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Dynamics of Salinization of Agricultural Areas in Koba (Boffa)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Climate change scenarios indicate an increase in soil salinization as a result of sea-level rise and its impact on coastal areas. In Guinea, our understanding of this phenomenon is limited. This article looks at the extent of salinization phenomenon and proposes farmers' solutions to deal with it in Koba area in Boffa, in the Republic of Guinea. The aim of this work is to analyze the changing dynamics of salinization in agricultural areas of Koba in this context of climate change. By the end, in addition to that, a cartographic survey approach with an image processing on QGis 3.4 was used as working method. This result show that salinization in Koba is progressing rapidly and that marine intrusion is now annual rather than cyclical (every 7 years). Several hectares of land have been abandoned because of the rising salinity, which progresses towards the mainland from year to year. In the space of 36 years, 3,196 hac. (6%) of land have been abandoned, which is equivalent to 88.6

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hac. Per year (0.17% per year) in Koba. The solutions proposed which deals with the rise in salinity under the influence of climate change in area with early warning systems for forecasting, water management at plot level, combining activities and changing activity if necessary. Local knowledge (the position of birds' nests on plains, direction taken by ants, etc.) is also a key factor.

Keywords: Salinization; agricultural areas; climate change; Koba; good practices.

1. INTRODUCTION

Soil salinization, with the accumulation of salts in the soil, is a major challenge affecting agricultural production worldwide. Agricultural soils in coastal areas are shrinking daily under the combined effect of impermeability, pollution and soil salinization [1,2,3,4,5,6,7,8].

According to section [8], salinization affects 8.7% of the planet, i.e. 160 million hectares of arable land. In sub-Saharan Africa, salinization is estimated that affect around 19.09 million hectares of land [9].

The Republic of Guinea has 300km of coastline, and in this part of the country, which contributes almost 24% of the country's rice production, climate change is reflected in rising sea levels, particularly in low-lying areas along coast in Koba, Kito Island, Kaback and Kakossa zones. In this area, rising water levels increase salinization of rice-growing plains, leading to the loss of land [10,11]. For this reason, this study focuses on changes in salinization of agricultural areas in Koba (Boffa), in this context of climate change.

This work began with a reminder of the studies carried out in the area, in particular studies on coastal plains, with a view to their exploitation for rice cultivation [12,13], the management of mangrove wood resources [14,15] and [16]; the exploitation of wood energy, [17,18], for the conservation of biodiversity, etc.

As far back in 2007, studies carried out as part of NAPA predicted that in Koba area, rice-growing plain, mangrove forest and dwellings (fishermen's camps) would be affected by rising sea levels, resulting in flooding, salinization of seafront, erosion and the disappearance of mangrove due to land clearance. The same observation is made in the latest IPCC report [19], which predicts a rise in sea level leading to marine intrusion and the loss of land through salinization. Despite these studies, none has specifically addressed the dynamics of salinization of agricultural areas, linked to climate change, with the use of remote sensing.

It is in response to this concern that the present study has been carried out to take stock of salinization of agricultural land and to develop a sustainable management mechanism for these salinized areas in this zone, taking into account the rise in sea level on one hand of demographic pressure on the other.

To answer this question, general objective of this study is to analyze the evolution of dynamics of salinization of agricultural areas in Koba in this context of climate change. Specifically, the aim is to (i) characterize salinization of agricultural areas in Koba coastal zone and (ii) assess spatiotemporal dynamics of salinization at different dates from (1986, 2003 and 2022).

This study is of two-fold interest. Not only does it enable communities to gain a better understanding of climate change issues and to prepare themselves to deal with them, but also It will also help politicians to raise awareness of climate change issues in Guinean coast.

2. METHODOLOGY

Koba RC stretches along the Atlantic Ocean. It is watered by several inlets. The Bokhinènè river crosses rice-growing plain of upper Koba, before flowing into the Atlantic Ocean. urban district of Koba, which is the subject of this study, it is bounded on the north by Boffa centre and Tamita, on the south by Dubréka centre and Khorira, on the east by Tanènè CR and on the west by the Atlantic Ocean, as shown in Fig. 1, attached.

