



# The Sea Swallowed our Houses and Rice Fields: The Vulnerability to Climate Change of Coastal People in Guinea-Bissau, West Africa

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## Abstract

Guinea-Bissau remains among the African countries most vulnerable to climate change due to its flat topography and large meandering coastal area invaded by the tides. We present a case study of the island-village of Djobel, showing the dramatic consequences of socio-environmental change. The inhabitants' attempts to mitigate the impact of extreme weather events and sea-level rise and adapt to the new circumstances have been hampered by the seizure of their upland territory by a neighboring village. In the context of a disconnect between state and society, Djobel's inhabitants want the state to guarantee their rights to productive land, water, and safe housing conditions. This case shows the need for legal protection of the rights of poor, marginalized, and underrepresented populations at risk of becoming climate refugees in the fragile context of politically unstable, failed, and often authoritarian states.

**Keywords** Climate-induced mobility · Socio-environmental change · Mangrove swamp rice production · Mangrove planting · Remote sensing · GuineaBissau, West Africa

## Introduction

Africa hosts some of the countries most vulnerable to climate change not only because of the projected frequency of extreme weather events on the continent but also because of the low Human Development Index and state fragility/failure in most of its countries. Additionally, as on other continents the main livelihoods of Africa's coastal populations are dependent on farming and fishing activities and hence are highly exposed to climate change (e.g., Adger et al., 2006; Matera, 2020).

Islands and deltas present extreme cases of vulnerability concerning many climate change impacts: sea-level rise, coastal erosion, marine storm surges and extreme waves (IPCC, 2014; Rangel-Buitrago et al., 2020). Indeed, climate change is already negatively affecting the livelihoods and welfare of

island inhabitants and may even jeopardize the existence of small islands through submergence (e.g., Bellard et al., 2014). Sea-level rise may also increase coastal erosion and saline water intrusion, further impacting ecosystem services and livelihoods (Brown et al., 2018; Failler et al., 2020).

The ecological vulnerability of insular communities' to sea-level rise, marine storm surges, and extreme waves increases in relation to several factors: community size, low elevation, the complexity of shoreline inlets, and the absence of rocky shores (Andréfouët et al., 2015). Extreme weather events (e.g., hurricanes) and slow-onset processes (e.g., seawater rise) have changed the living conditions of locals and may trigger a perception of insecurity that prompts them to abandon, permanently or temporarily, their houses and other assets by migrating to other regions or countries (Berchin et al., 2017: 147, 149). In this context, many islanders can quickly be transformed into what have been called "climate migrants", "climate refugees", or "environmental refugees" (e.g., Black, 2001; Farbotko & Lazrus, 2012; Berchin et al., 2017), especially when they live in authoritarian, failed or fragile states.

Narratives around climate migrants/refugees and climate conflicts have been spreading (for an overview, see Scheffran & Battaglini, 2011). These climate-related forced migrants were mainly associated with inhabitants of Small Islands Developing States (e.g., Farbotko & Lazrus, 2012; Bellard

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et al., 2014; Andréfouët et al., 2015; Eckersley, 2015: 482; ). However, the concept remains strongly questioned in development theories and policy narratives (e.g., Black, 2001; Hartmann, 2010; Farbotko & Lazrus, 2012) and has no legal status yet (e.g., Berchin et al., 2017). Thus, in the highly politicized arena of climate change, there is no normative protection from the United Nations High Commissioner for Refugees for the kind of forced migrants who are not running from political persecution but from environmental distress (Farbotko & Lazrus, 2012; Berchin et al., 2017).

Nevertheless, there is an increasing number of cases of extreme vulnerability and destitution among poor, climate-risk populations who are in urgent need of special attention and protection under a climate justice framework (Adger et al., 2006). Furthermore, some of these vulnerable people are also negatively impacted by green grabbing (Fairhead et al., 2012). However, climate justice has been framed in diverse ways and no consensus has been achieved as to how and by whom prevention, mitigation, and adaptation costs must be paid to the most vulnerable populations (e.g., Schlosberg, 2012).

As highlighted by several scholars (Black, 2001; Farbotko & Lazrus, 2012; Ribot, 2010; Matera, 2020), there are a significant number of drivers of precarity (structural, economic, and political) that increase the vulnerability of climate-risk populations and result in migration. Climate forced-migration policies are insufficient to address the problems (Black, 2001) of these socio-environmental migrants, so there is a need for the implementation of multiscale vulnerability reduction policies (Ribot, 2010: 62).

Guinea-Bissau has a high ratio of shoreline to land area and remains among the African countries most vulnerable to flooding (Ministry of Natural Resources & Environment, 2006; Schaeffer et al., 2014). Due to the country's topography and ecology, extensive marshy forests of mangroves can be found along the coast. These forests are often surrounded by mudflats along the seaside and by rice fields inland. There are many offshore islands of the Bijagós archipelago, but extensive intertidal areas surrounded by mangroves and inlets are also perceived as isles by their inhabitants and neighbours (given that contact with the mainland requires a canoe). The country has a low Human Development Index value (0.480 in 2019) and is characterized by poor governance, political instability, and deteriorating social and economic conditions (e.g., Chabal & Green, 2016).

We present the case of one Guinea-Bissau island-village, Djobel, whose inhabitants' resilience and long-term attempts to adapt to their vulnerable environment and, more recently, to climate change have reached a limit. In a context of state–society disconnect (Chabal & Green, 2016), the islanders' attempt to create a settlement area in the uplands

ended up in a conflict over land between Djobel and the neighboring village of Arame (Temudo & Cabral, 2021), resulting in several deaths and numerous injured people (e.g., REMUME et al., 2009). Despite the many years of claims for help and national television coverage during the 2017 rainy season when there were severe floods and the dike ruptured, no effective technical or financial assistance for climate change mitigation or adaptation measures (see Ministry of Natural Resources & Environment, 2006) has so far been provided either by the state, NGOs, or donors.

First, we describe the highly environmental-dependent livelihoods of the Guinea-Bissau's coastal people and the factors that have contributed to their decreasing resilience to climate change. In the next section, we present the methodology. Then, we focus on the specific case of Djobel island, using a "people and pixels" approach (e.g., National Research Council, 1998) to the study of socio-environmental change to portray land use-cover changes (LUCC) and to call for an intervention that takes into account local knowledge, coping strategies and livelihoods, people's cosmological beliefs and religious practices, as well as their community identity and political structure (see also Brown et al., 2018). Moreover, in a scholar-activist tradition and using Robinson's (2010: 1) words, our aim is to "amplify the voices of those people who have done least to cause climate change, but who are affected most severely by it"

## Guinea-Bissau Mangrove Swamp Rice Production: The Challenge of Climate Change

The majority of Guinea-Bissau's population lives on the coast (Ministry of Natural Resources & Environment, 2006: 15). Rice is the country's staple food, and the chief rice production system (exclusive to West Africa) is practiced in saline soils formerly covered by mangrove forests. Mangrove swamp rice production (*bolanha salgada* in Creole) depends upon the cutting down of the trees, the construction of dikes (and sometimes dams<sup>1</sup>), the division of the reclaimed land into parcels through the construction of secondary dikes, and the installation of ducts and dischargers in the dikes to allow water management (e.g., Linares, 1992; Cormier-Salem, 1999; Temudo & Cabral, 2017). Each parcel is plowed manually with a long-handled wooden shovel tipped with

<sup>1</sup> What we call a dike (*ourique* in Creole) is an earth bund made along the mangroves or a marigot to prevent brackish water entering the rice fields during high tides and to retain rainwater for rice growth. When a creek crosses a rice field, farmers may opt either to build a contour dike around it and/or create a dam (where rainwater accumulates) through the construction of a major dike perpendicular to the flow of the creek "to close the river" (*fitcha rio* in Creole).

an iron edge. Both canals and ridges play an important part in water management, weed control, feeding the rice plants with rainwater, and leaching salt and acids from the soil. Additionally, in the surrounding creeks (and in the canals), women use several kinds of nets and traps to collect small fish, shrimps, and crabs. Many men fish in the creeks and sea arms surrounding the rice fields using canoes and large nets. For coastal people, fish is the main daily source of protein and an essential source of cash income.

