GUINEA-BISSAU

Source: esri

General

Guinea-Bissau - officially the Republic of Guinea-Bissau – is bordered by Senegal in the North, Guinea in the East and the South and the Atlantic Ocean in the West. The area of the country is 3.6 Mha (million hectares) with in 2022 a population of 2.11 million, or 0.59 persons per ha (Wikipedia and United Nations, 2022).

Climate and geography

Guinea-Bissau is warm during the year and there is little temperature fluctuation (average 26.3 °C). The average annual rainfall is 2,020 mm, which almost entirely occurs during the rainy season between June and September/October. From December till April, the country experiences drought (source: Wikipedia).

Sylla (1994) describes that along the Geba River the tidal amplitude varies between 5,60 m in the mouth till 2,50 m about 100 km upstream.

Sylla (1994) also describes that mangrove rice growing started in the middle of the 18th century in Guinea and Sierra Leone and that the traditional systems are still the most widespread. They are applied, for example in Guinea-Bissau (*Bolanha* system), Guinea, Senegal (*Diola* system) and Sierra Leone. The *Bolanha* and *Diola* systems consist of small basins or strips of land that are surrounded by dikes. Within these polders the rice is cultivated on ridges. Drainage is required drain excess water and to flush the salts and acids that have accumulated in the polders during the dry season (Oosterbaan, 1983). The traditional systems of rice cultivation have functioned well until the persisting droughts started in 1969. The most affected zones are mainly in the northern, and drier part of coastal West Africa, including Guinea-Bissau, Gambia, Senegal and to a some extent Guinea.

Traditional construction of a Bolanha dike and drain by Balantas

The *Vakgroep Weg- en Waterbouwkunde en Irrigatie* (1988) describes that in the coastal area of Guinea-Bissau since generations polders have been made (*Bolanhas*), where the Balanta people cultivate there main food, rice. Van Gent and Ukkerman (1993) state that in Guinea-Bissau since the beginning of the 20th century Balanta people have reclaimed mangrove swamps for rice cultivation. They show a schematic cross section of the landscape (Figure 1). They also give a description of the different types of cultivation. In total about 100,000 ha of tidal foreland have been impoldered for rice cultivation (Oosterbaan and Vos, 1980; Group Polder Development, 1982; Oosterbaan, 1983).

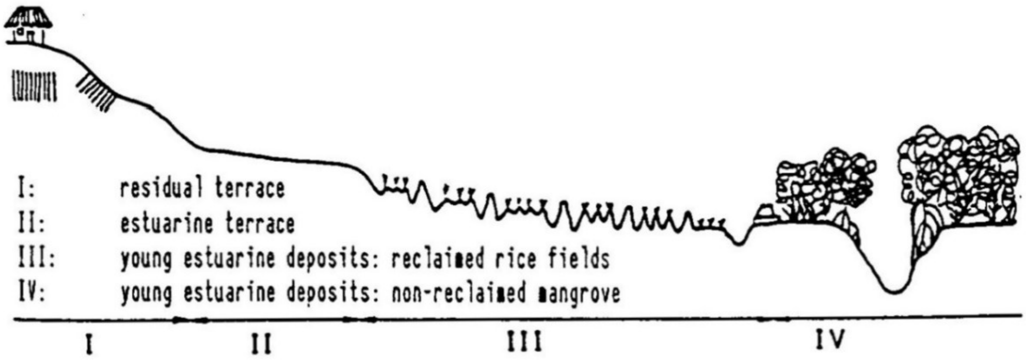


Figure 1. Schematic cross section of the landscape, showing the three major landscape elements (Van Gent and Ukkerman, 1993)

Existing polders

Oosterbaan (1983) shows an example of the coastal region (Figure 2) and presents soil data from four polders: Bissa-Tor, Comura, Pefiné and Bissauzinho. The first is an ancient polder and the others are recent polders.

General characteristics of the polders in Guinea-Bissau are shown in Table I. Characteristics of the water management and flood protection systems are shown in Table II.