2.1 Characterization of Salination of Agricultural Spaces

It is characterized by salinization of agricultural areas in Koba, we used survey method, with the techniques of semi-structured interviews, questionnaires and direct observation. The semi-structured interview was used for discussions with local authority (local councilors, rural development commission) and 10 agricultural advisors. For this study, which is an exploratory study, we used semi-directed individual interview

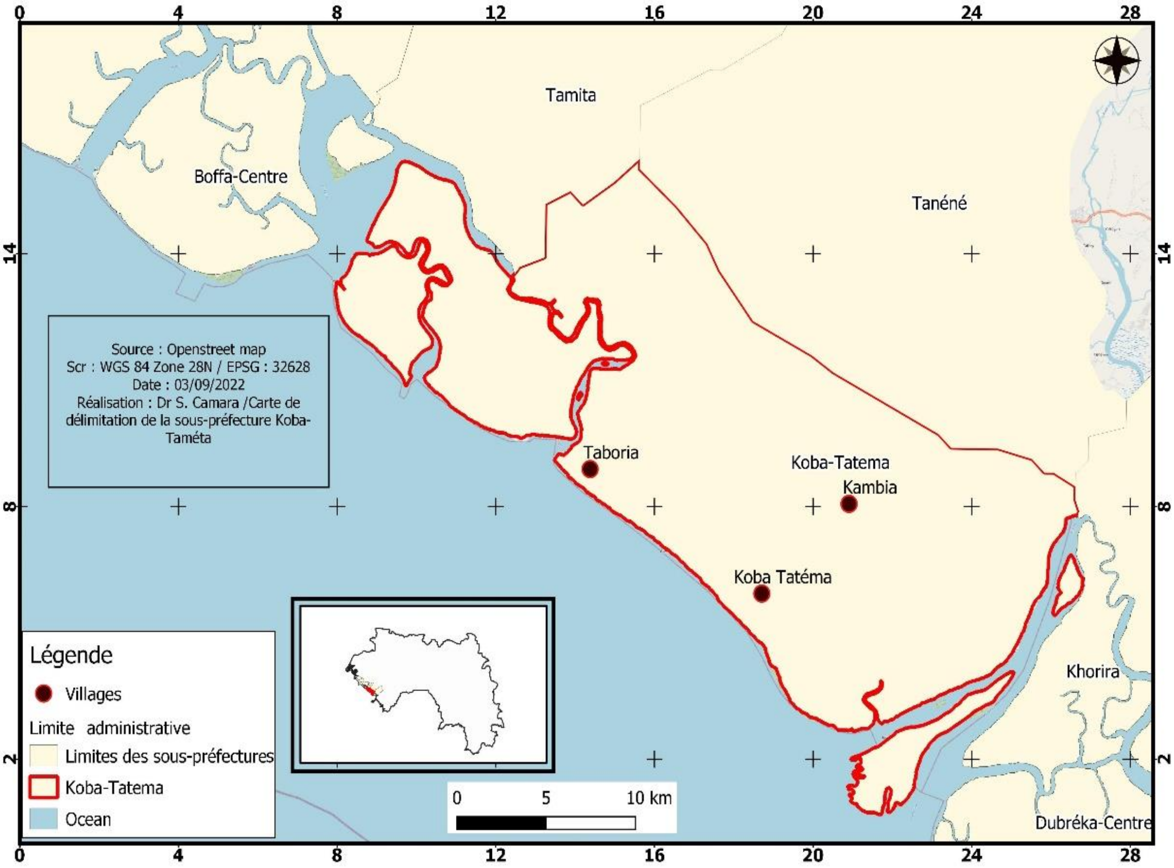


Fig. 1. Presentation of study area
Legend
Koba village
Bordering sub-prefecture
Koba tatema sub-prefecture
Atlantic Ocean