Guinea-Bissau has the largest area occupied by mangrove swamp rice cultivation in West Africa (e.g., Cormier-Salem, 1999). It is also the only country in which farmers continue to develop new techniques of mangrove swamp rice production and introduce new varieties of Asian rice (Temudo, 2011; Sousa & Luz, 2018), while still producing African rice varieties and natural hybrids of *Oryza glaberrima* with *Oryza sativa* (Temudo, 2011; Teeken et al., 2012).

This unique agriculture-fish-livestock farming system relies on the capacity to mobilize expert knowledge (for dike and dam construction and conservation, water management, the control of soil fertility and toxicity, and variety selection) and a large amount of labor at certain periods of the crop cycle (e.g., Linares, 1992; Cormier-Salem, 1999). In Guinea-Bissau, farmers traditionally used no external inputs, as the regular tidal flooding of the lower fields with brackish water during the dry season, plowing, and free-roaming cattle grazing on the rice stubble helped fertilize the fields and control weeds. Smallholders had their own traditional techniques of pest control and introduced, selected, and multiplied their own rice seeds (Temudo, 2011). However, the practice of letting the brackish water enter the rice fields is no longer used due to the frequent delayed onset, recurrent dry spells, and shorter duration of the rainy season. This has resulted in reduced fertility and increasing toxicity of the acid-sulfated soils developed under aerobic soil conditions (Cormier-Salem, 1999; Ritzema et al., 1996). Climate change has come with an increase in pest attacks according to many farmers who, in some villages, are using non-specific pesticides provided by traders.

The area and the productivity of mangrove swamp rice fields have been varying throughout recent history (Temudo & Cabral, 2017). At present, rice production in Guinea-Bissau covers half of the population's internal needs (FAOSTAT, last accessed on 25 January 2022). Only among the Balanta (the major ethnic group of the country settled all along the coast) and some Diola (Felupe/Baiote) can one find households able to produce a surplus. Among all the ethnic groups that traditionally produced mangrove rice, plowing is performed by family labor and village workgroups. The elders guaranteed the highly skilled labor of dike construction and maintenance. At present, except in some Balanta and Diola (Felupe/Baiote) households, cashew nut production for export has been drastically reducing rice production because of its (much) lower labor input and the

opportunity it provides to exchange the nuts directly with imported rice at the farm gate (Temudo & Abrantes, 2013; Temudo & Cabral, 2017).

Most external interventions on water management and the techniques associated with the construction of dikes and dams have had no, or even negative consequences (apart from the provision of PVC dischargers as substitutes for the traditional fan palm trunks) due to their failure to engage with local experts and to respect religious beliefs and practices (e.g., Temudo & Abrantes, 2013). Moreover, new agro-ecological and socio-economic conditions have shown up gaps in the rich knowledge and skills of Guinea-Bissau's farmers. Among these new conditions, we can single out (Temudo & Abrantes, 2013, 2014; Temudo & Cabral, 2017; Sousa & Luz, 2018): a) the weakening of knowledge transmission mechanisms between generations and among ethnic groups; b) social changes (young men can study, engage in non-agricultural activities, and create their own household when still very young) that have resulted in labor constraints for the regular maintenance of the main dikes and in a major increase in the cost of labor; c) climate change, which has been increasing seawater level, the strength and height of the tides (especially spring and perigean), the irregularity of the distribution of the rains, the number of extreme events, pest attacks, and soil salinity and acidity; d) declining soil fertility and rice productivity.

While mangrove swamp rice cultivation is the most productive rice system in the country (e.g., Temudo, 2011), it is also knowledge- and labor-intensive and highly dependent on regular and plentiful rainfall and predictable tide heights; thus, it is much affected by climate change and socio-economic transformations (Temudo & Cabral, 2017). By contrast, cashews are a low labor-intensive and land-extensive crop that provides both cash income and food (Temudo & Abrantes, 2014). Additionally, the trees create land ownership in a time when the value of land has increased exponentially and conflicts over land tenure are blooming (Temudo & Abrantes, 2016). Before the expansion of cashew trees, villages' boundaries were known and respected by all, and each household possessed permanent holding rights to specific parcels of land. Consequently, land tenure conflicts both among rural people and between villages were relatively rare (Temudo & Abrantes, 2016).

## Methods

### Empirical Data Collection

Research on the Diola ethnolinguistic group (also known as Djola, Jola or Jóola in Casamance, Senegal) living in around twenty villages of northern Guinea-Bissau started in 2015. Between 2017 and 2019, a survey exploring

these villages' livelihoods was carried out with 342 Diola households in the villages of Bulol, Elalab, Edjaten, Edjin, Jufunco, Susana (the Ajaamat sub-group known as Felupe in Guinea-Bissau) and Arame, Elia, and Djobel (Baiote sub-group). Diola family units (*fogon* in Creole) overlap with production units, and, when present, both husband and wife were interviewed together. The Djobel livelihoods survey was applied during January and February 2017 to all households, but qualitative research has continued to date with short-term visits of one–two weeks every year during the early dry season. Research techniques were mainly based on oral history (nine interviews with elders of Djobel [3], Elia [3], Elalab [1], Edjaten [1], and Susana [2]), informal group discussions and key-informants interviews (about the extreme events of the previous rainy season, their consequences, the coping measures adopted, and the food security status of the inhabitants). Youths from Djobel and the other villages took part in five group discussions about their living conditions in the cities of Bissau, S. Domingos, Dakar, and Ziguinchor in comparison with rural livelihoods. Additionally, countless informal conversations about the inter-village conflict between Djobel and Arame were held through the years with people of all genres and ages from the villages under conflict and the neighbouring Diola villages mentioned above. These conversations took place in many informal contexts (e.g., over drinking palm wine, while walking, or travelling on public transport) to avoid the construction of stereotyped narratives. In 2021, the former state administrator of S. Domingos region, who had a major role in trying to solve the conflict, was interviewed by the first author and Luísa Acabado. Two informal conversations took also place with the staff of the Cacheu Mangroves' National Park (in 2021), and another three (in 2021 and 2022) with the group of soldiers that has been recently settled in the Elia and Djobel upland to try to prevent further violence. We also had access to the reports made by the legal advisor (Dr Luciano Patron Matos) of the Minister of Territorial Administration, who tried to solve the conflict in 2019 and to help the villagers of Djobel to settle in a small fringe of their upland. All interviews were conducted by the first author either in Guinea-Bissau Creole or in Diola, with translations provided by a field assistant belonging to each village, when informants did not speak the local *lingua franca*. Unless otherwise stated, all empirical data were collected by the first author in Diola villages during a total of 12 months of fieldwork (distributed in periods of 2–3 months every year during the early dry season, when farmers are less occupied with farming activities).

