Hydrogeology of Guinea Bissau


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  Do you have more information on hydrogeology of Guinea Bissau? Please get
in touch.
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Present-day Guinea Bissau was historically part of the Mali empire from the 13th to 17th centuries, and later part of the Gabu (or Kaabu) kingdom from the 16th to 19th centuries. From the 15th century, the coast became a focus of slave trading by Portuguese merchants, and the coast and inland areas were fully colonised by the Portuguese in the 19th century. An armed rebellion against colonial rule from the 1950s led to independence in 1974 as a republic. Since independence, Guinea Bissau has experienced ongoing political instability. Initially, government was highly centralised, with multi-party governance established in 1991. However, since independence no president has successfully served a full five-year term, and there has been a succession of military coups.

Guinea Bissau adopted the CFA currency in 1997. There is some potential for mineral exploitation and possibly offshore hydrocarbon exploitation, but development has been impeded by political instability and armed conflict. The economy remains dominated by agriculture and fishing, with cashew nuts and groundnuts the most important export crops. GDP and HDI (human development index) are some of the lowest world-wide. Illegal drug trafficking is significant, with the country used as a transit point for drugs between South America and Europe.

Guinea Bissau has relatively abundant seasonal surface water resources, as a tropical country with high (but seasonal) rainfall, but dry season water supplies are largely sourced from groundwater.

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Contents

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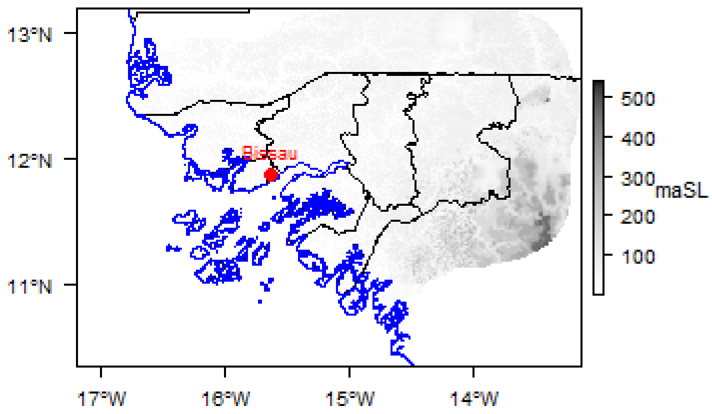
Terms and conditions

Geographical Setting



Guinea Bissau.Map developed from USGS GTOPOPO30; GADM global administrative areas; and UN Revision of World Urbanization Prospects. For more information on the map development and datasets see the geography resource page

General

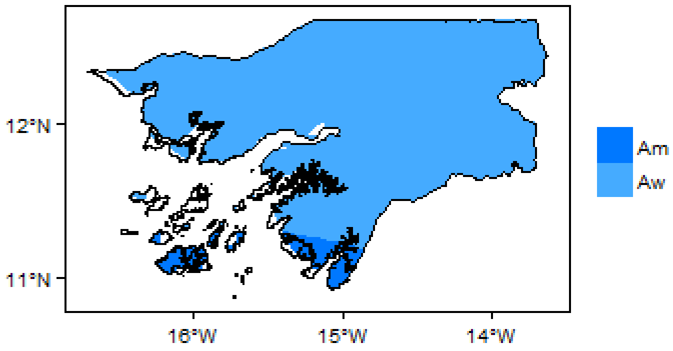
Guinea Bissau's territory includes the Bijagos archipelago, made up of more than 30 offshore islands. Most of the country is flat and low lying, with a maximum elevation of 40 m, and many areas of wetlands, including coastal mangrove swamps. The exception is the flat topped Boé Colline hills in the southeast, which reach 300 m elevation.

Capital city	Bissau
Region	Western Africa
Border countries	Senegal, Guinea
Total surface area*	36,130 km^2 (3,613,000 ha)
Total population (2015)*	1,844,000
Rural population (2015)*	962,000 (52%)
Urban population (2015)*	882,000 (48%)
UN Human Development Index (HDI) [highest = 1] (2014)*	0.4196