to gain better understanding of phenomenon of salinization of areas through experts' own words. The interview guide dealt with the characteristics of salinization in Koba, the constraints on rice-growing (rainfall, salinization, yield) and solutions proposed and adopted. questionnaire was intended for rice and market gardeners who were met in their fields in agricultural areas at the time of survey. The questions dealt with knowledge of agro-pastoral activities practised in area (rice growing, fishing, market gardening, saliculture, etc.), places where rice growing is practised, problems encountered (land tenure, disturbance, etc.) and solutions proposed and adopted. rainfall, saline intrusion, flooding, etc.), solutions adopted, and state of mangrove. Simple random sampling was used. Respondents were chosen at random in terms of survey. As the perimeters were contiguous after first choice, one plot was skipped and the next chosen if occupant was present at the time of survey. In this way, 32 people were selected, 16 vertically and 16 horizontally, including 6 women. Direct observation focused on landscape (type of land use, level of degradation and in our findings).

2.2 Evaluation of the Spatio-temporal Dynamics of the Salinization of Spaces in Koba

We used remote sensing to assess spatial and temporal dynamics of salinization in agricultural areas. Our study focused on the processing of images provided by the Landsat sensors, in three dates (Landsat 5 for 1986, Landsat7 for 2003 and Landsat 8 for 2022). The scenes are downloaded from the USGS Earth Explorer site (earthexplorer.usgs.gov) for one orbit (Path 203) and one row (Row 053). These images are processed on the QGis 3.4 software, in order to produce land use maps to show the dynamics of the salinization of the plains. For reasons of Landsat image quality, clearer images without clouds or fog were used for selected periods from(1986, 2003 and 2022); before major droughts in 1990s, after years of development in area from 2000 and finally with the acceleration and asphyxiation of Koba socio-ecosystem in 2022 (urbanization, population growth, rising sea levels - salinization - poverty, etc.). In the dry season from (January to March) was chosen from images downloaded. The methodology used for image processing is identical to that used in studies of land cover dynamics in Guinea using SPOT satellite imagery [20,21]. It includes: collection source and auxiliary data, pre-processing, classification of Landsat images (supervised classification), post-processing, manual correction and identification of changes. Between pre-processing and post-processing, a field survey was carried out to confirm classes selected. For this work

3. RESULTS AND DISCUSSION

3.1 Characteristics of Salination of Agricultural Spaces in Koba

According to the results of our surveys, agriculture is the main economic activity in Koba, employing almost 80% of the population. Encage in cereal crops, rice is the most widely grown, mainly on the estuary and mangrove plains.

Rice farmers claim that the salinization of agricultural areas in Koba is characterized by: (i) Rapid progression; that is, salinity is progressing rapidly in agricultural land; (ii) Annual and non-cyclical marine intrusion (every 7 years); the convergence of periods of marine intrusion, now every year, instead of every 7 years as in the past; (ii) an increase in the extent of arable land; the affected area is only increasing; and (iv) the appearance of salinity-resistant species in agricultural areas; salinity indicator plants colonize agricultural plains (weeds such as *Paspalum vaginatum, Philoxerus vermicularis, Sesuvium portulacastrum*). These results corroborate studies by [22] and [3], which emphasize that salinity in agricultural areas is a problem that affects soils in coastal areas; the same situation is reported in the report on Guinea's Second National Communication on Climate Change, which stresses that salinization of land is one of the problems of climate change management [23].

3.2 Spatio-temporal Dynamics of Land use in 1986, 2003 and 2022

Land use in 1986: Fig. 2a Shows the dynamics of land use in Koba from 1986, with an overall precision of 0.98 The Fig. 2a shows active rice-growing areas (areas that are cultivated and producing) and abandoned rice-growing areas (salinized areas that are no longer producing), mangroves and other types of land use (bare soil, buildings, agroforest, sea water and bodies of water). It can be seen that in 1986, the agroforest class, consisting mainly of palm, banana and sugarcane plantations, and the mangrove class occupied the largest areas, respectively 31.58% and 30.55% of the total area of all occupations in the area.