The demographic composition of the households, their productive activities and sources of income were analyzed by the age group of the household head (HH) using IBM® SPSS® Statistics 25.0 software. Considering that most people do not know their exact age, we decided to attribute

wide age grades of 10 years to HHs. Both boys and girls start to do agricultural work around 12 years old and usually marry after the age of 25. In this study, we classified household members who do not do agricultural work as children and those that work but are still unmarried as youth. Men and women work until they have no more strength; however, we classified them as elderly after age 70. Elders who could not work any longer, together with children and the disabled (just one in Djobel) were grouped as dependent members of the households.

A multivariate analysis of the variables associated with the characteristics of the heads of household (namely, age, gender, education) was carried out through multiple correspondence analysis (MCA) to define a typology of HHs using ANDAD® software, version 7.11., copyright (CVRM/IST) 2000. The results of the MCA indicate that the first factorial axis explains 80% of the variability of the HHs' characteristics (namely, age, gender, education). This factorial axis discriminated the group of HHs constituting the elderly and women from the group constituting the HHs younger than 69 and having more years of formal education. Following from that, the variables of household composition, workforce, productive structure, and sources of income were analyzed by age group of HH. The Gamma coefficient (for ordinal data) and the Contingency coefficient (for categorical data) were used to find out the level of association between each of the variables and the age of the HH. These values are presented whenever there are statistically significant differences between the age group of the HH and the variable under analysis (depending on the p-value).

### Land Use-cover Change Analysis

A total of seven land cover maps (1990, 1994, 2002, 2007, 2010, 2015, 2019) derived from Landsat images at a spatial resolution of 30 m were used to evaluate the socio-environmental changes that occurred between 1990 and 2019. Land cover data from between 1990 and 2015 was obtained from previous studies (Vasconcelos et al., 2015; Cabral & Costa, 2017; Temudo & Cabral, 2017), in which the second author worked on the satellite images processing and analysis. The 2019 land cover map was built specifically for this article. All maps followed the same methodology. Images were downloaded from the United States Geological Survey<sup>2</sup> and used the same selection criteria: minimal cloud cover, high quality images, and date of acquisition in the late dry season when available. For each year, Guinea-Bissau is covered by five Landsat scenes, pre-processed (geometrically and radiometrically)

<sup>2</sup> <https://earthexplorer.usgs.gov/>

to obtain clean and homogeneous mosaics. These mosaics were used to obtain the respective land cover maps by applying a supervised classification technique based on the maximum likelihood classifier (Lillesand et al., 2015). For that, a simplified legend of 11 land cover classes was adopted according to field knowledge and ancillary information: Forest, Woodland, Savanna woodland, Mangrove, Grasslands, Swamp rice field, Burnt, Mud, Water, Sand, and Clouds. Although Landsat images were selected for their minimal cloud cover, some Landsat mosaics showed some clouds and cloud shadows. Thus, where clouds existed, they were manually digitized over the image (visually on-screen) and a common mask was built and applied to each classified map to quantify only the area occupied by each class. Classification accuracy was assessed for 2010, 2015 and 2019 through a formal comparison between the corresponding classified image and a reference dataset composed by field data from 2010 (Vasconcelos et al., 2015) or by data collected for high-resolution images in Google Earth (GE). All validation datasets followed a stratified sampling strategy based on a 250 × 250 m systematic grid of points with a random origin (Vasconcelos et al., 2015). The remaining maps produced were not subject to a formal accuracy assessment since there was no ground validation data or GE high-resolution images (near or) of the same dates. However, when a consistent methodological procedure is followed during the entire period under analysis, it can be assumed that the validation accuracy of the most recent map is enough to support the validity of the historical dataset (Cabral et al., 2010; Vasconcelos et al., 2015). Two accuracy measures were calculated: the overall accuracy and the Kappa coefficient (Foody, 2002).

For each land cover map, the Djobel study area was extracted based on a polygon manually digitized on-screen over the high-resolution images from GE corresponding to the year 2018. As the existing houses are, in most cases, isolated or in groups of two, they were not detected in the land cover maps; thus, present-day houses had to be manually digitized on-screen over the high-resolution images of the GE and overlapped with them.

As no satellite images were available before 1990, a topographic map (1:50 000) produced by *Ministério do Ultramar/Junta das Missões Geográficas e de Investigações do Ultramar* in 1953 and an aerial photograph from 1976 (1:100 000) produced by the *Institut National de l'Information Géographique et Forestière* (IGN) were manually digitized on-screen to obtain more information on land cover types.

The accuracy results for 2010 and 2015 are published in Vasconcelos et al. (2015) and Temudo and Cabral (2017), respectively. Accuracy for the 2019 land cover map showed values of 89.3% and 84.9% for overall accuracy and Kappa

coefficient, respectively, which means a high agreement level with the validation dataset.

Land cover transitions between 1953 and 2019 and for each sub-period were analyzed, as well as the corresponding net change rates (which account for the expansion and reduction in the area covered by each type of land cover class). These values were calculated using the Puyravaud (2003) formula defined as:

$$r = (1/(t_2 - t_1)) \times \ln(A_2/A_1)$$

where  $A_1$  and  $A_2$  are the land cover class in the same region at two different times  $t_1$  and  $t_2$ .