* Source: FAO Aquastat

Climate

Guinea Bissau has a wet tropical climate, with a wet season typically from April to October and a dry season from November to March. The eastern part of the country has lower rainfall, and the western coastal zone has higher rainfall.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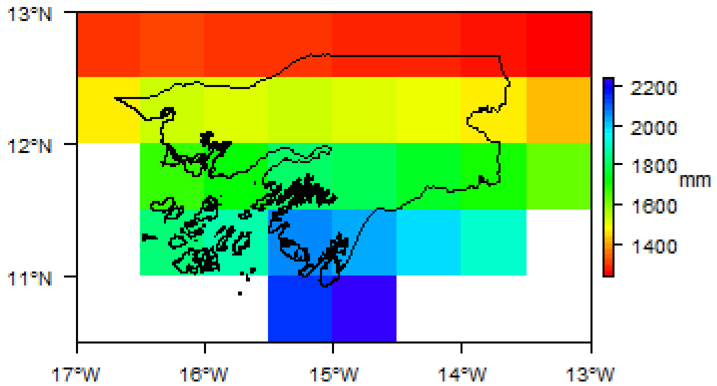
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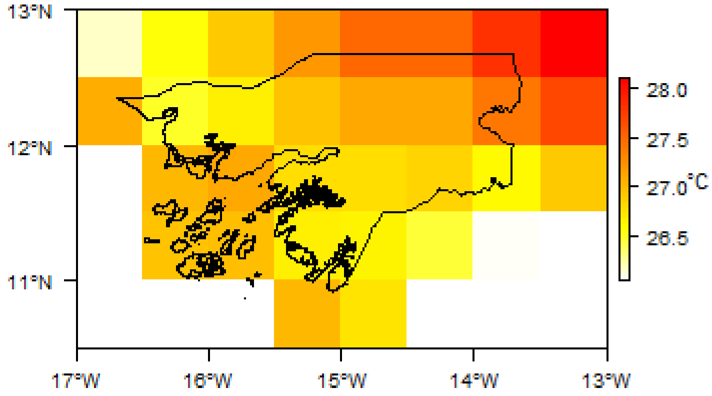
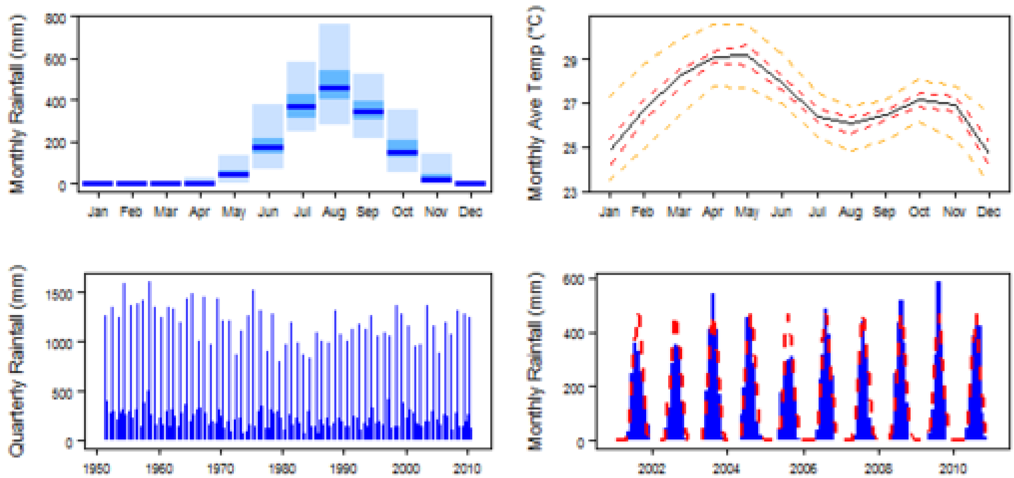


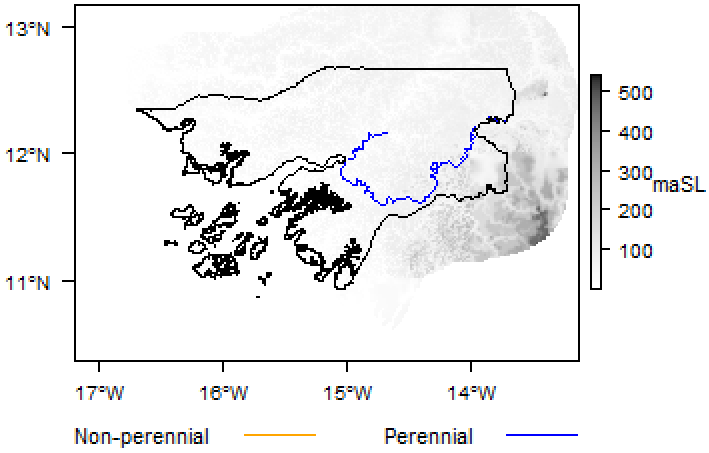


More information on average rainfall and temperature for each of the climate zones in Guinea Bissau can be seen at the Guinea Bissau climate page.

These maps and graphs were developed from the CRU TS 3.21 dataset produced by the Climatic Research Unit at the University of East Anglia, UK. For more information see the climate resource page.