The soil. Active rice paddies occupied 14.9% of the surface area of land uses, and rice paddies abandoned 11.73% due to rising salinity. The remainder of the surface area was divided between built-up areas, bare soil, water and seawater. The high superficie of plantations (agroforests) in this period can be explained by the fact that at time, there were still cash crops, sugar cane plantations in Koba, palm trees, banana trees and coconut palms, given that Lower Guinea, specifically Koba, was renowned at the time for its high sugar cane production. mangroves were only exploited for the needs of the populations of the capital Conakry (710.372 habitants) and Boffa (113.981 habitants), where Boffa was considered a small town with less than 150.000 habitants from the 1983 census. At that time (1984 to 1990), there was almost no pressure on resources, and water was simply collected for consumption. There was a balance within the mangrove system. Because of the existence of old colonial developments in Koba, mangrove rice was grown in these developed areas, with the risk that some of the cultivated areas, very close to sea, might not produce good harvests because, lack of water control, causing salt water to rise in these plots. Boffa had less than 150.000 habitants from 1983 census, in Koba sub-prefecture had far fewer. The lake was developed by Koba sugar project for sugar cane plantations. The body of water was developed by the "Koba sugar" project for sugarcane plantations.

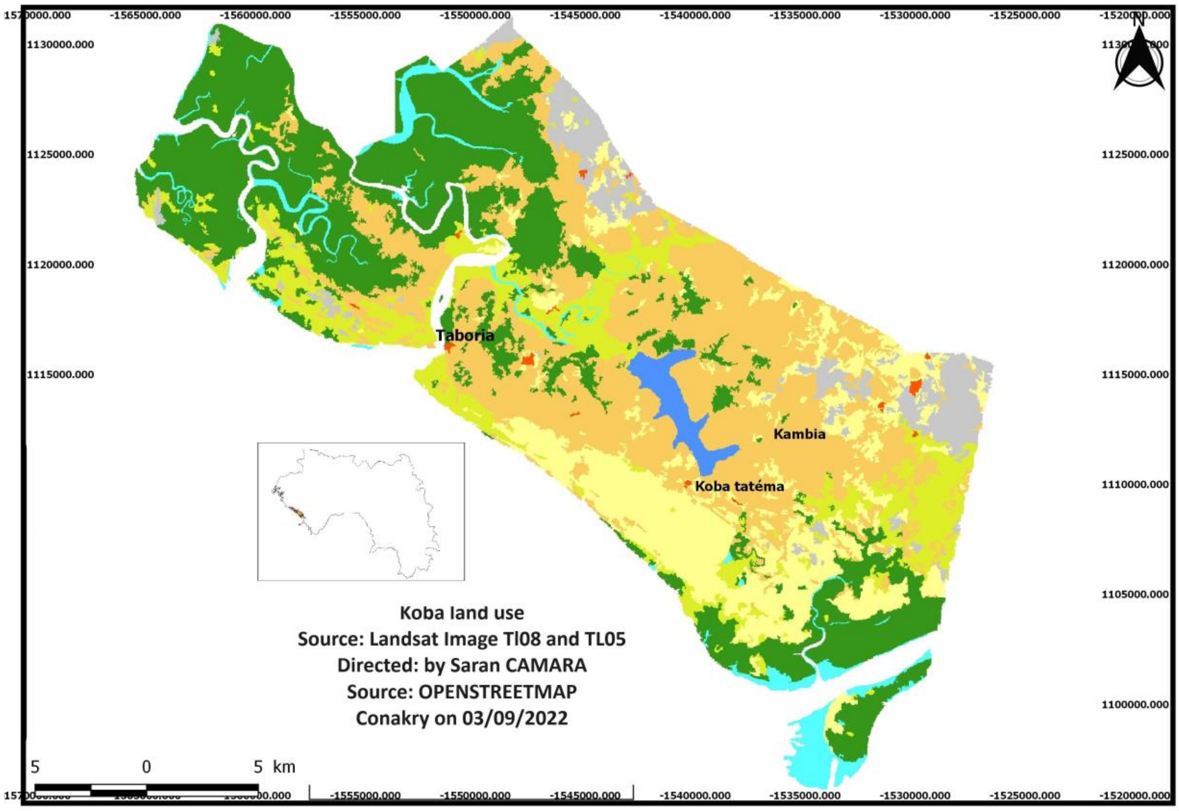
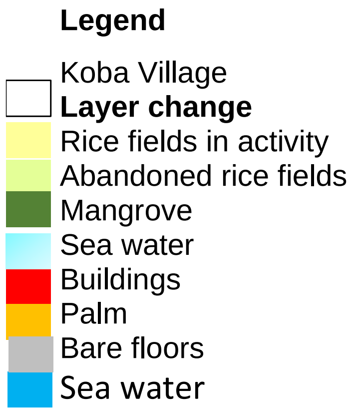