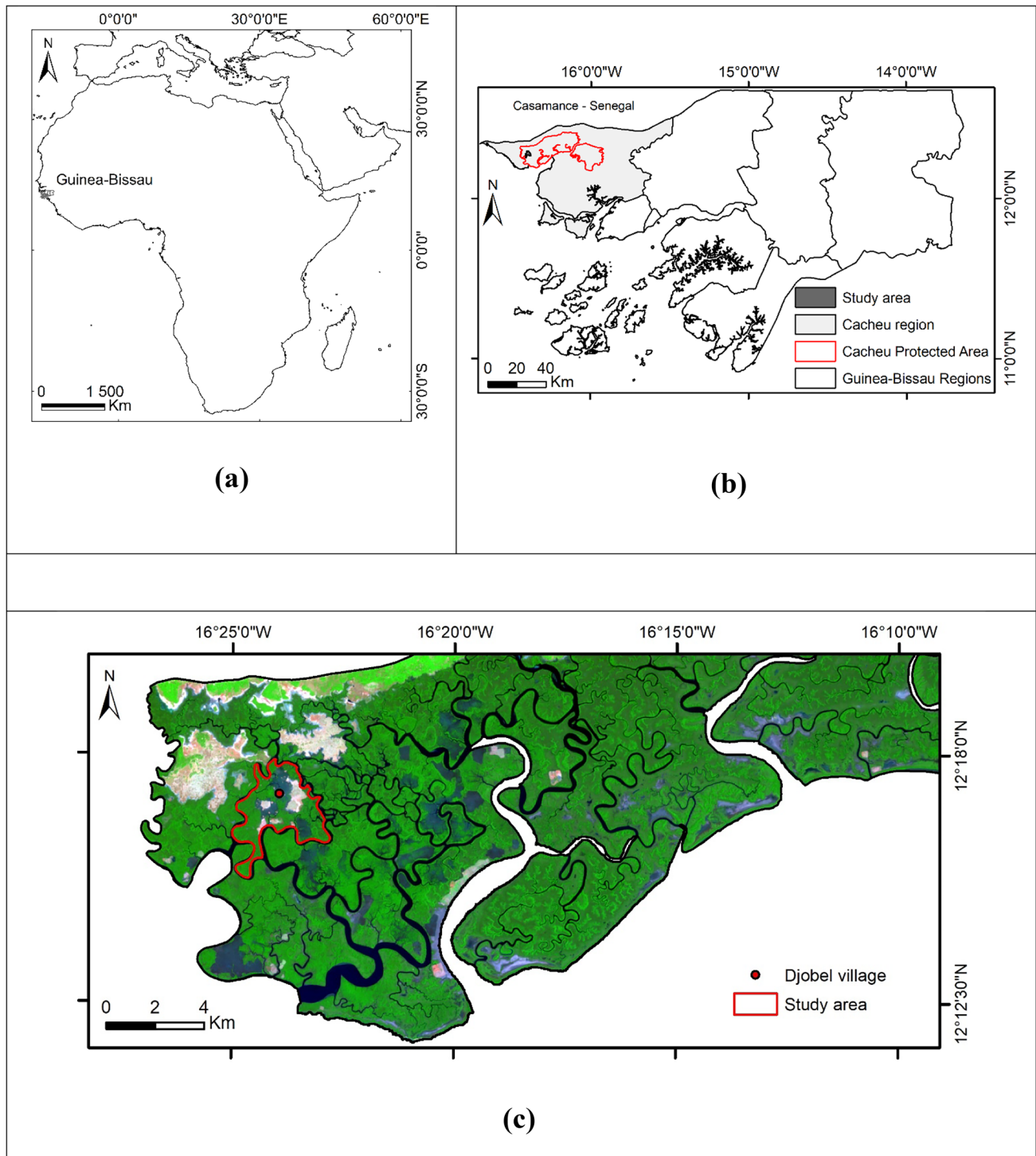
## Study Area: The Village of Djobel

Djobel is a northern Guinea-Bissau island-village located close to Casamance-Senegal border (Fig. 1), inside the Cacheu Mangroves National Park (PNTC). It has been peopled since colonial times by the Baiote – a sub-group of the Diola, which possesses characteristic cultural and religious practices, a high labor ethic, the prohibition of theft, and a preference for the cultivation of African rice varieties (Linares, 2002; Davidson, 2016). They have a segmentary (non-hierarchical) political organization, governed by a body of elders (Fig. 2) with both political and religious powers (Linares, 1992). The Diola (Felupe and Baiote sub-groups) have around 20 villages in the Guinea-Bissau territory.

Djobel village and rice fields are a bunch of small islands linked by intertidal mangroves (Figs. 1 and 3). According to oral history, the land where the village is located had few permanently emerged portions where some African baobab trees (*Adansonia digitata*; cabaceira in Creole) existed at the time it was discovered.

According to Djobel and Arame traditional authorities, Djobel inhabitants came from Casamance/Senegal several centuries ago searching for better livelihoods (*busca vida* in Creole) together with kin from the neighboring village of Arame, with whom they first settled. When the population density in Arame started to grow, one hunter discovered the land of Djobel and began to create mangrove swamp rice fields there. Eventually, others moved in and established a large village. As a result, the permanently dry land no longer provided enough room for their houses to plant rice and allow their livestock to roam.

Nogueira (1947: 746), who visited the island in colonial times, highlights that palisades surrounded the houses of each compound and that people had to use a canoe to visit each other during the rainy season because the sea arms enlarged. The inhabitants later decided to build two dams, a major contour dike and a canal to divert one sea arm, and



**Fig. 1** a Guinea-Bissau in the African Continent, b Cacheu region, the Cacheu protected area and the study area, c Landsat OLI (RGB754) color composite of the year 2019, with the study area defined by the sea branch surrounding Djobel village

many secondary dikes to allow for rice cultivation and the movement of people by foot during the rainy season. Thus, they created a polder in previous swampy land covered with mangroves, brackish water and mudflats (ibid). Soon, the

island became known in the region as "*Essuck Emanó*", literally meaning land of rice in Diola.

Women used to collect drinking water from shallow wells. However, by the end of the dry season, they had to paddle to



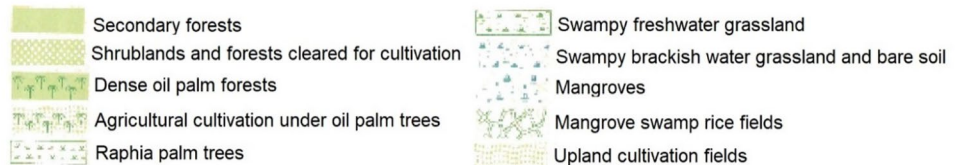
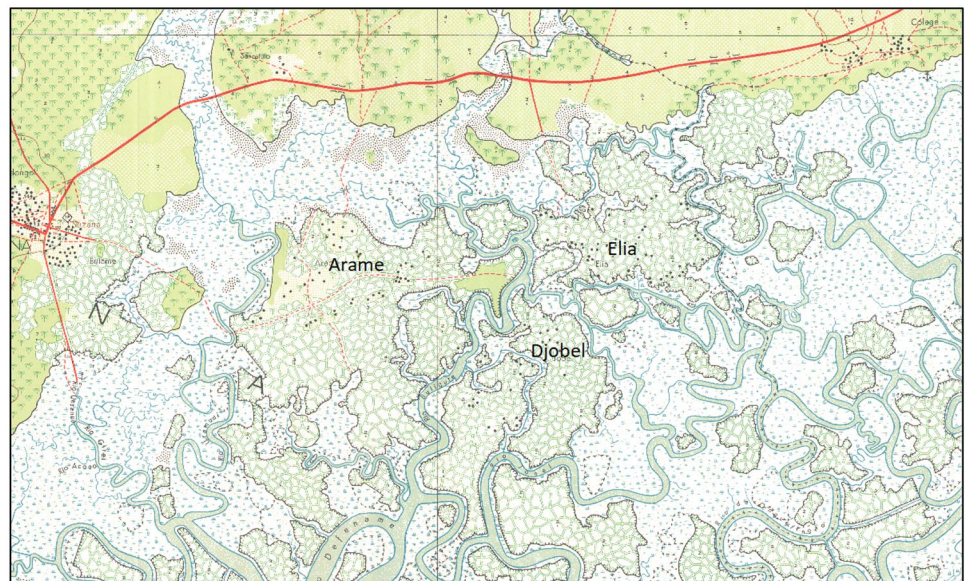
**Fig. 2** Partial view of a council of elders' meeting following a ritual at one of the main spirit's shrines

the neighboring village of Arame to fetch water from a well. Some artificial ponds provided cattle, goats, and pigs with drinking water for almost the whole dry season (see also Nogueira, 1947: 746). The roofing straw for their houses was usually harvested from a vacant upland territory that became theirs after the imposition by colonial authorities of forced labor to build and maintain the roads. According to interviewees from Djobel, Elia, Susana, and Elalab, this implied the establishment of village territories with fixed boundaries, even when the inhabitants lived on islands, as was the case for Djobel and Arame.

