 52 ha) declined. Between 2002 and 2014, built-up areas increased (from 534 to 903 ha), followed by a decrease in vegetation (from 421 to 349 ha) and agricultural land (from 613 to 345 ha). During the period from 2014 to 2024, built-up areas saw a slight increase (from 903 to 950 ha) and a shift in trends regarding vegetation (from 349 to 460 ha) and open land (from 64 to 235 ha), while agricultural land (from 345 to 13 ha) and beaches (from 47 to 44 ha) decreased further. These trends show that 86.29% of the territory underwent land-use conversion, compared with 13.71% that remained stable over these 36 years. The built-up area shows an estimated average annual growth rate of 9.4%, while vegetation increased slightly by 0.99%. In contrast, agricultural land declined by 11.20%, as did beaches and bare ground, which decreased by 1.31% and 0.82%, respectively. These trends reflect three phases of spatial dynamics: rapid expansion (1988-2002), consolidation (2002-2014), and spatial restructuring (2014-2024). Analysis of the NDBI index from 1988 shows values ranging from generally low to slightly negative (-0.42 and 0.02) to a higher value (0.21) in 2024. Spatial dynamics reveal rapid urbanization in Saly, requiring sustainable land-use policies that take natural areas into account and continuous monitoring of land use to better manage urban growth.

Keywords

Remote Sensing, GIS, Land Cover, Spatial Dynamics, NDBI

1. Introduction

Tourist areas are generally developed to support tourism-related activities. The creation of tourist resorts is part of an effort to enhance the natural and cultural potential of the area [1, 2]. The tourist resort thus becomes the core and the initial

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driving force behind socioeconomic development [3]. The area is organized around this center, which is marked by gradual urban development characterized by the opening up of the area, the construction of hotels, residential villas, and recreational facilities, etc., thereby promoting significant spatial expansion [4].

However, tourist destinations are characterized by significant and rapid changes in their environment [5]. The availability of supply and demand (both public and private) has fostered human settlement and the sustainable organizational and functional transformation of these areas [6]. This global dynamic drives the process of coastal development, which has a significant socioeconomic impact [3]. However, these spatial changes are naturally accompanied by environmental pressures and the degradation of coastal ecosystems due to the presence of human settlements along the coast [7-9].

In Senegal, the development of the tourist resort in Saly Portudal in the 1980s set in motion the transition from a small village to a highly urbanized town [10]. It is within this context that this study aims to assess the spatial dynamics of the Saly resort between 1988 and 2024. The goal is to highlight changes in the evolution of the built environment in relation to other spatial units of land use and the current challenges of sustainable coastal zone management.

2. Study Area

Saly Portudal is a municipality located about 80 km from Dakar, between the towns of Mbour and Malicounda to the east, Sindia to the north, Ngaparou to the west, and the Atlantic Ocean to the south. Formerly a fishing village, it was developed into a seaside resort beginning in 1984 and has since established itself as the leading tourist destination in West Africa.