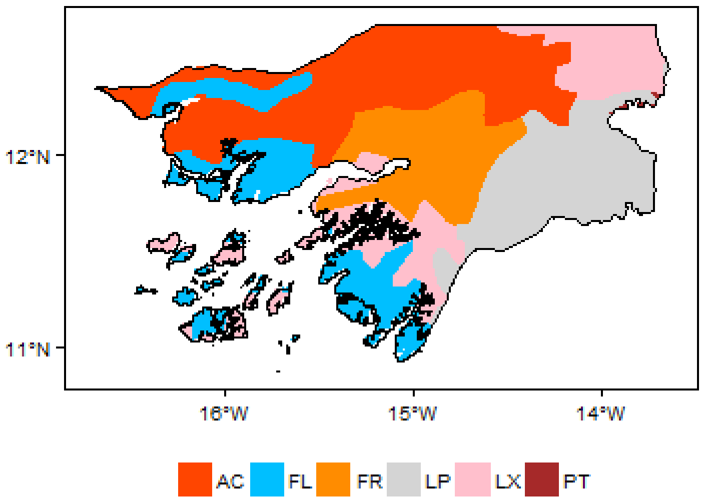
Surface water

The larger rivers in Guinea Bissau include the Corubal and the Geba rivers, which rise in neighbouring Senegal or Guinea. Smaller coastal rivers include the Cacheu, Mansoa, Geba-Corubal, Grande de Buba, Tombali, Cumbidja and Cacine rivers.



Major surface water features of Guinea Bissau. Map developed from World Wildlife Fund HydroSHEDS; Digital Chart of the World drainage; and FAO Inland Water Bodies. For more information on the map development and datasets see the [surface water resource page]

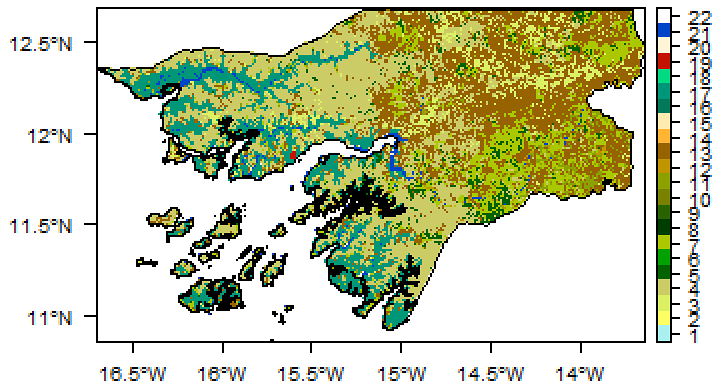
Soil



Soil Map of Guinea Bissau, from the European Commission Joint Research Centre: European Soil Portal. For more information on the map see the [soil resource page]

Land cover

Much of Guinea Bissau was originally dominated by wooded savannah and forest, but there has been widespread clearance of forest and woodland in recent decades, for local or exportable timber use or for cultivation.



Land Cover Map of Guinea Bissau, from the European Space Agency GlobCover 2.3, 2009. For map key and more information on the datasets used to develop the map see the land cover resource page

Water statistics

	1996	2000	2005	2012	2014	2015
Rural population with access to safe drinking water (%)						60.3
Urban population with access to safe drinking water (%)						98.8
Population affected by water related disease	No data	No data	No data	No data	No data	No data
Total internal renewable water resources (cubic metres/inhabitant/year)					8,677	
Total exploitable water resources (Million cubic metres/year)	No data	No data	No data	No data	No data	No data
Freshwater withdrawal as % of total renewable water resources		0.5573				
Total renewable groundwater (Million cubic metres/year)					14,000	
Exploitable: Regular renewable groundwater (Million cubic metres/year)				350		
Groundwater produced internally (Million cubic metres/year)					14,000	
Fresh groundwater withdrawal (primary and secondary) (Million cubic metres/year)		31				
Groundwater: entering the country (total) (Million cubic metres/year)	No data	No data	No data	No data	No data	No data

Groundwater: leaving the country to other countries (total) (Million cubic metres/year)	No data	No data	No data	No data	No data	No data
Industrial water withdrawal (all water sources) (Million cubic metres/year)			11.9			
Municipal water withdrawal (all water sources) (Million cubic metres/year)			34.1			
Agricultural water withdrawal (all water sources) (Million cubic metres/year)		144				
Irrigation water withdrawal (all water sources) [1] (Million cubic metres/year)	No data	No data	No data	No data	No data	No data
Irrigation water requirement (all water sources) [1] (Million cubic metres/year)	26.3					
Area of permanent crops (ha)					250,000	
Cultivated land (arable and permanent crops) (ha)					550,000	
Total area of country cultivated (%)					15.22	
Area equipped for irrigation by groundwater (ha)	530					
Area equipped for irrigation by mixed surface water and groundwater (ha)	7,371					

These statistics are sourced from FAO Aquastat. They are the most recent available information in the Aquastat database. More information on the derivation and interpretation of these statistics can be seen on the FAO Aquastat website.

Further water and related statistics can be accessed at the Aquastat Main Database.