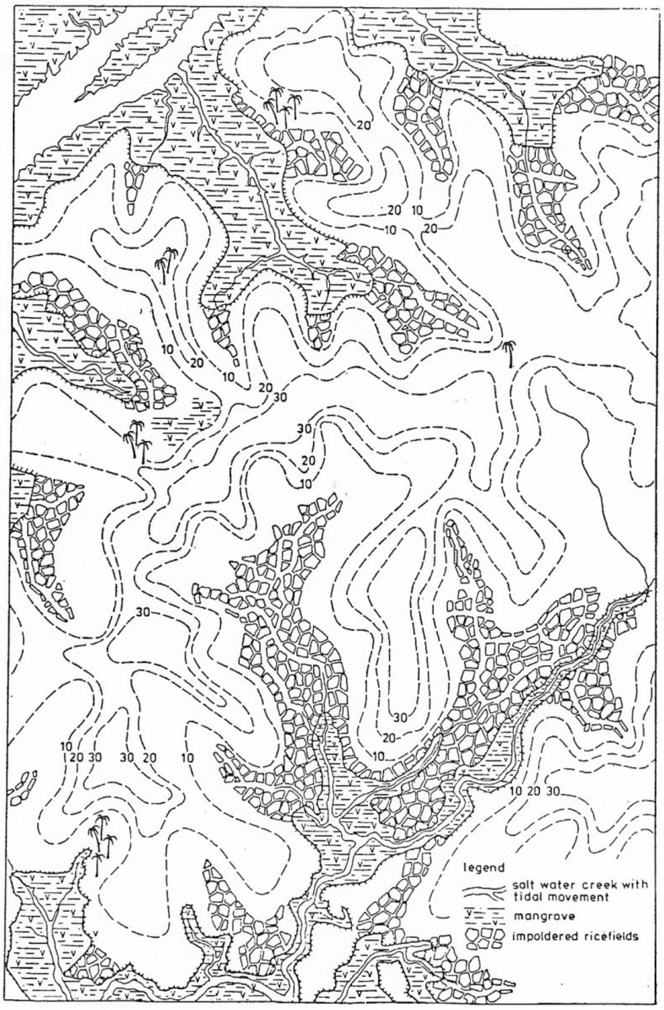


Figure 2. Example of the coastal region (Oosterbaan, 1983)

Cultivation of rice in rows in a bolanha

Rice harvest in a bolanha - picture Pierre Campredon

Proposed polders

No proposed polder could be identified.

Drainage and flood protection

The *Vakgroep Weg- en Waterbouwkunde en Irrigatie* (1988) shows a schematic lay out of a *Bolanha* system (Figure 3). They give a description of the construction of the ancient polders. For the construction of the outer dike, a track was first cut in the mangrove. The dike body was constructed from clay by digging a drain on the polder side along the course of the future dike and by digging holes on the salt-water side between the mangroves. Where necessary, the dike body was reinforced with stakes and mangrove twigs. When crossing creeks, a skeleton of branches was first made that were connected with each other with a kind of lianas, *Malila*. The clay was thrown between and against these stakes. The clay was excavated in chunks with a spade (*Arado*). The chunks were passed from person to person, placed in long rows about 1 m apart, and thrown with force against the bottom or dike body at the place where the dike was to be built. Oosterbaan (1983) describes that dikes along tidal creeks were 1.5 to 2.0 m high so that the land behind the dikes was no longer inundated by sea water at high tide. The crest of the dikes was only 5 to 10 cm above the level of the highest spring tides that occur at the end of the rainy season. When the farmers fear that the water would still flow over the dike they lay a strip of clay with the *Arado* at the lowest points of the dike. the extra height thus obtained was often just enough to hold back the water. In the event of extreme spring tides, for example caused by wind, it might happen that salt water flowed into the *Bolanha* over large parts of the outer dike for a short time (*Vakgroep Weg- en Waterbouwkunde en Irrigatie*, 1988). The traditional dams in creeks were made of rows of mangrove trunks filled with clay (Figure 4).