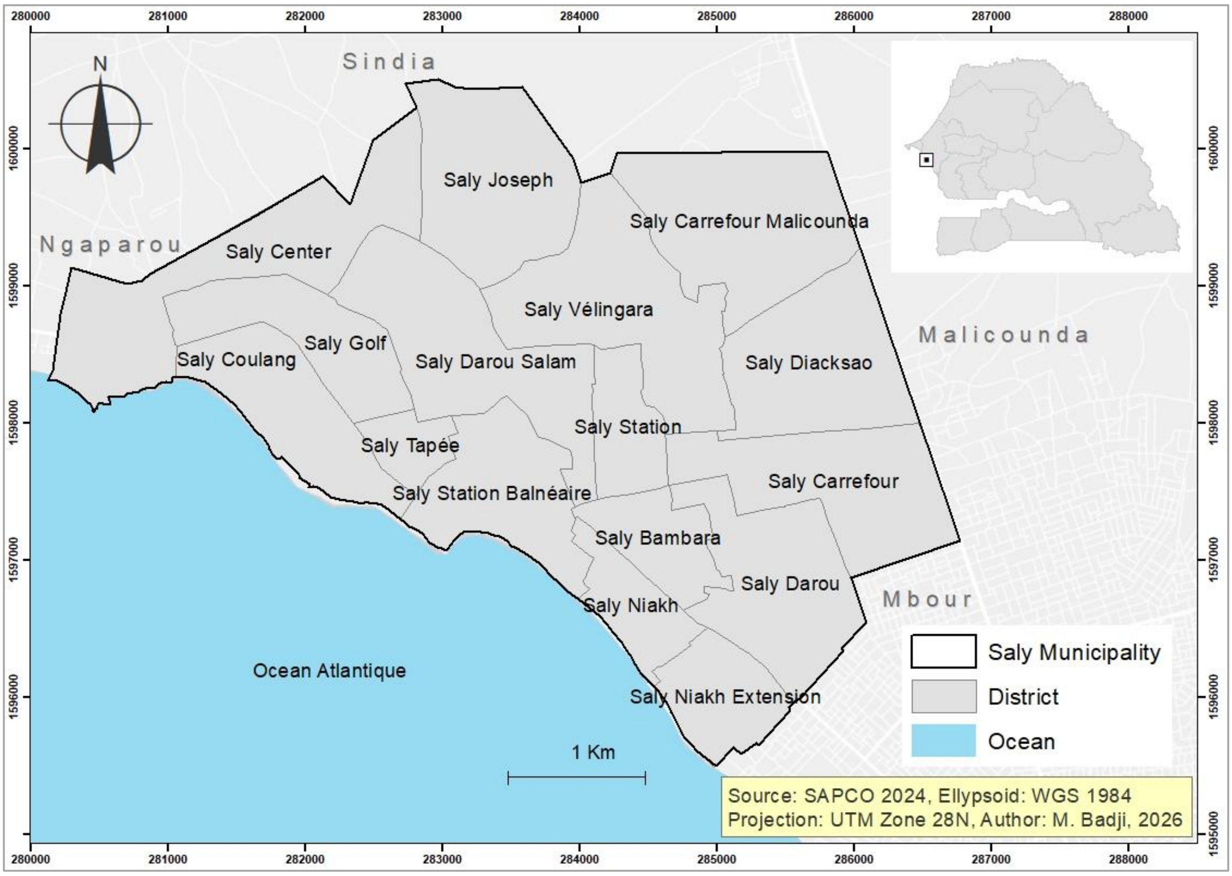

Figure 1. *Location of the town of Saly.*

The seaside resort of Saly is known for its mild, pleasant climate, beautiful beaches, and high-quality tourism infrastructure, making tourism the main driver of its socioeconomic life. However, these various factors have led to the town's rapid development, giving rise to numerous challenges and significant environmental issues, such as land grabbing and the degradation of natural ecosystems, particularly the coastal zone. As such, the municipality of Saly is a strategic area facing a wide range of environmental, territorial, demographic, and socioeconomic issues, as well as challenges related to sustainable development and coastal zone management.

3. Materials and Methods

3.1. Satellite Images

The analysis of land-use changes in Saly was conducted using satellite imagery processed into maps. The images, obtained from the U. S. Geological Survey platform, were acquired from Scene 205-50 using three Landsat sensors. The years were selected based on the timing of the general population and housing censuses. Thus, the image from March 1988 was captured by the “Thermatic Mapper” sensor, and the one from January 2002 was captured by the “Enhanced Thermatic Mapper Plus” sensor. The images from March 2014 and 2024, meanwhile, were captured by the “Operational Land Imager - Thermal Infrared Sensor” (OLI-TIRS) on Landsat 8 and Landsat 9, respectively. All of these images were taken during the dry season, specifically in March, with the exception of the 2002 image, which was taken in January, and have a resolution of 30 m.

To minimize errors, geometric correction of the images was performed using ENVI 5.6, using image 2024 as a reference. Geometric correction was performed using the nearest-neighbor method combined with a first-order polynomial transformation [11, 12]. This approach allows for a perfect alignment of spatial units that closely matches reality while preserving the radiometric values of the pixels [13, 14]. The validity of this operation was confirmed using the standard error and the root mean square error (RMSE). This metric is used to assess the level of accuracy of georeferencing [14, 15]. However, additional validation was performed through a visual inspection of seventy-two (72) field points selected from the overlay of calibrated images, using the RMSE value which was less than one pixel as the criterion, in accordance with generally accepted standards in remote sensing.

3.2. Normalized Difference Built-Up Index

The Normalized Built-up Area Index (NDBI) is widely used to analyze urban changes and monitor built-up areas due to its simplicity and its applicability to multispectral images such as Landsat [8, 16]. The NDBI is derived from multispectral satellite image bands using the normalized difference between short-wave infrared (SWIR) and near-infrared (NIR) reflectance. The NDBI is calculated as follows:

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR} \tag{1}$$

Built-up areas generally appear with high reflectance in the SWIR and low reflectance in the NIR [17]. The NDBI highlights artificial areas relative to other spatial units. However, in semi-arid environments, bare soil is sometimes mistaken for built-up areas due to similarities in spectral signatures, which can reduce the index’s effectiveness [17].

3.3. Supervised Classification

Supervised classification involves assigning labels to each pixel or object in a satellite image based on defined training sets [18, 19]. The goal is to build a model capable of estimating the class of new entities whose attributes are known, but whose labels are not [20]. Analysis of object-oriented classification reveals that the size of the training area and the choice of classification algorithm have a strong influence on accuracy [4].