By the beginning of the 1960s, the African Party for the Independence of Guinea-Bissau and Cape Verde (henceforth PAIGC) had started to mobilize Diola villagers. Arame's youth adhered to the party in huge numbers, followed by some Djobel young men, but, in the neighboring village of Elia, forced mobilization and the kidnapping and assassination of those who refused made the elders ask for help from the Portuguese army. The colonial army's bombing of Arame forced the inhabitants to flee and take refuge in Casamance in the mid-1960s. Djobel and Cassu inhabitants followed them a year after (see also Dias, 1974: 84, 114). Refugees from these three villages returned after Independence (1974), but around half of the population of Djobel decided to stay in Senegal.

Today, the inhabitants of Djobel live in extreme precarity. As we will see in the following sections, the settlement now

**Fig. 3** Djobel, Arame, and Elia islands located over a topographic map (1:50 000) from 1953 and produced by *Ministério do Ultramar—Junta das Missões Geográficas e de Investigações do Ultramar*





**Fig. 4** Google Earth high-resolution image of one of Djobel's neighborhoods (9/11/2018)

seems to present similarities to those portrayed by Nogueira (1947) during his first visit to the island: once again, the houses are surrounded by sea water and the inhabitants need to move about by canoe (see Fig. 4).

Our study, conducted in 2017, revealed that Djobel had a total of 281 permanent inhabitants, distributed across 53 households. A large percentage of the household heads (HH) were illiterate (47.2%) and less than 50 years old (58.5%); only one was less than 30 and three of the household heads were over 70 (Table 1). Taking into account these results, and to avoid groups with only one case ( $\leq 30$  years or  $\geq 80$  years), we defined five groups of household head: up to 39 years old (there is only one case under 30 years old); from 40 to 49 years old; from 50 to 59 years old; from 60 to 69 years old; and the group composed of widows and elderly, which includes six widows, one male over 70 (but still working), and two men under 70 but no longer capable of working.

The family structure is composed, in general, of a man and his wife with four children and no youths and/or dependent elderly or disabled people (Table 2). There were only two cases of bigamy (one man with two women in both cases), which exemplifies the current dominance of monogamous marriages among the Diola of Guinea-Bissau, according to our research. It should be noted that there is a strong, negative correlation between the size of the household during the dry season and the age of the HH ( $p$ -value = 0.001; and Gamma coefficient is negative). A strong, negative correlation is also found between the number of children and the age of the HH ( $p$ -value < 0.001 and Gamma coefficient is negative). This shows that, contrary to what we observed in other Diola villages, urban migrants do not send their children to be raised by grandparents because they are not in a position to house and take care of them in the flooded territory of Djobel (as we will see).

During the rainy season, most of the urban migrants who are studying (and some of the ones who are working) return to Djobel to help in the rice fields, and the population increases up to about 500 inhabitants. Thereby, the workforce (men, women, youth and active elderly) almost triples (161.9% growth; see Table 3). The number of migrants who return to their household in the rainy season varies from zero to eleven, with an average of more than four (Table 2). Each household has an average increase of four people during the rainy season, which corresponds to an 80.1% increase in the number of household members. During the rainy season there is no significant difference between the size of the labor force and the age group of the household head (Table 3).

As we will see in the next section, Djobel's difficult living conditions and the lack of space for new couples to build a house explains the reduced number of households whose head is under 39 years old. However, some young men return for a few years to fish and save the money needed to continue their studies; young women usually return to the village while they are pregnant and breastfeeding. In other Diola villages, these short-term stays sometimes become permanent when youths can see the advantages of rural livelihoods.

## Djobel Livelihoods and Land-Use-Cover Changes

Among the Diola, African rice is vital for both people's survival and religious activity (Linares, 2002). All Diola households try to store African rice as a risk insurance measure against bad harvests, to use in mourning ceremonies, and to conduct rituals at spirits' shrines. The cereal can be offered or lent to family and neighbors in need, but only the old rice can be sold. Traditionally, Djobel inhabitants accessed other goods, such as cassava, peanuts, palm oil, wine, and clay pots through the direct exchange of rice and fish at weekly Diola markets. However, the growing destruction of rice fields during recent decades has reduced their capacity not only to keep rice stocks but also to be self-sufficient. In the past two decades, income from fish, shrimps, and oysters has started to be used as the main currency to buy rice, other food items, and cloth, and to pay for school expenses. However, according to Djobel inhabitants, income from these activities has been decreasing due to the growth of industrial fishing by foreign countries and the increasing number of people from neighboring villages now engaged in artisanal fishing and oyster collection. As previously noted, most of young people only return during the rainy season for plowing (men) and planting (women), leaving the major work of dike repair and maintenance to the decreasing number that stay in the village.