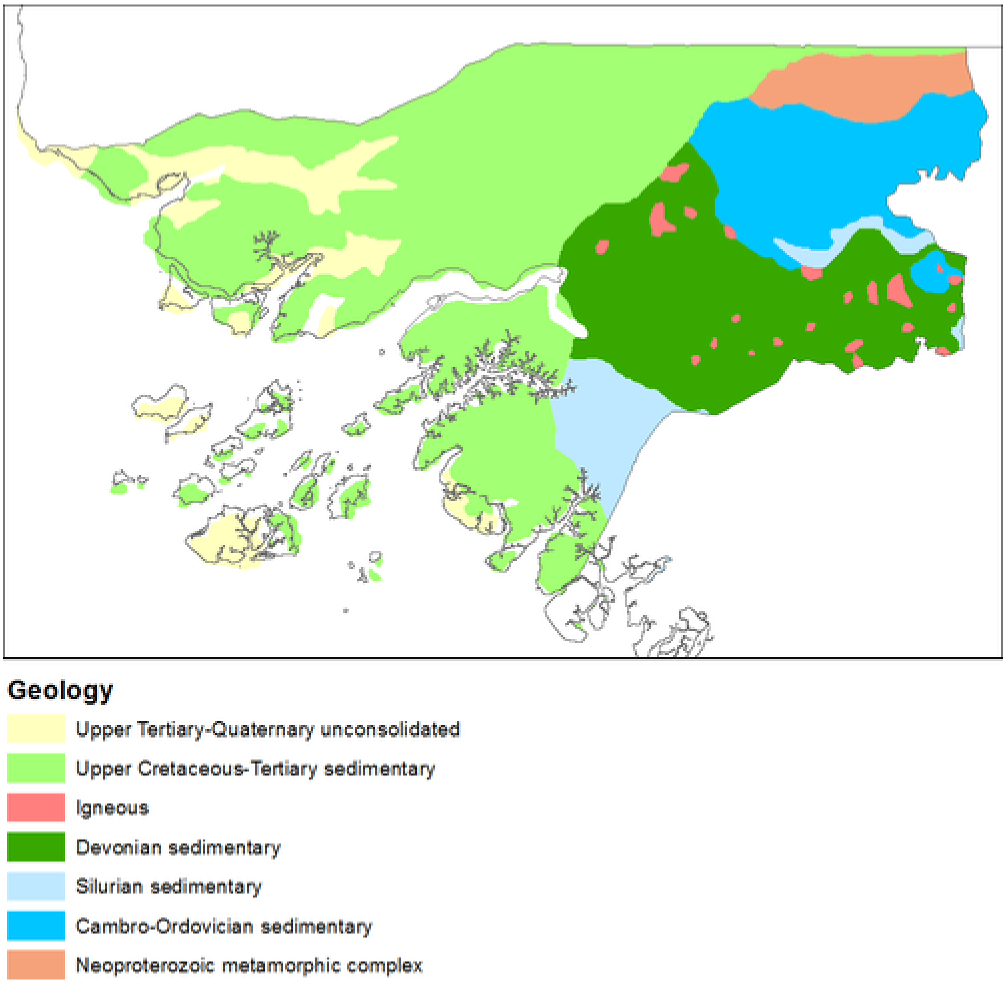
[1] More information on irrigation water use and requirement statistics

Geology

The geology map below shows a simplified version of the geology of Guinea Bissau at 1:5 million scale (see the Geology resources page for more details).

A more detailed geology map of Guinea Bissau is available to view and interrogate online at the **Visualizador de Mapas geoPortal** (published 2014). This map was created by the Uidade de Informacao Geocientifica of the Portugese National Laboratory of Energy and Geology (LNEG).

This report provides more information on the Geology of Guinea Bissau: **Geologia da Guiné-Bissau** (Alves 2010).



Geology of Guinea Bissau at 1:5 million scale. Based on map described by Persits et al. 2002/Furon and Lombard 1964. For more information on the map development and datasets see the geology resource page.

Summary

Guinea-Bissau lies between the Fouta Djallon massif, of uncertain Palaeozoic age, and the Mesozoic-Cenozoic Senegal basin (UN 1988). It can be roughly divided into two geological units:

- an eastern zone with predominantly clastic sedimentary Paleozoic rocks, and some Precambrian rocks; and
- a western zone with mainly Cenozoic sediments of Cretaceous to Tertiary age, mainly of marine origin (University of Guelph).

There is Quaternary alluvium infill in many valleys, and marine/coastal Quaternary unconsolidated sediments on coastal plains.

A buried sequence of Mesozoic sedimentary rocks is thought to rest on the Palaeozoic sequence, the equivalent of the 'intercalated continental' series known in Senegal. These do not crop out at the surface in Guinea Bissau, and so are not shown on the geology map. Little is known of these rocks in Guinea Bissau, as they are buried at depths of over 800 m (UN 1988). They are thought to include schists with some sandstone and limestone intercalations in the northeast, and a dominantly continental series of schists with intercalations of fine sandstone in the centre of the country. This series is 120 m thick at Safim and 330 m thick at S. Domingos (UN 1988).