Knowledge of the terrain facilitated the creation of training zones and made it possible to identify five land-use categories: built-up areas, agricultural areas, bare ground, beaches, and vegetation. The classification was performed using the maximum likelihood algorithm. This algorithm is based on probabilistic methods that assign each pixel to the class with the highest probability of membership, as estimated using spectral means and covariance matrices from the training areas [21, 22]. This method estimates a normal (Gaussian) distribution of the spectral markers of the entities.

3.4. Accuracy Assessment

The confusion matrix specifically the Kappa coefficient was used to verify the accuracy of the classification. This coefficient measures the agreement between an image and the actual conditions on the ground [23-25]. The results indicate a satisfactory level of accuracy for the processed images. This accuracy ranges from 92.97% to 96.01%, with a Kappa coefficient ranging from 0.90 to 0.93, which lends further credibility to the reliability of the results. These values correspond to a near-perfect agreement as indicated by the Kappa coefficient. According to [26], this is classified into five categories of agreement: very low (0 to 0.20), low (0.21 to 0.40), moderate (0.41 to 0.60), substantial (0.61 to 0.80), and nearly perfect (0.81 to 1.0).

3.5. Analysis of Spatial Changes

The analysis of land-use changes was conducted by calculating absolute changes and estimating the average annual rate of expansion. This was done using the formula proposed by Bernier (1992) [27]. Area (S) is the variable considered. For two dates, T1 and T2, corresponding respectively to areas S1 and S2 within the same land cover category, the average annual expansion rate (T) is calculated as follows:

$$T = \frac{(\ln S_2 - \ln S_1)}{t \ln e} \times 100 \tag{2}$$

1) (t) is the number of years of evolution;
2) (ln) is the natural logarithm;
3) (e) is the base of the natural logarithm.

4. Results

4.1. Analysis of Land Use Dynamics

The analysis of land-use dynamics between 1988 and 2024 was based on a classification of five spatial units: built-up areas, vegetation, agricultural land, bare soil, and beaches (Figure 2). Land use in 1988 was characterized by the predominance of cropland, which covered 56.41% of the municipal territory. Next were vegetation and bare soil, accounting for 18.98% and 18.45%, respectively. Beaches, at 3.93%, and built-up areas, at 2.23%, were moderately represented.

In 2002, the municipal area was characterized by two trends. A gradual increase in built-up areas and vegetation, which accounted for 31.45% and 24.79%, respectively. In contrast, agricultural land which covered 56.41% in 1988 saw a sharp decline of 36.10% in its area by 2002. At the same time, open land accounted for 13.86% of the total area. Beaches remained relatively stable at 3.06%.

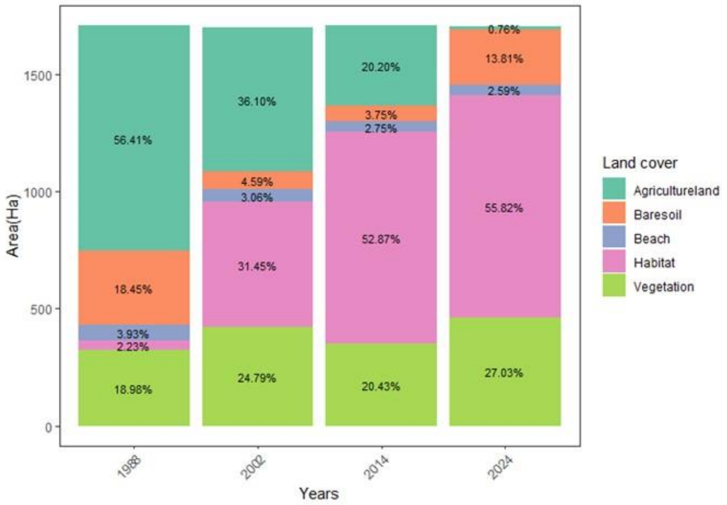

Figure 2. Land Use Statistics from 1988 to 2024.

In 2014, changes in land use were dominated by built-up areas, which increased by 21.42% compared to 2002. However, the other land-use categories experienced a decline. Vegetation covered only 20.43%, and agricultural land 20.20%, whereas these two categories had previously accounted for 24.79% and 34.10%, respectively. The same trend was observed for bare land (3.75%) and beaches (2.75%). In 2024, built-up areas continued to expand, accounting for 55.82%. Vegetation and bare soil increased slightly, reaching 27.03% and 13.81%, respectively. However, agricultural land declined significantly and became virtually nonexistent, accounting for only 0.76%, while beach areas remained relatively stable at around 2.59%.