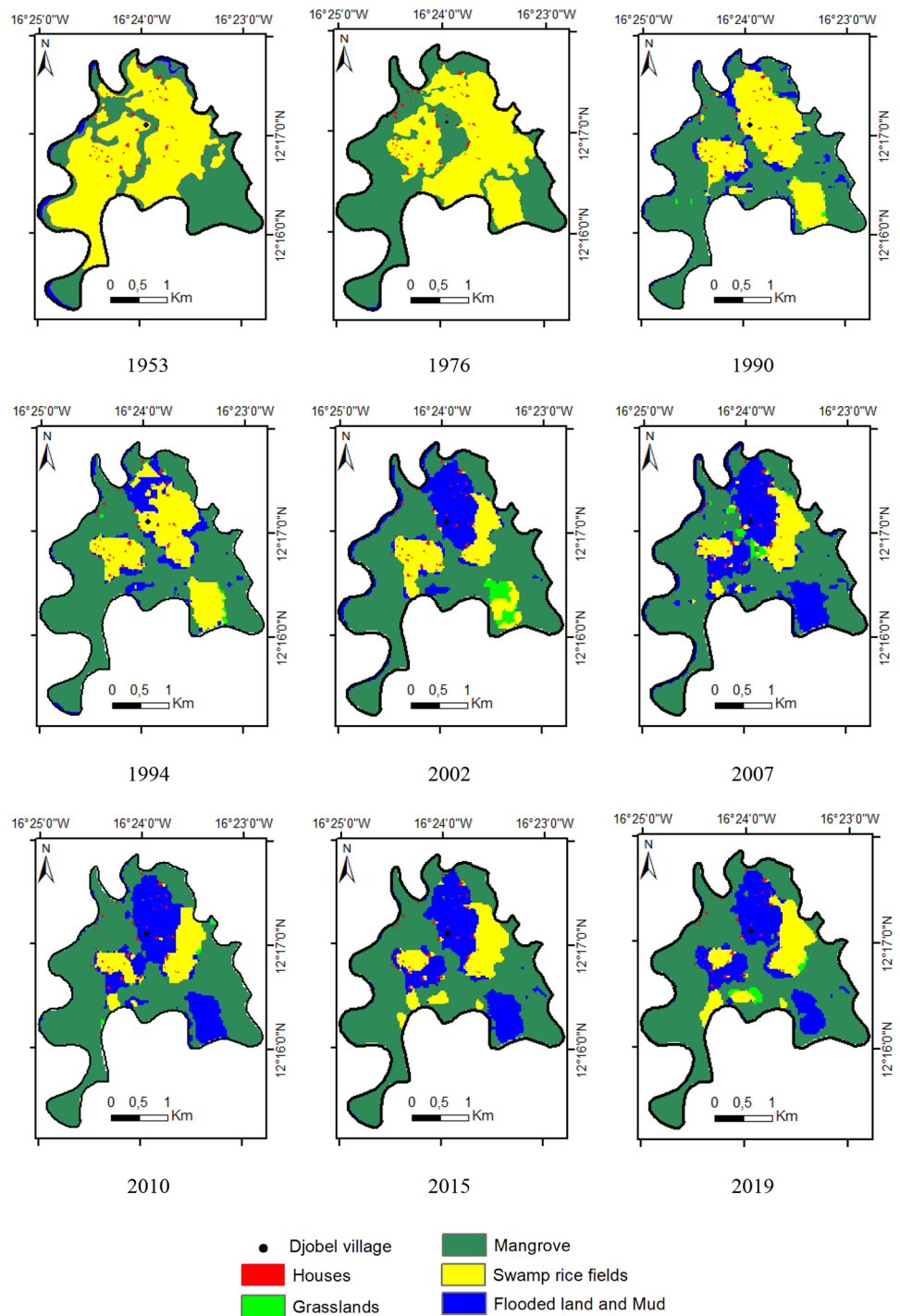


All households produce mangrove swamp rice (both *O. glaberrima* and *O. sativa* varieties), but they mostly value African rice varieties (see also Table 4). This community does not grow vegetables or have fruit trees as they have almost no permanent dry land on the island and the village of Arame occupies their upland territory. Almost all households have chickens and pigs (98.1% and 96.2% respectively), about half of the families have goats

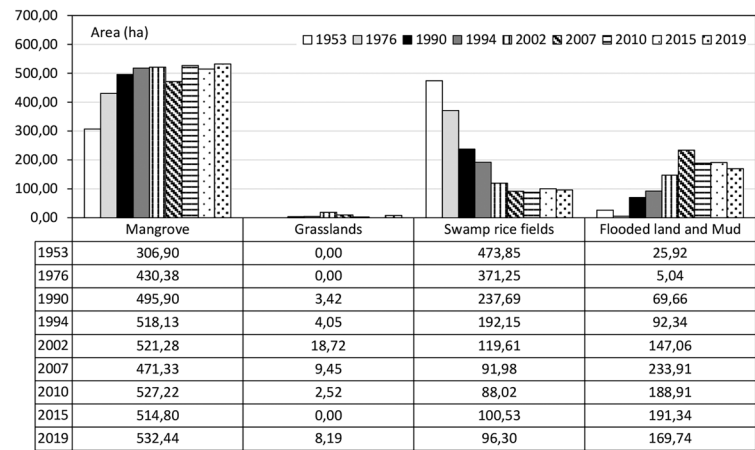
(49.1%), a third have cows (34.0%), and only a quarter raise ducks (24.5%). There are very few cows, and these are usually collectively owned by the descent groups as they are used in ceremonies and rituals, and any pigs, goats, and chickens are frequently killed by epidemics.

As people do not keep an account of their income and expenses, it is difficult to assess the relative importance of each source of revenue. According to our interviewees,

**Fig. 5** Land cover maps for the core study area in the period 1953–2019. The first two years (1953 and 1976) were obtained from topographic map (1:50 000) produced by *Ministério do Ultramar—Junta das Missões Geográficas e de Investigações do Ultramar* and from aerial photography (1:100 000) produced by the Institut National de l’Information Géographique et Forestière (IGN), and 1990–2019 was obtained from Landsat satellite images



**Fig. 6** Land cover evolution and net annual change rates in the period 1953–2019 for each land cover type. The first two years (1953 and 1976) were obtained from topographic map (1:50 000) produced by *Ministério do Ultramar—Junta das Missões Geográficas e de Investigações do Ultramar* and from aerial photography (1:100 000) produced by the Institut National de l'Information Géographique et Forestière (IGN); for 1990–2019, data was obtained from satellite images



Change rate (%yr-1)	1953-1976	1976-1990	1990-1994	1994-2002	2002-2007	2007-2010	2010-2015	2015-2019	1953-2019
<i>Mangrove</i>	1.5	1.0	1.1	0.1	-2.0	3.7	-0.5	0.8	0.8
<i>Grasslands</i>	0.0	140.4	4.2	19.1	-13.6	-44.1	-156.6	225.3	31.1
<i>Swamp rice fields</i>	-1.1	-3.2	-5.3	-5.9	-5.3	-1.5	2.7	-1.1	-2.4
<i>Flooded land and Mud</i>	-7.1	18.8	7.1	5.8	9.2	-7.1	0.3	-3.0	2.9

Djobel households' cash income (see Table 5) mainly comes from fishing (practiced by 86.8% of the male heads of household) and oyster harvesting (practiced by 88.7% of the married women). About one-third of the household heads migrate to fish in the open sea during some months of the dry season (32.1%), and this provides a large revenue either for extra expenses (e.g., a feast, ceremony or to buy roofing straw), to invest in the purchase of, for instance, domestic animals or a canoe, or to spend on hiring labor groups in the rainy season. There is a strong significant association between the household head's age and the fishing income ( $p$ -value  $< 0.001$ ). All families with heads up to the age of 60 years have this income source.



**Fig. 7** View of a new contour dike and of a former rice field now covered with mangroves planted by Djobel inhabitants

However, the income from fishing declines among older men and widows: old men no longer fish with canoe and nets, and few women possess a canoe to collect oysters and shrimps.

Domestic animals are another source of income for the households, albeit irregularly because of frequent epidemics. Pigs are sold (88.7% of cases) when the household has many but are most valued as payment for agricultural labor groups. Goats (37.7%) are also raised for selling, but chickens are only sold when people have a pressing need (50.9%). The reception of remittances sent by urban migrants is significantly related to the age of the head of the household ( $p$ -value  $< 0.05$ ). However, only a small number of households (18.9%) receive remittances and, for most of them, this form of help is merely sent at critical moments (such as illness, lack of rice, and, more frequently, during the rainy season, when they need money to hire labor groups). Indeed, those that migrate to study must also work (women as maids and babysitters and men usually as night guards) to pay for their needs, but salaries are usually low.

The alarming situation reported by Djobel inhabitants is portrayed by the remote sensing analysis and was also witnessed and photographed by the first author. Almost seven decades of observation (Figs. 4 and 5) reveal a substantial loss of swamp rice fields (an annual net loss of -2.4%) and a regeneration of mangrove areas (an annual net gain of 0.8%), together with an increase in flooded land and mud (an annual net gain of 2.9%). Grasslands occupied only a small area during the whole period under study.