Geological Environments

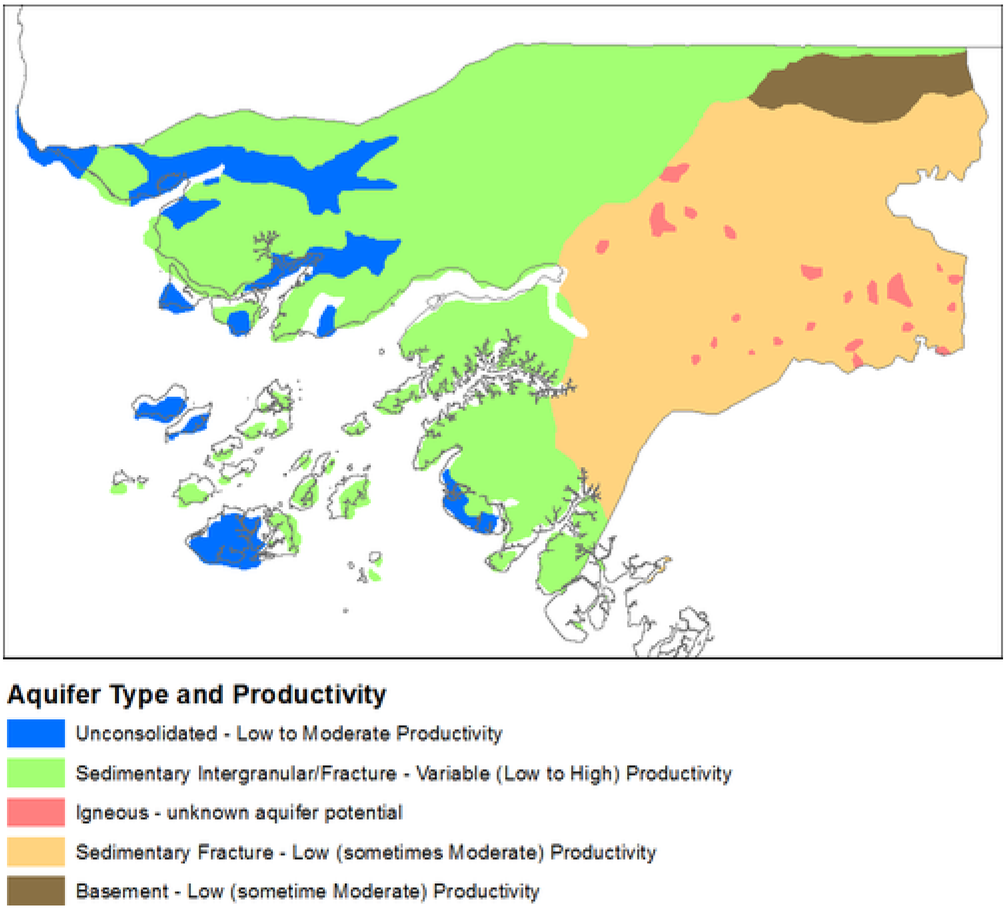
Period	Lithology
	Quaternary unconsolidated
Quaternary	Coastal sediments, including beach sands; river and coastal alluvium. Including sands, silts, and clays. These often overlie similar lagoonal-coastal Oligocene-Miocene sediments (see below).
	Tertiary to Upper Cretaceous sedimentary
Tertiary (Palaeocene-Eocene, Oligocene, Miocene); Cretaceous (Maastrichtian)	A sequence of largely marine, coastal or lagoonal sedimentary rocks, including limestones, marls, clays, silts, sands and phosphates. Most are of Tertiary age. A strip of Cretaceous rocks of Maastrichtian age lie along the eastern boundary of this western zone. The Palaeocene-Eocene sequence is dominantly marine, formed of sandy marl-limestone formations with dolomitic intercalations (UN 1988). The Oligocene-Miocene 'continental terminal' series comprises Oligocene lagoonal fine grained, clayey sandstones at the base, overlain by Miocene marine limestone-marls that are sometimes sandy (UN 1988). The Cretaceous series is very thick (1360 m at S. Domingos and 600 m at Safim). The base of the sequence consists of schists with some limestone-dolomitic intercalations, overlain by dark shales with some sand, and terminating at the top in a thick sandstone layer of Maastrichtian (top Cretaceous) age (UN 1988). This top sandstone is up to 490 m thick in the northwest (S. Domingos) and 540 m in the west (Cangongue) (UN 1988).
	Igneous
	Little is known of the igneous rocks in Guinea-Bissau.
	Palaeozoic sedimentary
Devonian	Shales and sandstones over a large area in the east of the country, forming a northwest/southeast syncline. At the base of the series are Lower Devonian sandstones, seend in the Cusselinta-Saltinho area. These are mostly well-consolidated micaceous and feldspathic sandstones. Overlying this is the Middle to Upper Devonian Bafata Group, comprising argillaceous schists with intercalactions of fine grained quartz sandstone.
Silurian	The Buba Group: mostly sandstones with some organic rich/carbonaceous black shales. Drilling in the southeast of the country showed very compact black, carbonaceous schists with fine grained sandstone intercalations, and some doloritic layers. In the northeast, schists interbedded with dolerite were seen, with varying indications of metamorphism, and fine grained, clay-rich sandstones at the top at the transition to the overlying Devonian rocks.