Fig. 2a. Land use map in Koba, 1986



Land use in 2003: The types of land use in Koba in 2003 are shown in Fig. 2b. This Fig. 2b shows the surface area by class. In 2003, there was a decline in mangrove class, which occupied 14.611 hectare, or 27.4% total area, instead of 30.55%.

previously. Rice fields in use and those abandoned occupy more or less than the same percentages, at 6.404 ha (12%) and 6.438 ha (12.1%) respectively. Agro-forestry, essentially plantations (palm, banana, cashew), increased slightly, with 38.2%. The rest of the surface area is occupied by seawater, buildings, bare soil and water. The pressure on mangrove was already being felt, with number of fishermen increasing and several development projects being carried out since 1997, not to mention the increase in population and their needs, as a result, there was more pressure, leading to a reduction in surface area of almost 3% (1545ha) in 17 years (between 1986 to 2003), i.e. 0.18% loss of surface area per year (approximately 90.8ha per year). In 2003, there were almost as many active rice fields as abandoned rice fields, and more plantations (especially of palm and cashew trees) than in 1986, when there were more sugar mills.

Land use in 2022: Fig. 2c. shows the different land use classes, i.e. active and abandoned rice-growing areas, mangroves, agroforests, water, bare soil, built-up areas and seawater in 2022. In this year, there will be a reduction in mangrove class, which will occupy 22.5% of the total surface area, while abandoned rice fields will account for 17.8%, active rice fields will occupy 9.6%, agroforests will occupy 36.4% and buildings will occupy 2.1%. The confusion matrix for the validation of the quality of the classification gave us an overall index of 0.83 and a kappa index of 0.80.

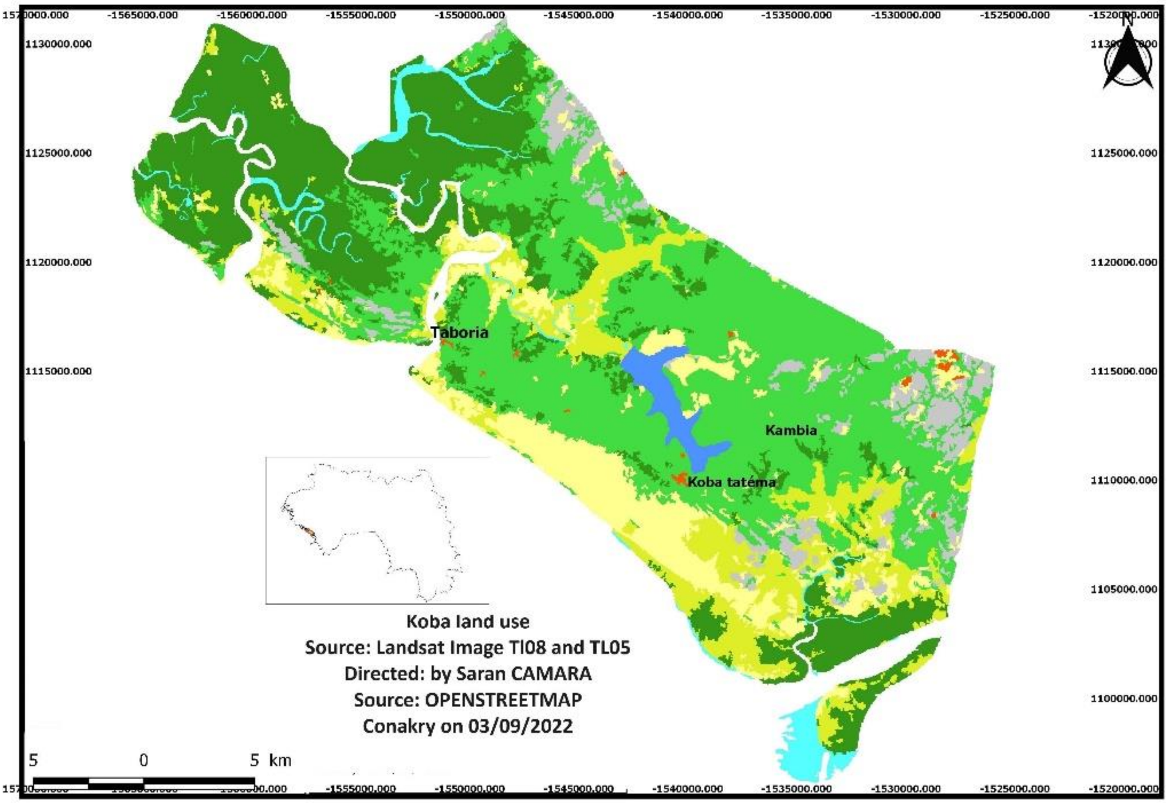
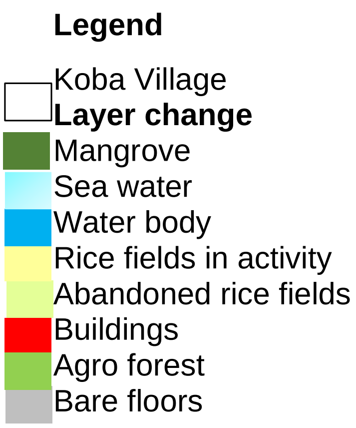