In 1953, Djobel was characterized by a large and continuous area of rice cultivation. However, in 1966, the village's population was forced to take refuge in Casamance/

**Table 1** Characteristics of the household heads in terms of age, sex, and school attendance

Age group of the household head (HH)	Households		Household Head (N°)			Schooling of the HH (N°)		
	Nr	%	Male	Female	Dependent Male	None	Primary (1st–4th)	≥5th grade
≤30 years	1	1.9	1	0	0	1	0	0
30–39 years	16	30.2	16	0	0	4	3	9
40–49 years	14	26.4	14	0	0	2	6	6
50–59 years	10	18.9	8	2	0	6	0	4
60–69 years	9	17.0	5	2	2	9	0	0
70–79 years	2	3.8	1	1	0	2	0	0
≥80 years	1	1.9	0	1	0	1	0	0
<b>Total</b>	<b>53</b>	<b>100.0</b>	<b>45</b>	<b>6</b>	<b>2</b>	<b>25</b>	<b>9</b>	<b>19</b>

Senegal. As mentioned, after Independence (1974), only around half of the former population returned to Guinea-Bissau. Many youngsters got jobs outside agriculture in Senegal, and others were studying and decided to stay. Consequently, the village had much less labor with which to rebuild and maintain the dike infrastructure constructed during colonial times. Additionally, some of the rice fields were covered by mangroves (as confirmed in Figs. 5 and 6 for the year 1976). As a result, many distant fields were abandoned, and the villagers' efforts became focused on the fields near their houses. Despite the destruction caused by seven years of refuge in Casamance, the inhabitants were able to rebuild the water management infrastructures needed to quickly achieve rice self-sufficiency. According to Djobel elders' public statements – which were never contested by Arame traditional authorities and urban elite representatives, who challenged other statements made by Djobel villagers, and were corroborated by Elia elders – although Djobel villagers helped the inhabitants of Arame in their post-war reconstruction work, their neighbors refused to help them in return. Instead, help was provided by those that had decided

to stay in Casamance and by inhabitants of Elia. At that time, no water was visible inside the main polder, where both the houses and the nearer rice fields were located (as confirmed in Fig. 5). Nonetheless, according to farmers, the dike structure never again attained the previous level of robustness and regular maintenance.

In the abandoned distant fields, where the dike structure had been destroyed, the villagers decided to plant mangroves to increase the pace of mud deposition, with the aim of creating new rice fields in the future. The idea came from one elder who had visited the village of Oussouye in Casamance and seen mangroves being planted there. He shared the proposal with the other elders and, from then on, they started to plant mangroves in abandoned fields.

From the mid-1990s, the main dike of the village polder started to rupture during the rainy season, leading to the gradual abandonment of some more rice fields despite continuous attempts to rebuild the contour dike again and maintain the rice production area. This effort was made possible by the return of students and migrants during the rainy season and the support of distant migrants, who sent money to

**Table 2** Household demographic composition according to the age group of the household head

Age group of the HH	Youth (n)	Children (n)	Dependent Adults (n)	Migrants (rainy season)	Total members (n)	
					In the dry season	In the rainy season
≤39 years	0.9	3.1	0.1	3.7	6.2	9.9
40–49 years	1.1	2.8	0.3	4.2	6.1	10.3
50–59 years	0.5	2.9	0	5.4	5.4	10.8
60–69 years	0.6	0.6	0	4.0	3.2	7.2
Widows and elderly HH	0.2	1.4	0.6	4.4	3.6	8.0
<b>Total (n)</b>	39	131	11	225	281	506
<b>p—value</b>	0.288	<b>0.001</b>	0.325	0.371	<b>0.000</b>	0.343
<b>Gamma</b>	—	<b>- 0.413</b>	—	—	<b>- 0.455</b>	—
Mean	0.7	2.5	0.2	4.2	5.3	9.5
Mode	0	4	0	2 or 3	6	9
Minimum	0	0	0	0	1	2
Maximum	4	6	2	11	10	18

**Table 3** Household labor force according to the age group of the household head.

Age group of the HH	Labor force per household (n)	
	(dry season)	(rainy season)
≤ 39 years	2.9	6.6
40–49 years	3.0	7.2
50–59 years	2.5	7.9
60–69 years	2.6	6.6
Widows and elderly	1.6	6.0
<b>Total</b>	<b>139</b>	<b>364</b>
<b>p—value</b>	<b>0.009</b>	<b>0.951</b>
<b>Gamma</b>	<b>- 0.417</b>	—
Mean	2.6	6.9
Mode	2	6
Minimum	1	2
Maximum	6	15

hire labor groups. Villagers also continued planting mangroves in areas near dike ruptures and in destroyed fields to mitigate the negative impacts of strong tides and marine storm events on the dike structure and of intense winds on the houses. They plant randomly and consider their technique more efficient in terms of mud deposition and mangrove forest recovery than the scientific technique, introduced by conservation projects, of planting in lines. To prevent/reduce rice losses from shattering, the villagers also adopted the sickle, and both men and women now harvest quickly (traditionally, women harvested panicle by panicle with a knife).

It was also in the mid-1990s that Djobel villagers began asking the state regional administration to help them take possession of their upland territory, which was being planted with cashew trees by some Arame villagers (after they had filled their own upland with cashew trees). In addition, women in Djobel were prevented from collecting the roofing straw from their own upland and from fetching drinking water from one Arame well (after finding that feces had been thrown into it), and thus forced to go to further away to fulfil these vital needs.

In the early 2000s, the crops of mangrove swamp rice farmers across the whole country were destroyed

when high tides accompanied by torrential rains and strong winds caused the rupture of the main dikes and the influx of saltwater (Ministry of Natural Resources & Environment, 2006; Temudo & Cabral, 2017). In the case of Djobel, the main dike structure started to break in a way that made reconstruction impossible. Thus, Djobel's resilience to socio-environmental change and its ability to adapt to and mitigate against extreme weather events started to show major weaknesses. This can be observed in the land cover map of 2007, where large areas of Djobel's previous rice fields are shown flooded and covered in mud (Fig. 5). In 2009, 2014, 2015, and 2016 extremely high and strong tides further destroyed the village contour dike. Despite these events, in 2007 and 2015 there was a small decrease in the mangrove area due to attempts to open some new rice fields, but in 2019, the cultivation area contracted again (see also Figs. 5 and 6). Meanwhile, flooded areas have been progressively covered by mangroves (Figs. 5, 6 and 7).

During the 2017 rainy season, marine storm surges, heavy rains, and extreme waves during high tides destroyed most of the rice fields' infrastructure, and ten families became houseless. Many families now have their houses on what could be called minute islands (e.g., Figs. 8 and 9). Most of the dikes that used to be the trails linking the houses have been destroyed, and some children go to school by canoe while others must swim. Having to date received scarce support from the state, NGOs, or international donors, Djobel's inhabitants are being transformed into climate migrants/displaced people with nowhere to go.