Ordovician and Cambrian	Sandstones, shales, conglomerates and rare limestones. These are found in the northeast of the country, overlying older Neoproterozoic metamorphic rocks. The Ordovician rocks distinguished on the geology map are dominated by the Canjufa-Canjadude series of quartz-arenites. The other dominant Ordovician series is the Gabu sandstone series, thought to be mostly steeply dipping at up to 50 degrees. At its base is a white, coarse grained sandstone unit up to 170 m thick, overlain by less compact, sandier strata of considerable thickness, and then by a fine grained sandstone unit that is 10-30 m thick (UN 1988). Cambrian rocks are dominated by fine grained sandstones and shales, including shales of Pirada and Canquelifa, schist-sandstones of Cantari, and the younger Caium sandstones of Upper Cambrian age.
Precambrian (Neoproterozoic) metamorphic complex	
Neoproterozoic	A volcanic and metasedimentary complex, including schists, quartzites and metavolcanic rocks. There are few outcrops - these mostly in the far north-east - as they generally lie below fairly thick younger geological formations.

Hydrogeology

The hydrogeology map below shows a simplified version of the type and productivity of the main aquifers at a national scale (see the hydrogeology map resource page for more details).

More information on the hydrogeology of Guinea Bissau is in the report United Nations (1988) (see References section, below).



Hydrogeology of Guinea Bissau at 1:5 million scale. For more information on how the map was developed see the hydrogeology map resource page

Summary

There is relatively little information on hydrogeology and groundwater potential of the aquifers in Guinea Bissau. The UN report of 1988 describes information from some groundwater reconnaissance projects before 1988.

In the eastern part of the country, the Basement and Palaeozoic Sedimentary (Fracture flow) rocks typically have low permeability and form small and discontinuous aquifers, which are controlled by the distribution, nature and degree of fracturing and weathering. Boreholes must be sited and drilled with great care to locate them in the most productive zones.

In the west of the country, the Cretaceous-Tertiary-Quaternary sequence forms more continuous aquifers. The three main aquifers are:

- Maastrichtian sands
- Palaocene-Eocene (limestone)-Oligocene (sand), and
- Quaternary sand and laterite.

In general, although rainfall is high, evapotranspiration is also high, which may limit the amount of recharge available to aquifers, particularly in the eastern zone. Runoff recharge to the Mesozoic aquifers from adjacent higher ground of the Palaeozoic zones is thought to be significant (UN 1988), although much of the groundwater abstracted from the deeper Mesozoic aquifers may be of fossil origin (UN 1988).

Unconsolidated

Aquifer	Aquifer Productivity	Description
Quaternary to Tertiary	Low to Moderate Productivity	Mostly coastal/marine sands, with small banks of Tertiary (Miocene) limestone. Laterite is found over most of the central and western regions. These aquifers are usually unconfined and provide low storage and low borehole yields, although yields can vary from place to place and from season to season (UN 1988). Thicker and coarser grained sediments may form locally higher productivity aquifers. Groundwater is subject to pollution and is often highly mineralised.

Sedimentary - Mixed Intergranular and Fracture flow

Aquifer	Aquifer Productivity	Description

Tertiary (Palaeocene-Eocene-Oligocene)	Low to High (Variable) Productivity	These marine sands, sandstones, and limestones form an important aquifer, which is buried below ~175-200 m, depending on the area. There are no major low permeability beds in the sequence, and so the whole unit behaves as a single aquifer, which is confirmed by groundwater levels (piezometry) and groundwater chemistry. The sands and sandstones are likely to be dominated by intergranular flow, and the limestones by fracture flow. The aquifer has been explored by a number of deep boreholes for groundwater reconnaissance and exploitation (UN 1988). The upper surface of the aquifer was proved at depths of ~180 m at S. Domingos and Cagongue, where it is between 275 m and 315 m thick. The aquifer is typically confined, with deeper piezometric levels than the underlying Maastrichtian aquifer, indicating that there is no hydraulic connection between the two. However, there are different water levels in the sand-sandstone and the limestone formations. The aquifer typically has low to moderate yields. Only the uppermost sand-sandstone Oligocene formations, if they are thick enough, have relatively uniform permeability and provide high storage capacity and yields. The lower limestone series have more variable permeability, both vertically and laterally. However, the very wide lateral extent of the aquifer gives it high potential overall. The highest mineral content (1000 ppm) is seen in the northwest coastal zone. Sulphate concentrations and hardness are higher than in the Maastrichtian aquifer (UN 1988).