Fig. 2b. Land use map in Koba, 2003



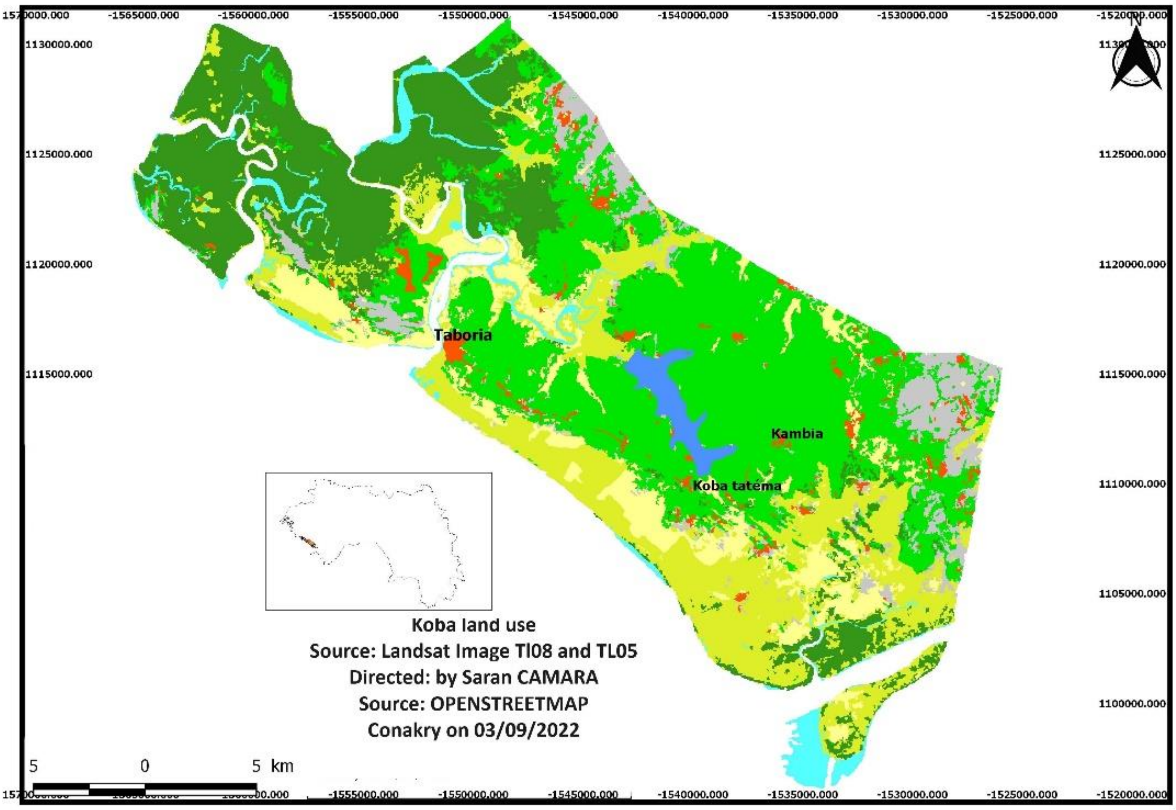
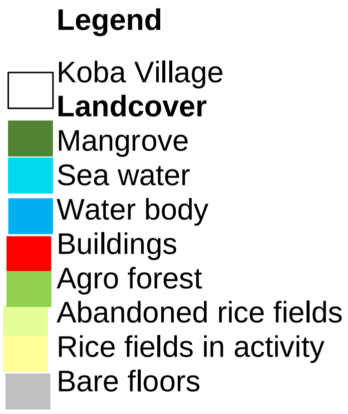