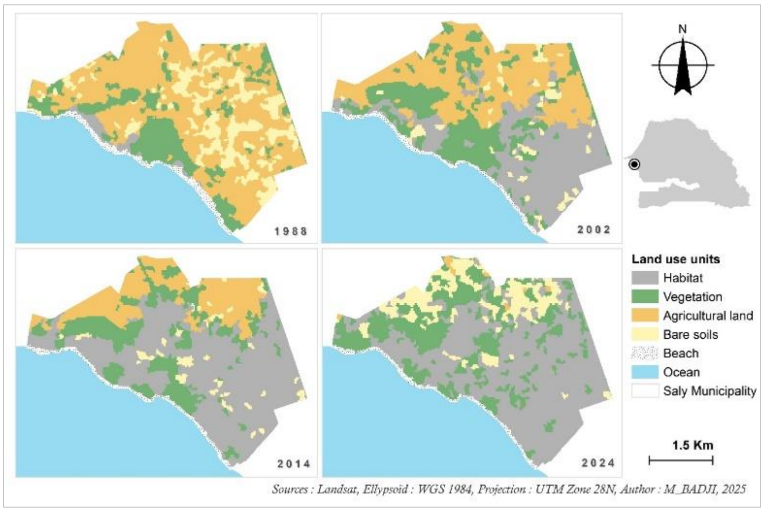

Figure 3. Land Use Changes in Saly from 1988 to 2024.

An analysis of changes by land-use category during the study period (1988-2024) reveals, on the one hand, a progressive trend characterized by land-use categories such as built-up areas and vegetation, and, on the other hand, a regressive trend encompassing the remaining land-use categories. Built-up areas are the only land-use category that showed a significant progressive change between 1988 and 2024 (Figure 4). Its area was 38 ha in 1988, 534 ha in 2002, 903 ha in 2014, and 950 ha in 2024. In contrast, agricultural areas have been on a downward trend. They covered 963 ha in 1988, 613 ha in 2002, 345 ha in 2014, and 13 ha in 2024. Beaches also showed a declining trend throughout the study period. They covered 67 ha in 1988, 52 ha in 2002, 47 ha in 2014, and 44 ha in 2024. In contrast, vegetation cover has shown a discontinuous trend. It covered an estimated area of 324 in 1988, 421 ha in 2002, 349 ha in 2014, and 460 ha in 2024. At the same time, bare soil areas have shown an erratic trend. Their areas are estimated at 315 ha in 1988, 78 ha in 2002, and 64 ha in 2014. However, a clear increase is observed in 2024, with an area of 235 ha.

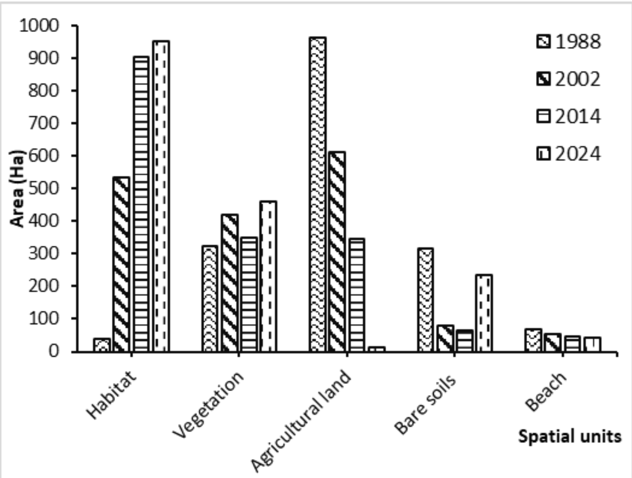

Figure 4. *Summary of dynamic for each land-use.*

4.2. Quantitative Assessment of Changes

Between 1988 and 2002, changes in land use in the municipality of Saly revealed a strong spatial dynamic characterized by a shift in spatial units. These changes resulted in the conversion of 1,237.74 ha or 63.25% of the study area's total area while 719.30 ha, or 36.75%, remained unchanged. This change is marked by rapid urbanization, with built-up areas expanding by 352.05 ha at the expense of vegetation, agricultural land, and bare soil, which lost 305.03 ha, 196 ha, and 38.73 ha, respectively. Agricultural areas show a conversion rate of -33.63%, representing a loss of 311.10 ha of land to built-up areas, vegetation, and bare soil. As for the beach, it has lost a significant portion of its area nearly -84.75 ha corresponding to a rate of regression of -61.90%. This sharp regression has led to a retreat of the shoreline and the development of the coastal zone. In line with this trend, bare land remains by far the land-use category that has experienced the sharpest decline, with a rate of -74.81%, corresponding to a converted area of 235.64 ha. Bare land is generally converted into built-up areas, agricultural land, or green spaces. Vegetation, on the other hand, has increased by nearly 86.00%, or 279.43 ha. This conversion has come at the expense of agricultural land and bare land. Overall, the Saly Portudal area underwent significant spatial change between 1988 and 2002, with a high rate of land-use conversion. Over the course of 14 years, extensive urbanization was observed across the area, at the expense of agricultural land and bare soil, alongside contrasting trends in the expansion of vegetation. However, the early signs of coastal erosion were beginning to appear.