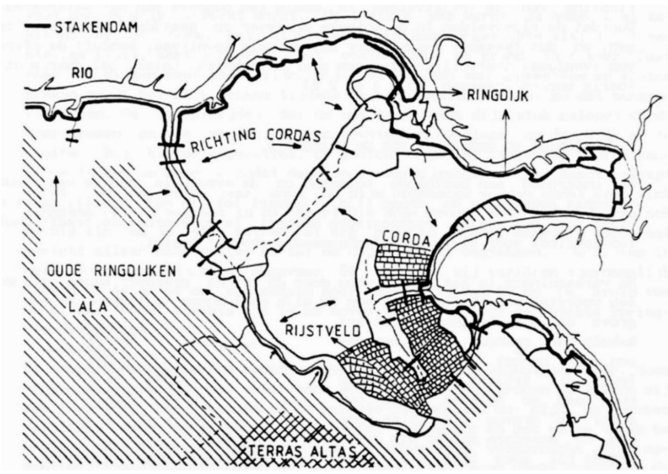


Figure 3. Schematic view of a Bolanha system with dams in the creeks (Vakgroep Weg- en Waterbouwkunde en Irrigatie, 1988)

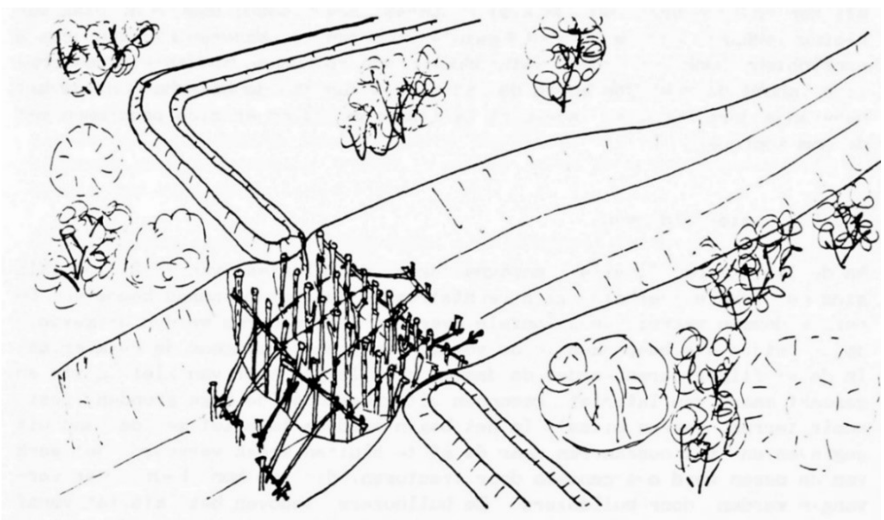


Figure 4. Schematic view of a traditional dam in a creek made by mangrove trunks (Vakgroep Weg- en Waterbouwkunde en Irrigatie, 1988)

After endiking a desalination process started. This was done by collecting rainwater in the endiked areas and then draining this water with the dissolved salts into the river.

Oosterbaan (1983) describes that the drainage is limited to surface drainage. In addition, detention of water in the polders plays a primary role, first to prevent extremely high discharges and second to store water during periods of high tide. Excess water is discharged through outlet gates in accordance to hydrological and agricultural needs (Figure 5).