Particularly since 2002, Djobel village authorities have regularly asked the local government for support to take possession of the upland that traditionally belonged to them; a claim that Arame inhabitants have refused to accept, placing a traditional symbol of declaration of war in the area. After their return from Casamance, Arame inhabitants preferred to invest in the less labor-intensive inland swamp rice cultivation and cashew tree planting. Cashews have the advantage of providing both an alcoholic beverage and the money to buy imported rice (which can also be obtained through direct exchange with the nuts), and Arame villagers do not want to give back the

**Table 4** Household agricultural production according to the age group of the household head

Age Group of the HH	% of African Rice seeds used	Livestock (%)				
		Chicken	Ducks	Pigs	Goats	Cattle
≤ 39 years	55.5	100	41.2	94.1	58.8	47.1
40–49 years	53.7	100	21.4	100	50.0	21.4
50–59 years	55.3	100	12.5	100	62.5	50.0
60–69 years	48.1	100	0	80.0	40.0	20.0
Widows and elderly HH	43.1	88.9	22.2	100	22.2	22.2
<b>Total of the HH</b>	<b>52.6</b>	<b>98.1</b>	<b>24.5</b>	<b>96.2</b>	<b>49.1</b>	<b>34.0</b>

**Table 5** Household main sources of income according to the age group of the household head

Age Group of HH	Fishing (%)	Oysters (%)	Domestic animals (%)	Seasonal migration (%)	Remittances (%)	Others (%)
≤ 39 years	100	82.4	82.4	35.3	17.6	29.4
40–49 years	100	92.9	92.9	42.9	14.3	7.1
50–59 years	100	100	87.5	62.5	0	0
60–69 years	60.0	60.0	100	0	40.0	0
Widows and elderly	44.4	100	100	0	33.3	11.1
<b>Total of the HH</b>	86.8	88.7	90.6	32.1	18.9	13.2
<i>p</i> -value	<b>0.000</b>	0.126	0.562	<b>0.028</b>	0.313	0.174
Contingency coefficient	<b>0.551</b>	–	–	<b>0.402</b>	–	–

**Fig. 8** Houses settled on minute "islands"

Djobel upland that they have progressively occupied with the cash crop. In 2019, the government finally attributed to Djobel a piece of their upland, on which they could build houses. Nevertheless, during their attempts to slash-and-burn the area, several people were injured and some killed by Arame inhabitants, supported by Casamance rebels (one was caught and imprisoned). Djobel's lack of voice in getting its rights recognized by the state is due, according to its inhabitants and many interviewees from other villages, to the strong representation that Arame has both in the army and in the main political party, which has governed the country for most of the time since Independence.

A project funded by the International Union for Conservation of Nature (IUCN) and executed by the Institute for Biodiversity and Protected Areas (IBAP) of Guinea Bissau (see <https://www.thegef.org/projects-operations/projects/9521>, last accessed in 18.01.2022) provided new hope. However, the COVID 19 pandemic delayed field activities, and the actual support given for dike reconstruction has been minute, as the project is mostly focused on strengthening

institutional and coordination capacities to scale-up and finance mangrove restoration. Djobel inhabitants want to be helped with a food-for-work aid intervention to rebuild the village protection

**Fig. 9** View of a settlement at low tide

**Fig. 10 a and b:** Partial view of the destruction produced by Arame villagers in Djobel's new settlement (photos taken by Djobel villagers in July 2021 and sent to the first author through WhatsApp).



**(a)**



**(b)**

dikes and create new rice fields. However, no external institution seems to believe that such a gigantic task can be achieved. In 2021, the new government (elected with Djobel political support) did finally help the villagers to take possession of the small fringe of their upland formerly demarcated as belonging to them by the legal advisor to the Minister of Territorial Administration of the previous government. However, the house foundations, hundreds of cement bricks (the area becomes flooded during the rainy season and the traditional mud bricks cannot be used), and the drinking water infrastructure built with the financial support of the state and the UN were all destroyed one night by Arame villagers (see Fig. 10), some of whom were caught by soldiers and imprisoned. During the 2021 rainy season, more rice fields and a total of seven houses were destroyed by the rains and flooding, and a child drowned. The villagers' are beyond desperate, and have asked the state for authorization to make a traditional war against the village of Arame: "We do not want to violate the law, but if the state does not help us, we'll have no other choice (...) we may all die, but at least one 'seed' (someone) will survive."

### **Conclusions: The Island where Land Scarcity Makes Pigs Swim and Fish**

Djobel was once an island surrounded by mangroves and sea water, where the settlement area and the nearest rice fields were protected by a major water management infrastructure. These characteristics intensified the susceptibility of the inhabitants and of rice production to socio-economic change

(such as increased schooling and migration), which in turn increased their vulnerability to climate change. Additionally, not only has the government failed to defend the inhabitants' human rights, but both the state and conservationists have also failed to recognize and compensate them for their management practices, which contribute to GHG emission reduction and carbon sequestration, and/or to provide funds for climate change adaptation and mitigation measures (e.g., through the National Programme of Action of Adaptation to Climate Changes).

Considering their long-term vulnerability, their decreasing resilience after Independence, and the existence of other drivers of vulnerability before climate change, we do not know whether Djobel's inhabitants should be considered climate migrants/refugees or socio-environmental migrants. But why does it matter when their lives are at risk and they have become landless people in need of protection?

The combination of social sciences and GIS/remote sensing techniques and the long-term analysis adopted in this research has proved clearly that Djobel's inhabitants' household economy (depending on rice cultivation, fishing, and animal breeding), culture (much centered on African rice cultivation) and even their political identity as a village are at risk of disappearing. The villagers can no longer survive in the rising waters of the rainy season and sea level rise. Yet, they have no place to go, and poor governance has been a major hindrance to their climate change mitigation and adaptation strategies. Their return to Casamance as refugees/migrants is not an option, as the

region is fraught with a long-term civil war, and there is little chance of them finding another territory (besides that usurped by Arame) in Guinea-Bissau in which to settle, as formerly vacant land across the country is now occupied by cashew trees (Temudo & Abrantes, 2014). In summary, there is an urgent need for the state to guarantee the human rights of Djobel's inhabitants, to put an end to the inter-village conflict (which can be only achieved through the disarmament of Arame and Cassu farmers<sup>3</sup> and the expulsion of the Casamance rebels from the Guinea-Bissau territory), to support the resettlement of Djobel's inhabitants in their traditional upland territory, and to conduct georeferencing and create an official register of the villages' territories (conducted with the mediation of elders and religious and political authorities of other Djola villages).

As Ribot (2010: 48) so eloquently states, vulnerability "is produced by on-the-ground social inequality; unequal access to resources; poverty; poor infrastructure; lack of representation; and inadequate systems of social security, early warning, and planning". Climate change acts in synergy with other human-induced changes, but adaptation measures must incorporate issues of equity and justice (Adger et al., 2006; Borrás & Franco, 2018), especially when the survival of a population is at risk and social conflicts over land are emerging. Both sudden events and slow-onset processes of climate change can expose poor, marginalized, and underrepresented people to the violation of their human rights, undermine their food, water, and shelter needs, and trigger national or international migration or even a civil war. Thus, the legal protection by both governments and the UN of the rights of climate-related forced migrants is an imperative matter, and a consensus around climate justice mechanisms must be achieved soon.

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<sup>3</sup> All hunting shotguns and bows and arrows processed by Elia and Djobel farmers were taken by the army in 2019, but Arame and Cassu villagers were able to keep their heavy weaponry.

**Data Availability** The datasets used and/or analyzed in this study are available from the corresponding author upon reasonable request.

## Declarations

**Ethical Approval** All research was conducted according to the ethical guidelines provided by the host institutions the authors are affiliated with.

**Informed Consent** All participants provided informed consent and were aware that the interview data would be used for publication and scientific purposes.

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