Between 2002 and 2014, the land-use trends observed in the municipality of Saly showed a tendency toward stability. Nearly 998.74 ha, or 58.46%, remained stable, compared with 709.54 ha that were converted, or 41.55%.

The built-up area continued to expand gradually. Its total area increased by 364.60 ha, corresponding to a rate of change of 40.37%. During this period, the expansion of the built-up area occurred largely at the expense of agricultural land and, to a lesser extent, at the expense of vegetation and bare soil. In contrast, agricultural land declined during this period, with a rate of change of -44.10%, or -270.76 ha. Much of this decline was due to urbanization, and the remainder was due to vegetation and bare soil. However, unlike the period from 1988 to 2002, the area of the beaches remained stable, with a stability rate of 22.49%. Nevertheless, the net change is approximately -7.16%, indicating a relatively significant decline, possibly due to coastal erosion. Bare soil, meanwhile, recorded a loss of 14.77 ha, corresponding to a rate of change of -18.83%. Only 6.15 ha of bare land remained stable. At the same time, vegetation also declined by 71.91 ha a rate of change of -16.93% in favor of built-up areas and agricultural land, in contrast to the period from 1988 to 2002.

In light of these various findings, the territorial dynamics of the municipality of Saly during the 2002-2014 period were characterized by growing and consolidated urbanization and a more or less stabilized beach, in contrast to agricultural lands and green spaces, which experienced a sharp reduction in area and a weakening of the buffering role of bare soil. These 12 years were marked by a decrease in the conversion rate (41.54%) compared to the period (1988-2002), when it accounted for more than half (63.25%). This shows that the first phase was one of rapid change, followed by a second phase of territorial restructuring that promoted urbanization.

The 2014-2024 period followed the same trend as the 2002-2014 period. This period was characterized by stability. Thus, during this period, 1,042.55 ha remained stable, representing 60.96% of the total area. Land-use conversions accounted for 667.74 ha, representing 39.04% of the total area.

The built environment, primarily characterized by urbanization, continues to expand steadily. However, with a rate of change of 5.71%, the growth of the built environment during this period was less significant than in previous periods. During the 2014-2024 period, 51.56 ha of construction took place on other land-use categories such as vegetation (129.64 ha), agricultural land (63.22 ha), and bare land (17.79 ha). This expansion reflects gradual urbanization in an area experiencing increasing urban density. Agricultural areas have virtually disappeared during this period, with a net change of -329.89 ha representing a loss of -332.23 in land area due to land-use conversion. This loss has given way to bare land, vegetation, and built-up areas. Rapid urbanization and the resulting land-use conversion explain the transformation of farmland into residential areas. As for the beach, 40.51% of its area has remained stable. However, the net change is a loss of -3.18 ha. This loss reflects moderate coastal erosion, which, at the very least, remains persistent. An increase in bare soil was observed between 2014 and 2024, with a rate of change of 267.39%, representing 170.29 ha gained primarily at the expense of cropland and vegetation. At the same time, vegetation has seen a marked increase, with a rate of change of 31.49% and a net gain of 111.13 ha. This increase is due primarily to the conversion of agricultural areas and bare land, as well as the intentional planting of vegetation for its ornamental value.

The trends observed over the 2014-2024 period are generally characterized by a moderate pace of urbanization, the near disappearance of agricultural areas, a notable increase in bare land which serves as a transitional buffer zone between different land uses significant revegetation, and partial stability in beach areas despite a slight decline. An analysis of the entire study period, from 1988 to 2024, provided an overall assessment of the changes that have occurred (Figure 5). Over the course of these 36 years, Saly has experienced a significant change in land use. 1,473.94 ha have been converted, representing 86.29% of its total area. In contrast, 234.17 ha remained unchanged, representing 13.71% stability.