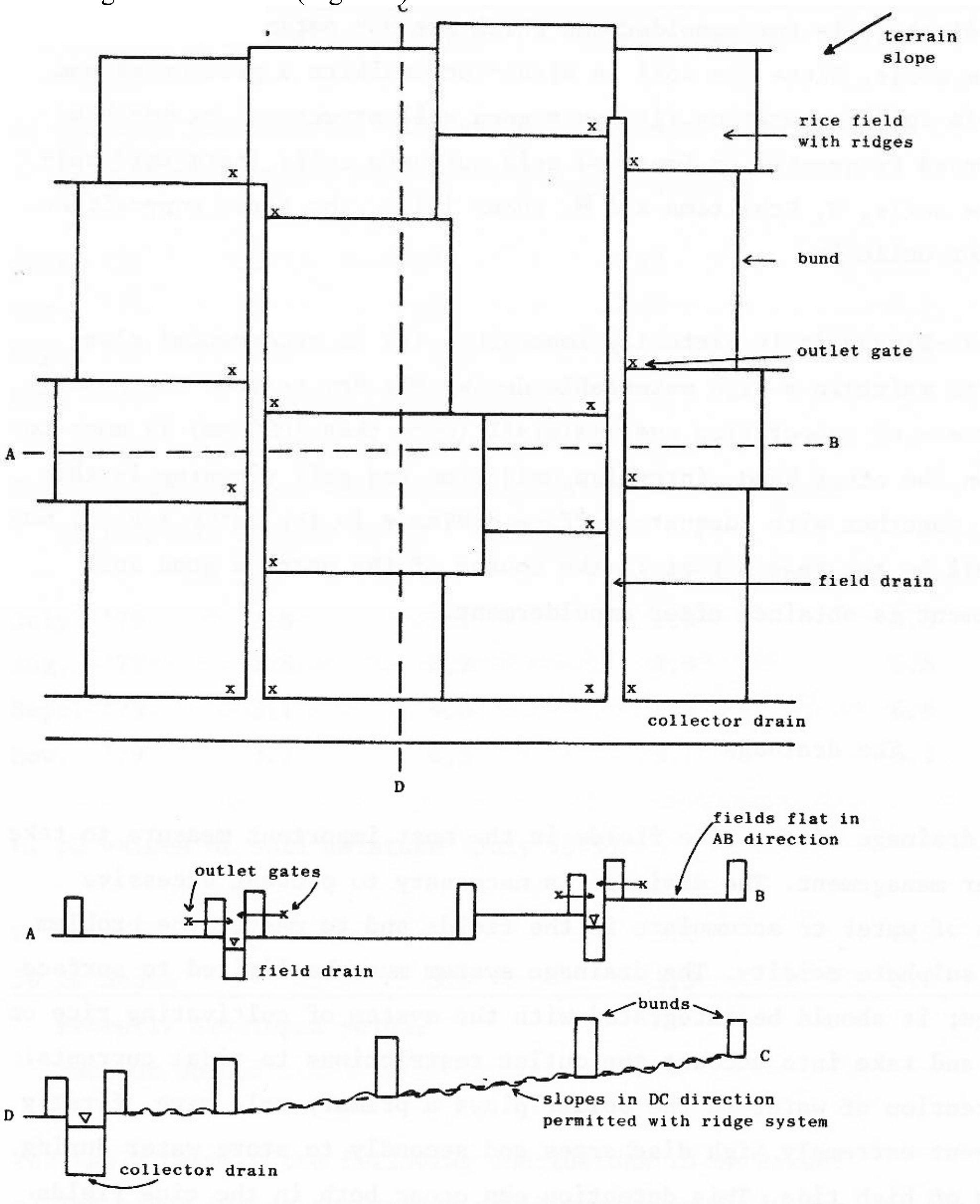


Figure 5. Model of a surface drainage system (schematic drawing, not to scale) (Oosterbaan, 1983)

The drainage canals were made when the dikes had been constructed. The main drainage canals were formed by the endiked creeks. The construction of canals specifically for irrigation or drainage, apart from the canals created during the construction of the dikes, is very rare. Occasionally, very small pieces of canal were dug to drain seepage water or other excess water. At the end of the independence struggle, in the early 1970s, the Portuguese built some larger drainage canals using bulldozers. At the same time, some locks were constructed. The drainage of *Bolanhas* takes place on the tidal creeks during low water levels. Just before and after high tide, no drainage is possible and the sluices were closed.