Cretaceous		Low to High (Variable) Productivity	The main Cretaceous aquifer is the thick sandstone bed of Maastrichtian age, at the top of the Cretaceous sequence, which is an aquifer of major importance in Guinea Bissau. It has been explored and exploited most intensively and at shallowest depths close to its outcrop zone in central and southern regions, and by a number of deeper boreholes 200-260 m deep on the island of Bissau and at Farim (UN 1988). The aquifer productivity declines in the direction of the Silurian rocks, because they become shallower and change from poorly consolidated sand to a more compact, well consolidated sandstone that has lower permeability (UN 1988). Test pumping indicated the following aquifer properties: • Permeability of 0.1 m/d in clay-rich sandstones in the extreme south of the aquifer, with low specific yields of 0.2 to 0.3 l/sec/m. • Permeability of 10 m/d in fine to coarse grained sands in the centre-south of the aquifer (Buba-Empada-Catio). • Permeability of 1 m/d to the north of this area, where there are layers of clay and fine sand in the aquifer sequence. Very high yields have been recorded of 15-25 l/s, and rarely up to 40 l/s (UN 1988). The aquifer is largely confined, except at rare points where it crops out. Artesian heads occur across much of the centre and west of the country, but not in the southern part of the coastal zone. Artesian heads at Farim and Mansoa were measured at +6m and +7m. Close to the sea and estuaries, groundwater heads are affected by tides. The main direction of groundwater flow appears to be towards the northwest and west (UN 1988). The groundwater is mainly of bicarbonate and calcium sulphate type, with relatively low sulphate and relatively soft. In the centre of the country it tends to have a low mineral content (<500 ppm) but up to 1500 ppm in the south (Bolama) (UN 1988). Occasional instances of saline intrusion were identified, such as as Bedanda (4000 ppm of chlorides) (UN 1988).

Igneous

Aquifer	Aquifer Productivity	Description

Mesozoic Igneous Intrusive rocks	Unknown	Very little is known of the aquifer characteristics of these rocks. They are likely to be crystalline with very low intergranular porosity and permeability, so that groundwater potential will depend largely on the degree and type of weathering and/or fracturing in the rocks. Groundwater is likely to be present mainly in the uppermost few tens of metres. Overall aquifer productivity is likely to be low.

Sedimentary - Fracture flow (Palaeozoic aquifers)

Aquifer	Aquifer Productivity	Description
Devonian	Low Productivity	Drilling into these rocks at shallow depths to about 20 m in the Nhabijocs plain (Bombadinca) showed them to be well consolidated with low permeability and to form a poor aquifer.
Silurian	Low Productivity	The Buba Group has been explored by drilling water boreholes in a number of places at Buba, Guilege, Gadamael and Sangonha in the northeast and southeast of the country. The dominantly fine grained, sometimes clay-rich sandstones, black carbonaceous shales and intercalations of dolerite, sometimes metamorphosed, all have low permeability and formed very poor aquifers.
Cambro-Ordovician	Generally Low, occasionally Moderate Productivity	The Cambrian rocks, dominated by fine grained, well consolidated sandstones and shales, generally form very poor aquifers. Small local aquifers can be found in shallow weathered zones, and particularly in sandstones, which typically have slightly higher permeability. Little is known of the groundwater potential of the Ordovician sandstones, although drilling in the Canjadude region showed the sandstone to be compacted, with low permeability, and unproductive.

Basement

Aquifer	Aquifer Productivity	Description
Precambrian (Neoproterozoic)	Low to Moderate Productivity	Crystalline basement rocks have virtually no intergranular porosity and permeability, and groundwater flow and storage is entirely dependent on the nature and degree of weathering and/or fracturing of the rock. A typical pattern in basement rocks is 'pockets' of weathering forming weathered basins, typically a few tens of metres deep and a few tens or hundreds metres across, in which there is enhanced permeability and groundwater storage potential. Typically, these kind of weathered basins have enough permeability and groundwater storage capacity to supply a borehole hand pump supply.

Groundwater use and management

Groundwater use

Groundwater is the main source of rural water supply for drinking water in the dry season. Traditional groundwater abstraction supplies are largely from hand dug wells, water holes in low lying areas (called bolanhas), and artesian springs. Newer abstractions include improved dug wells, often equipped with a rope and bucket system; improved dug and drilled wells equipped with a handpump; and drilled wells equipped with wind or solar pumps (Visscher and van der Werff 1995). More detail on groundwater use practices, in rural and urban areas, can be found in a report by Visscher and van der Werff (1995).

Groundwater is also used for small scale (garden) irrigation, traditionally via shallow, hand dug wells. Groundwater is not used much for large scale commercial irrigation, although in at least one area - Granja de Pessub - drilled boreholes up to 300 m deep are used for irrigation (Aquastat).

Groundwater management

The Directorate General of Water Resources (Direccion Geral de Recurson Hidricos / DGRH), within the Ministry of Energy, Industry and Natural Resources (MEIRN), is the main responsible body for water supply and sanitation.

Other state agencies with responsibilities for water resources include:

- The Ministry of Public Health, which provides a link between water, hygiene and sanitation
- The Public Enterprise for Electricity and Water Supply (EAGB), which manages water supply utilities of the capital, Bissau.
- The Directorate General of Energy (DGE), which manages water supply in several semi-urban centres.
- the Council Interministerial for Water Resources (CIMA) and the Water Technical Committee, which exist to harmonise water management activities between different sectors and to drive water policies.
- the Ministry of Agriculture, Forestry, Hunting and Livestock, through the Directorate of Rural Engineering Services (DSER), which deals with the development, use and management of water for agricultural use.