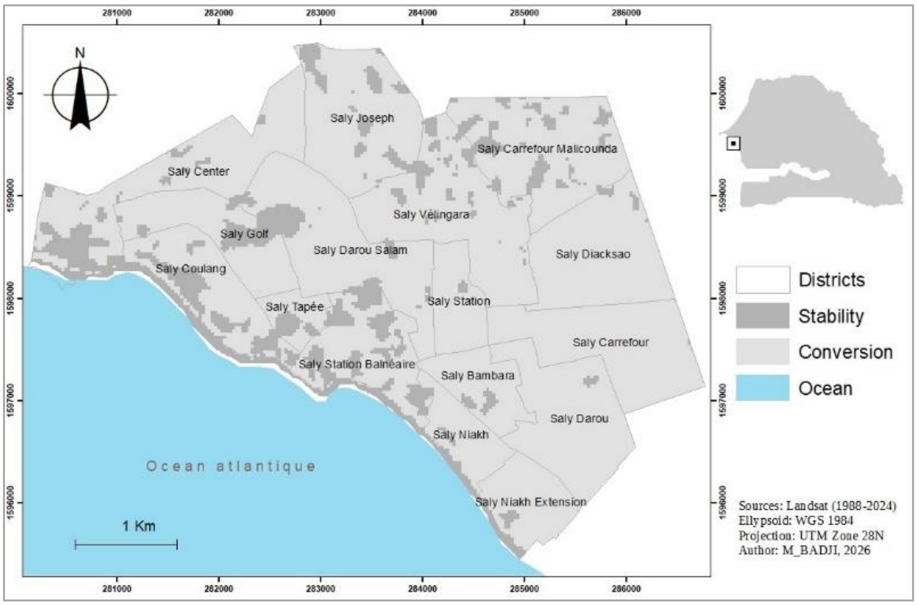

Figure 5. *Changes in spatial units between 1988 and 2024.*

These results provide ample evidence of significant human alteration of the environment, reflecting a major shift and high land-use pressure on natural areas. This situation confirms the rapid expansion of land use, marked by a transition from a natural environment to a heavily human-altered one.

When examining the spatial, temporal, and sequential evolution of the municipal area, disparities emerge regarding the changes observed in land use (Figure 6). Over the 36-year period, the built-up area showed an overall rate of change of 2442.14%, representing an average annual change of 67.84%. Its expansion occurred at the expense of cropland (513.03 ha), bare land (216.40 ha), and vegetated areas (184.70 ha).

Agricultural land, which covered a larger area in 1988, has been extensively converted, showing a rate of change of -98.61%, or an average annual rate of -2.74%. This reflects the near-total disappearance of agricultural areas between 1988 and 2024, replaced by built-up areas, bare soil, and vegetation.

Overall, the coastal zone showed a rate of change of -37.75% over the study period, or an average of -1.05% per year, indicating a high degree of relative stability. However, its net change remains negative, with a loss of 25.53 ha, reflecting gradual erosion that has been relatively offset by human interventions.

As for vacant lots, they show a rate of change of -25.72%, representing an average annual decline of -0.71%. This category represents a transitional buffer zone that draws from agricultural land to be converted into built-up areas or green spaces. With a net change of -81 ha, their decline masks significant internal transformation, characteristic of rapidly developing areas.

Between 1988 and 2024, vegetation showed a net increase of +139.10 ha, representing a rate of change of 42.81% and an average annual change of 1.19%. This accounts for a relatively significant increase at the expense of agricultural land and, naturally, the recolonization of bare land.

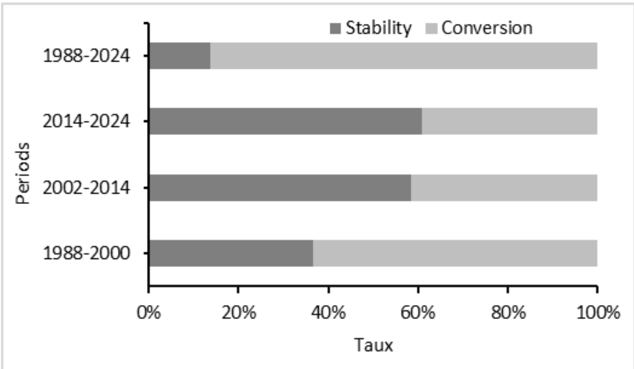

Figure 6*. Spatiotemporal dynamics of Land-use categories Between 1988 and 2024.*

In light of these various periods of spatial change in Saly, three phases of evolution emerge: rapid expansion, consolidation, and restructuring (Table 1). The period from 1988 to 2002 (rapid change) is characterized by a higher rate of land-use conversion 63.25 percent reflecting fairly rapid territorial dynamics. With 36.75 percent of the area remaining stable, the urban fabric continued to develop. The 2002-2014 period (Consolidation of Land Uses) was marked by a reversal of the trend, with stability (58.46%) exceeding conversion (41.54%). This situation indicates a slowdown in spatial changes, supporting existing land uses. The most recent period, 2014-2024 (Spatial Reconfiguration), shows the same trend as the previous one, with a high level of stability (60.96%), while the conversion rate (39.04%) declines. However, this phase does not simply represent stabilization but rather a reconfiguration observed within spatial units.