In *Departamento Hidraulica Agricola e Solos* (DHAS) (1981) a drainage criterion of 11.6 1/s/ha over 18 hours per day is assumed. The Food and Agriculture Organization of the United Nations (FAO) (1984) assumes 19.1 1/s/ha over 16 hours per day. The *Vakgroep Weg- en Waterbouwkunde en Irrigatie*

(1988) mentions that these values are considered to be high. For major interventions, for example when closing off creeks that drain several thousand hectares and where the probability of exceedance should only occur once every 100 or 1000 years, they could be realistic. However, for the small locks for the regulation of water management of 300 to 1,000 ha, where an exceedance of once every 10 years was considered acceptable, lower criteria could be used. This is also more in line with the farmers' practice where for the higher fields 2 l/s/ha was considered to be acceptable and for the lower fields 6 l/s/ha.

Within the rice polders small bunds of 0.30 m high divide the polders into compartments of irregular shape and size. Excess rainwater is drained from the polders trough culverts, traditionally made of hollow trees and provided with a stop to prevent entry of saline water (Oosterbaan, 1983). Oosterbaan (1983) also describes that in the 1970s a program of casting dams across the smaller creeks was introduced. In this way, the number and length of dikes could be considerably reduced (Figure 7). In the report of the *Vakgroep Weg- en Waterbouwkunde en Irrigatie* (1988) it is mentioned that in the 1960s in the coastal area forty of such dams had been made and that there were plans to make another forty. However, this activity was not very successful for various reasons.

Figure 6. Irregular size and shape of the rice polders (Bolanha) (source: Google Earth)

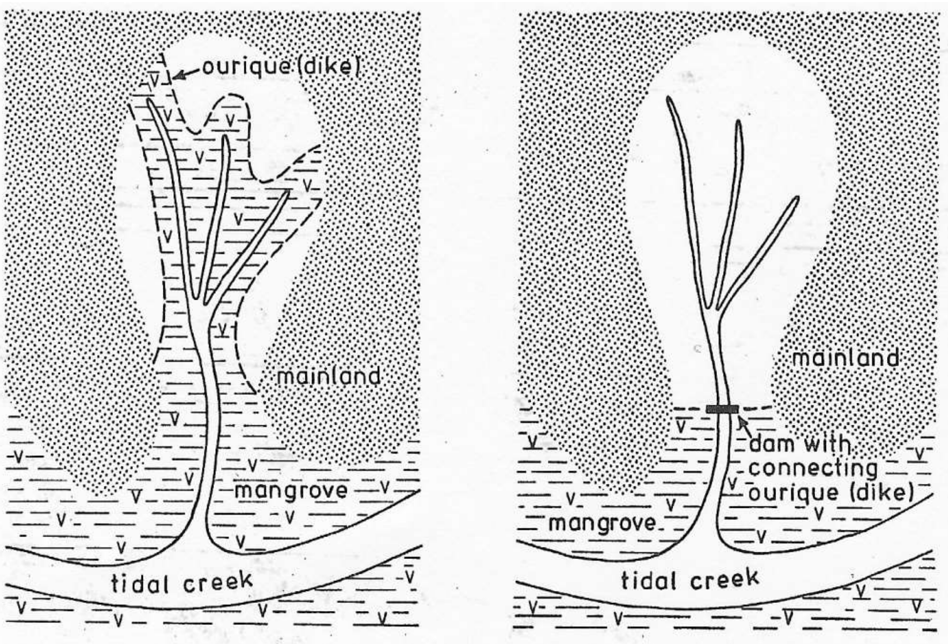
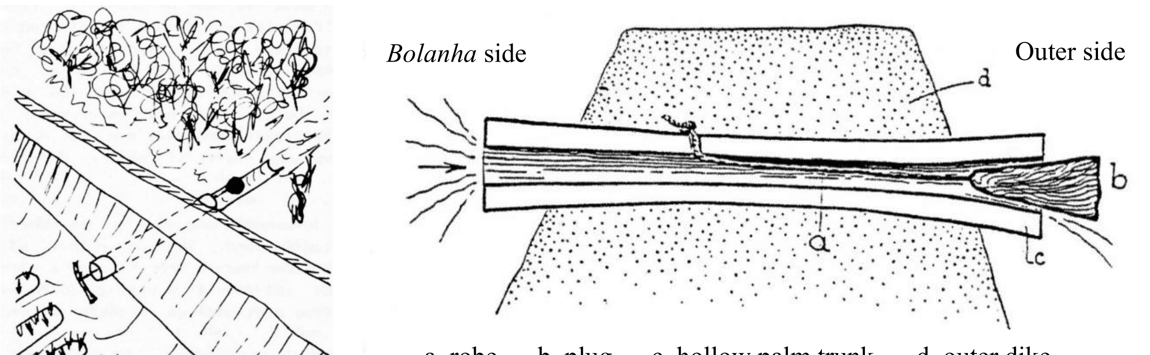