At a local level, the operation of water infrastructure is largely managed by the beneficiaries themselves through associations or management committees, in collaboration with the DSER, extension services, NGOs and other relevant authorities.

More information on the history of groundwater management from independence to 1995 can be found in a report by Visscher and van der Werff (1995).

A number of international agencies have provided support for groundwater management in Guinea Bissau. The IRC worked from 1987 to 1995 on a project to support the sustainability of newly installed groundwater points in the south of the country, and the institutional development of of the DGRH (Visscher and van der Werff 1995).

The UNDP carried out projects identifying pressure on groundwater resources and supporting the development of a groundwater database (2009) and a report (2012).

Since 2012, UNICEF has been providing support for updating the national groundwater point/borehole databases (eg Fussi et al. 2018) and specific projects around identifying suitable areas for manual drilling (eg Fussi et al. 2017a and Fussi et al. 2017b).

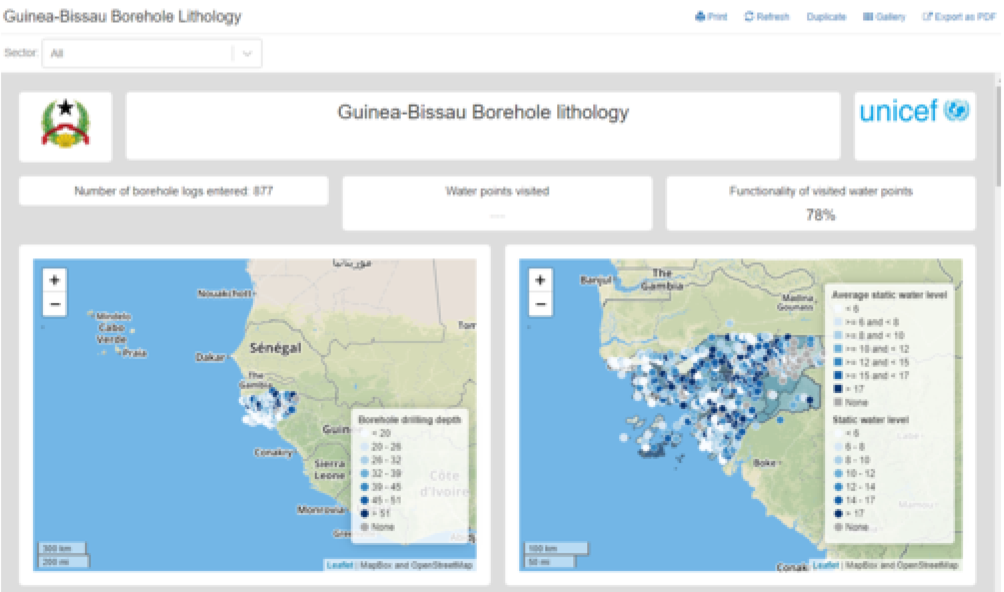
Groundwater legislation

Groundwater legislation falls under the Water Code, 1992. This establishes the general regime for the management, use and conservation of water resources, and determines the institutional framework. It recognises that water is a public good whose development and management must be planned. Use rights are granted by the State, taking into account the productivity of water, the respect of pre-existing rights and the protection of the environment. The State is responsible for the conservation and protection of the water environment both qualitatively and quantitatively. Customary water law is enforced and respected at the local level by rural people.

Groundwater data

A **national database** stores groundwater data, including information on borehole drilling logs, groundwater levels and groundwater chemistry. This database is held by the national water authority, the DGRH. Its development has been supported by UNICEF, including systemising the database design and operation and updating it with new information (eg Fussi et al. 2018). Information from the database, including groundwater levels and quality, can be viewed in an online **MWater portal**.

In 2018, there were 4300 registered boreholes in the database, but some boreholes have more information available than others. For example, only 20% of these had borehole logs available, and those logs that are available are not standardised and not always complete. Work is ongoing to improve the amount and quality of groundwater information in this database, between government agencies, UNICEF, drilling companies and researchers from Milano Bicocca and Padova universities in Italy (eg Fussi et al. 2018).



MWater portal showing outputs from groundwater borehole database for Guinea Bissau.

Transboundary aquifers

Guinea Bissau shares the Senegalo-Mauritanian Basin aquifer (of Upper Cretaceous to Tertiary age) with the Gambia, Mauritania and Senegal. With an area of approximately 350,000 km^2, this aquifer basin is the largest in the Atlantic margin of North-West Africa. More information on this aquifer can be found in the report Travi et al. (2017) (and see also this presentation: IAEA (2019). In early 2019, the four countries involved held initial discussions to exchange knowledge and towards collaboration on management of this transboundary groundwater resource.

For further general information about transboundary aquifers, please see the Transboundary aquifers resources page.

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References with more information on the geology and hydrogeology of Guinea Bissau can be accessed through the Africa Groundwater Literature Archive.

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