Table 1*. Summary of the Phases of Spatiotemporal Change in the Saly Region.*

Periods	Conversion	Stability	Changes Observed
1988-2002	63.25%	36.75%	Rapid transformation
2002-2014	41.54%	58.46%	Usage consolidation
2014-2024	39.04%	60.96%	Spatial reconfiguration

Overall, the spatial dynamics of the Saly region between 1988 and 2024 reveal fairly significant land-use conversion trends, characterized by five (05) major trajectories (Figure 7). The first reflects the direct conversion of agricultural land into built-up areas, while the second occurred in two stages. The first stage is characterized by the conversion of agricultural land into bare land. The second stage is marked by the conversion of agricultural land into built-up areas. The third is characterized by the colonization of agricultural areas within vegetated zones. The fourth highlights the conversion of bare land into built-up areas, while the fifth trajectory shows a direct conversion of vegetation into built-up areas.

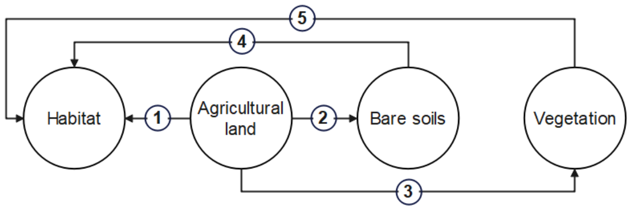

Figure 7*. Saly's Spatial Dynamics Between 1988 and 2024.*

These trends confirm a profound change in land use, shifting from a predominantly agricultural rural environment in 1988 to a densely urbanized area in 2024. Over the course of these 36 years, agricultural land has virtually disappeared, having been largely converted to other land-use categories. As for the beaches, coastal erosion continues to this day.

4.3. Analysis of the Building Index for 1988 and 2024.

An analysis of built-up areas using the Normalized Difference Built-up Index (NDBI) identified built-up areas in 1988 and 2024 (Figure 8). The 1988 NDBI shows generally low and slightly negative values ranging from -0.42 to 0.02. This result indicates very low and sporadic development around neighborhoods such as Saly Station Baln éaire, Saly Tap é, and Saly Coulang in 1988. However, the rest of the territory is characterized by natural areas with little human impact, representing a sparsely developed area with a built-up core.

In 2024, the NDBI values show a marked increase, reaching 0.21, evidence of significant urbanization in the area. Significant densification is evident in neighborhoods such as Saly Center, Saly Golf, and Saly Station, while expansion is observed toward Saly V élingara, Saly Diacksao, and Saly Carrefour, and sustained urbanization is taking place in the Saly Niakh and Saly Niakh Extension areas. The 2024 NDBI shows a territory characterized by a fairly dense and continuous urban fabric with a few remaining uninhabited areas, reflecting widespread and structured urbanization linked to the growth of tourism in the seaside resort of Saly.

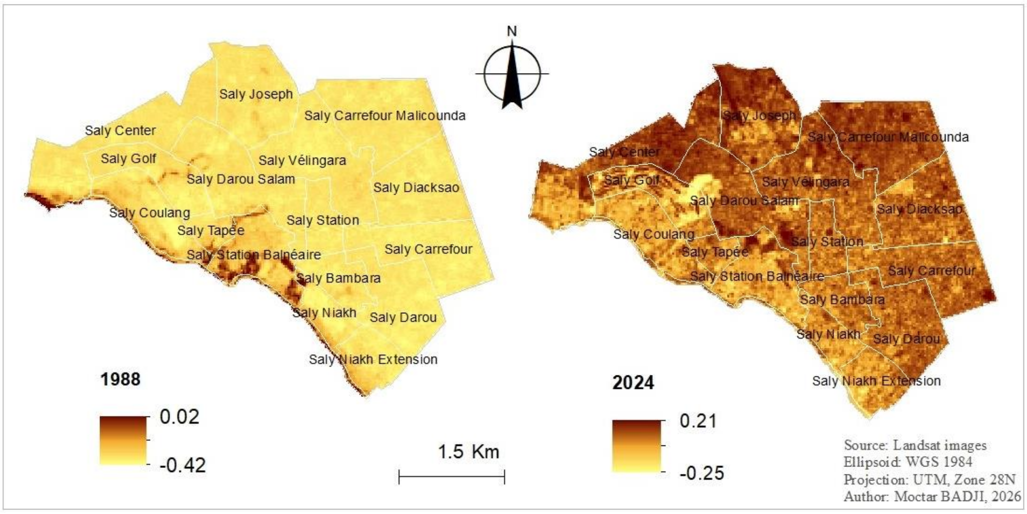

Figure 8. *Normalized Difference Building Density Index (NDBI) An analysis of development trends between 1988 and 2024 reveals a remarkable increase in the normalized built-up difference index, marked by a sharp expansion of built-up areas. The area is transitioning from scattered housing in 1988 to an urban fabric in 2024, characterized by a major reconversion of existing spatial units and a significant reduction in natural areas. These trends reflect an area under land-use and demographic pressure due to the development of tourism and related activities.*

5. Discussion

5.1. Factors in Urban Expansion

The spatial restructuring of Saly began with the creation of the tourist resort, much like in many coastal tourist cities [28, 29]. Farmland, vegetation, and bare soil have been transformed into hotel zones in Marrakesh, Morocco [30], as well as in Addis Ababa, Ethiopia [31]. This trend has been observed in China in the small karst basin located in the Guangxi region, as documented in the work of Sun et al. (2023) [32], which indicates a gradual transformation of agricultural land into tourism infrastructure and of natural environments into developed areas since 1990.