Figure 7. Polders with dikes (left) and dam (right) (Oosterbaan, 1983)

During the reclamation in the first year, the newly reclaimed land was first divided into strips (*Cordas*) among the families of the men who helped with the diking. These strips were subdivided into smaller fields (*Periques*). According to Linares (1970) the size of the fields depended on the slope of the land, the greater the slope the smaller the fields. Other factors also played a role, such as population and soil type. In principle, each family received a piece of land that bordered directly on the outer dike, for which maintenance was then required. In the second or third year, the newly reclaimed land was put into use for the first time. Most families cultivated 3 - 6 ha of rice fields, depending on the size of the household, the status one enjoyed and the quality of the soil (Pauline, 1957; Quintino, 1971; Linares, 1981; Vervoort, 1985). In the outer dike, a drain was made for each adjacent field for dewatering. This drainage could consist of a hole or a hollowed-out trunk of a palm tree dug into the dike (*Sibi*) or a discarded canoe (Figure 8a, b). This lock was closed off with a plug made from a mixture of banana and/or palm leaves and clay or wood. Sometimes this closing system was automatic and the stopper is fixed with a rope on the inside of the hollow log. At high tide, the stopper is pushed against the end of the pipe, so that the salt water cannot enter the polder. At low tide, the stopper opens automatically in case of pressure from the inside, so that the excess water can drain from the adjacent field. The height at which the trunk was buried in the dike corresponded to the height of the water level that one wanted to have in the field (Péllisier, 1966; Quintino, 1971). In principle, all systems are very similar, although the implementation may differ per area and population (*Vakgroep Weg- en Waterbouwkunde en Irrigatie*, 1988).

Tillage in a paddy field with two previously treated Periques in the background
(*Vakgroep Weg- en Waterbouwkunde en Irrigatie*, 1988) and construction of a dam in a creek



(a) (b)

Figure 8 (a) Principle of a bomba (Vakgroep Weg- en Waterbouwkunde en Irrigatie, 1988) and (b) sluice in the outer dike, made from a palm trunk (Quintino, 1971)

According to Péllisier (1966) there could be three such locks above each other in certain places. The lower one was opened only when all the water from the field was used to regulate the water level during the growing season when the crop was in the field and the upper one was only closed when as much water as possible must be left standing, e.g. to dissolve accumulated salts.

In the 1950s the construction of the dams was changed and they were made from laterite that was excavated from the higher areas. In the 1970s concrete sluices were introduced for the drainage of excess water through the dams, or to let saline water in for flushing of acidity (Figure 9).