Fig. 2c. Land use map in Koba, 2022



Mangrove has decreased by 7.7% in 36 years (1986-2022), or 0.22%/year; this is equivalent to a loss of 4123 hectares in 36 years and 114.5 hectares per year in this area. In space of 36 years, area of abandoned rice paddies has increased by 3.196 hectares (6%), equivalent to 88.6 hectares per year (0.17%/year). The advance of saline tongue is reducing the surface area of areas that were farmable in 2000 but are no longer so. In 2022, there will be an explosion in number of fishing camps, with more needs to be met.

So, speaking of changes in land use at Koba, this study found two types of land use change, conversions and modifications. Land cover conversion is considered to be a Land cover change is the replacement of one type of land cover by another and is measured by the transition from one land cover category to another, as in the case of agroforestry, bare soil or the expansion of built-up areas. Land cover modifications are more subtle changes that affect the character of the land cover without changing its overall classification. This is the case here with the intensification of abandoned rice-growing areas or the gradual degradation of mangrove swamps, which is consistent with studies [20] on land cover dynamics in Guinea where these types of changes are highlighted.

Land-use maps show that salinization is gaining ground, with more and more land being lost, not only to salinization on the one hand, but also to mangrove cutting and the spread of buildings on the other. Rice growers claim to have noticed this situation for a very long time (over 20 years). However, they point out that the phenomenon has become increasingly recurrent in recent years. Faced with this situation, the farmers don't know what to do, other than to adapt.

To mitigate the advance of salt tongue into rice fields, rice growers use traditional materials to build traditional dykes almost every year. These are generally built exclusively from sand from rice fields. In the case of Bassengué district, where rice growers organize themselves into working groups to repair and raise sides of dykes that have failed. Our results corroborate those of [24] in Boké, where farmers organize themselves to work; and [25] in their study in Lower Casamance on constraints towards the development of rice plots, where farmers do the same for anti-salt dykes.

4. CONCLUSION

Koba coastal zone is under the influence of two factors: rising salinity and rainfall disturbances. The salinization of agricultural land, although natural, is exacerbated by climate change (marine intrusion due to rising sea levels) in Koba area, a phenomenon that has become recurrent.

The general trend is to increase area abandoned for rice fields at the expense of active rice fields and dry land vegetation. This trend is as a result of poorly implemented development, with salinization and acidification of rice fields and their gradually abandonment by local populations. In space of 36 years, the area of abandoned rice fields has increased by 3,196 ha (6%), or the equivalent of 88.6 ha per year (0.17% per year). These results are in line with perceptions of rice growers, who rank salinization as the main problem they face, followed by marine intrusion and flooding. Land comes last, as they have already found a solution to this problem in the commune.

The solutions proposed to deal with salinization of agricultural land in Koba are water management at plot level, monitoring and combination of activities, changing activities and use of early warning systems.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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