Tourism investments and the improved accessibility of the area served as a catalyst for accelerating spatial changes [33]. According to Diagne (2004) [10], tourism has significantly altered villages on the Petite Côte such as Saly, Ngaparou, Somone, and others, transforming agricultural areas into tourist enclaves and disrupting the local economy and land use. Similar studies [34-36] confirm this observation that investments play a major role in changes in land use in tourist areas. Comparable case studies in Morocco, Brazil [37], and Portugal [38] support this view, arguing that the influx of tourism capital has led to increased demand for land, a change in land use, and a gradual spatial restructuring of tourism-oriented areas. Improved access and tourism investments have fostered the conversion of spaces, the functional specialization of the site, and the restructuring of land uses in Saly.

Saly's spatiotemporal evolution is part of a global trend in the development of tourist sites, leading to ongoing changes in land use under the combined influence of land-use pressure and public and private investment. This situation has significantly transformed natural environments, land uses, and environmental balances.

5.2. Result Comparison

An analysis of land use in Saly in 1988 reveals a pre-tourism period when socioeconomic activity centered on fishing and agriculture. This finding corresponds to the baseline conditions used as a reference by various studies on land-use dynamics, notably in Niger [39], Ethiopia [40], and Senegal [41]. The results of the spatiotemporal dynamics observed in Saly over these 36 years (1988-2024) are generally similar to those reported by Yomo et al. (2023) [42] for Agoènyivé in Togo and by Bousseman et al. [43] for Sousse in Tunisia. In Agoènyivé, an increase in built-up areas (38.71% increase) was observed, while vegetation (22.69% decrease), cultivated land/bare soil (22.89%), and wetlands (a loss of 3.36%) all declined over the 1986-2020 period. The work of Ideki and Ajoku (2024) [44] highlights that in various West and East African countries (Senegal, Kenya, Tanzania), agricultural lands and areas of natural vegetation have significantly declined in favor of human settlements along the coastline. This same trend was observed by Muchelo et al. (2024) [45] in Kampala, Uganda, where urbanization increased from 7.1% to 55.1% between 1989 and 2015, while agricultural land decreased from 48% to 16%. Studies [46, 47] highlight that in coastal Benin, rapid urban expansion is occurring at the expense of palm groves, forests, and wetlands. These authors point out that since 1990, the conversion of agricultural land and forests into built-up areas driven by urbanization has been one of the main factors behind the various changes observed along the coastline. Specific examples are highlighted in Laos, Nigeria [48], and The Gambia [49], where urban development has occurred at the expense of croplands and vegetation.

The changes observed in Saly's spatiotemporal analysis reveal similar approaches in West Africa for characterizing the phases of rapid dynamics, deceleration, and restructuring [50, 51]. West African coastal areas, often developed for tourism, are consequently undergoing accelerated urbanization and a reconfiguration of coastal land uses [52]. Changes in land use in Saly are part of a trend toward the coastalization of the coastal zone, driven by increased demand for land resulting from the growth of tourism and the proliferation of recreational infrastructure. Coastal cities particularly those focused on tourism are experiencing rapid development driven by socioeconomic appeal, job availability, and population growth, which are fostering the transformation and conversion of land-use patterns.

6. Conclusion

This article aimed to assess the spatial dynamics of the Saly tourist resort between 1988 and 2024 through a cartographic analysis based on satellite imagery from the Landsat program. The findings of this study indicate that only 13.71% of Saly's territory remained stable, while 86.29% underwent changes. The observed spatial dynamics are characterized by varying conversion rates for each spatial unit. Land use is marked by a significant expansion of built-up areas, with an average annual growth rate of 9 percent, reflecting the accelerated urbanization of the territory at the expense of agricultural land and bare soil. This situation calls for strengthened land-use planning in order to anticipate future trends and promote sustainable development and sound land management, which are key to ensuring the region's strong appeal to tourists.

Abbreviations

NDBI	Normalized Difference Built-up Index
RMSE	Root Mean Square Error

Author Contributions

Moctar Badji: Conceptualization, Data curation, Funding acquisition, Methodology, Supervision, Validation, Writing – review & editing

Hyacinthe Sambou: Conceptualization, Methodology, Software, Supervision, Writing – review & editing

Cheikh Mbow: Conceptualization, Methodology, Supervision, Writing – review & editing

Fode Amata Drame: Data curation, Methodology, Software, Supervision

Conflicts of Interest

The authors declare no conflicts of interest.

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