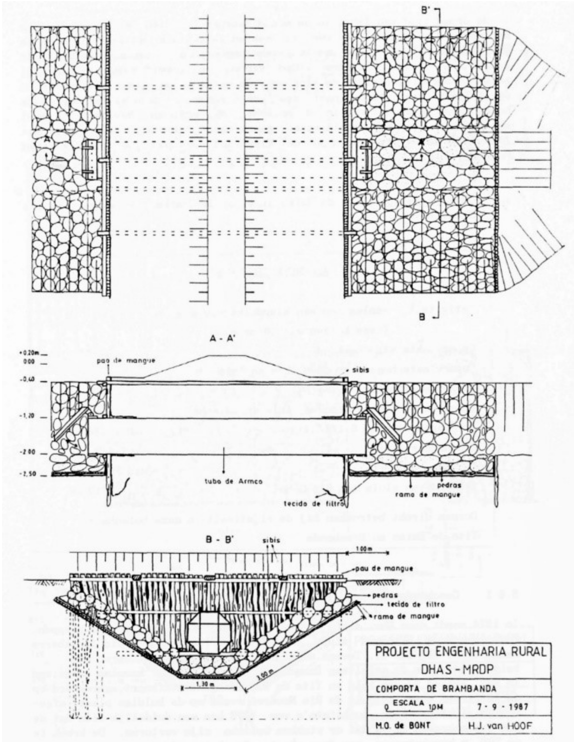


Figure 9. Flapgate sluice situated in Brambanda
(Vakgroep Weg- en Waterbouwkunde en Irrigatie, 1988)

During the growth period, dike monitoring is being done, especially during spring tides, to prevent a breach and subsequent saltwater intrusion at high tide. In the dry season, salt water is let in to kill weeds and to enable tillage of the low fields (Péllisier 1966; Van der Zaag 1986). An additional advantage of bringing in salt water is that the soils longer remain saturated with water. The high chloride content suppresses microbiological oxidation and this will limit the formation of acidity and the period in which this takes place (van Breemen, 1973; Silverman, 1967). Drainage generally takes place from field to field and finally ends in the deepest fields. One of the problems is the silting up of drainage canals and estuaries. Due to this the lowest-lying fields cannot be properly drained by gravity. As a result, the deepest fields have to deal with flooding and, moreover, the leaching of salts and acids is limited in this way (Teixeira da Mota, 1950; Vervoort, 1985). This impedes the possibilities of letting in salt water during the dry season for the benefit of tillage. The intention is to inundate the fields with salt water once every 3 to 10 years. The farmers first plant the high fields because they soon dry up again. The low fields can only be planted later because they are generally saltier and more acidic. Also, after the high fields have been planted, these fields are not flooded too deeply, so that they can only be planted after the water level has dropped again and salt and acid have thus also been washed out.

The *Vakgroep Weg- en Waterbouwkunde en Irrigatie* (1988) has also analysed the discharge capacity of a sluice under the following assumptions: i) the sluice consists of a pipe with an inner diameter of 80 cm, which can be closed off on both sides by means of valves; ii) the maximum discharge capacity of the pipe is 1.4 m^3/s; iii) the normal water level, also in the low fields, would preferably be 10 cm above the ridges. The available amount of water is then a total of 20 cm, 10 cm between the ridges and 10 cm above it. Under extreme circumstances, for example after transplanting in the second half of August and the first half of September, it is accepted that the water level in the *Bolanha* may rise an extra 10 cm. The area to be drained by the sluice is 350 ha. Based on the design discharge the following required capacity for the sluice was determined: for the high fields (*Mato* and *Lala*) 175 ha * 2 1/s/ ha = 350 1/s, and for the low fields (*Lala* and *Bolanha*) 175 ha * 6 1/s/ha = 1,050 1/s.

Location of the polders in Guinea-Bissau as shown on the World polder map

The location of the polders in Guinea-Bissau is shown in Figure 10.

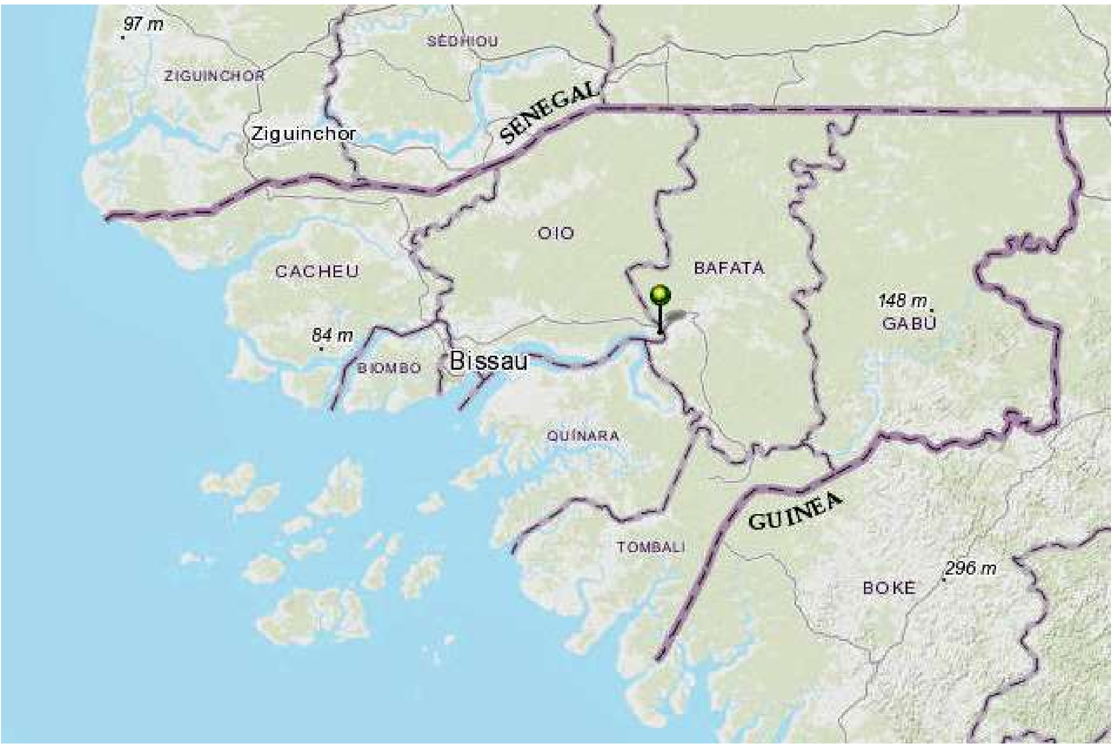


Figure 10. Location of the polders in Guinea-Bissau (source: esri – Batavialand)

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Table I. General characteristics of existing polders in Guinea-Bissau

Name	Reclamation	Area in ha	Type *)	Latitudes	Longitudes	Elevation in m+MSL	Land use
Bissa-Tor			LGS	11° 58’N	14° 58’ W	6	Agriculture, rice
Comura			LGS	11° 58’N	14° 58’ W	6	Agriculture, rice
Pefiné			LGS	11° 58’N	14° 58’ W	6	Agriculture, rice
Bissauzinho			LGS	11° 58’N	14° 58’ W	6	Agriculture, rice
Total		100,000					

*) RLL = reclaimed low-lying land; LGS = land gained on the sea; DL = drained lake

Table II. Characteristics of the water management and flood protection system of existing polders in Guinea-Bissau

Name	Design criteria in chance of occurrence/year						
	Water management						Flood protection
	Drainage					Irrigation	Rural
	Type	Design criterion	Percentage of open water	Discharge capacity			
				m^3/s	mm/day		
Bissa-Tor	LGS						Dikes 1.5 – 2.0 m high
Comura	LGS						Dikes 1.5 – 2.0 m high
Pefiné	LGS						Dikes 1.5 – 2.0 m high
Bissauzinho	LGS						Dikes 1.5 – 2.0 m high
General criteria					17.5*) 11.0**)		
Farmers practice				Higher fields 2 l/s/ha Lower fields 6 l/s/ha			

***)** Department of Rural Engineering and Irrigation (1981)
**) Food and Agriculture Organization of the United Nations (FAO) (1984)