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Mangrove Habitats in São Tomé and Príncipe (Gulf of Guinea, Africa): Conservation and Management Status

27

R. Haroun, A. Herrero Barrencua, and A. D. Abreu

Abstract

São Tomé and Príncipe is a small island state located in the Gulf of Guinea (West Equatorial Africa) with fragile mangrove habitats along its coastlines. These habitats are threatened by historical conversion to land for agriculture uses, overharvesting for firewood and charcoal, changing hydrology and coastal erosion; the last impacts increasing their vulnerability to sea-level rise. In the case of São Tomé mangroves, road construction (sometimes very close or even crossing through the habitat itself) is considered as a major factor leading to its transformation.

In this contribution, we identified the major botanical and faunal (vertebrate and invertebrates) species encountered in this unique forest ecosystems. We also described some ecosystem services such as food supply and nursery habitat for diverse fish and invertebrates, with a short mention of its carbon sequestration role.

Most of the mangrove hábitats in São Tomé are located inside the Parque Natural Obô of São Tomé, thus, they are under some degree of protection. In the case of Príncipe Island, there are three main remnants of mangrove forests: Praia Salgada, Praia Caixão and Praia Grande, all of them outside the Parque Natural Obô of Principe.

The potential development of ecotourism activities (such as birdwatching, trails, etc.) similar to those already in place at Malanza mangrove (São Tomé) and the restoration of the remnants of mangrove habitats combined with capacity building actions could support community development and job opportunities, especially for women and young people, with high relevance at local level.

27.1 Introduction

The Democratic Republic of São Tomé and Príncipe, one of the youngest and smallest countries in Africa, is made up of two main islands and several islets located in the Gulf of Guinea about 440 km to the south and 225 km to the west, respectively, of the coasts of Nigeria and Gabon, very near to the equatorial line.

In the recent worldwide review of mangrove forests by Spalding et al. (2010) these habitats were cited only for a number of estuaries in the bigger island of São Tomé, whereas in Príncipe island their presence was not confirmed, probably as the major regional environmental information sources, such as Corcoran et al. (2007) and FAO (2007) did not have distributional data on these keystone ecosystem from this equatorial insular country.

Mangroves are essential ecosystems, providing multiple ecological services including fisheries, shoreline stabilization, nutrient and sediment trapping and high biodiversity. For example, mangroves in Western Central Africa are among the most carbon-rich ecosystems in the world, with estimates that 1299 tonnes of carbon dioxide storaged in pristine mangrove habitats (Ajonina et al. 2014). Although mangroves forests are internationally recognized for their importance to the well-being of human populations (FAO 2007; Spalding et al. 2010; UNEP 2016a), there is scarcely any information on these ecosystems for São Tomé and Príncipe State. In recent years, the economic development of São Tomé and Príncipe is highly dependent on blue economy sectors, and this represents both challenges and great potential for biodiversity conservation issues (UNEP 2016b).

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This chapter provides updated information about environmental, conservation and management issues related to mangrove habitats present along the coasts of São Tomé and Príncipe islands. We described the botanical and faunal composition of this unique forest ecosystem, which hosts many species coming from both the marine and the terrestrial realms. Then, its current distributional pattern along the shorelines of both islands are shown. After that, the historical and current uses are presented. Subsequently, we characterized the major threats affecting the remnants of these unique habitats in the islands. Finally, the current management issues are presented together with the most relevant conservation initiatives to promote the sustainable use of diverse ecosystem services provided by these transitional habitats.

27.1.1 Geographical Features

São Tomé and Príncipe islands are aligned in a volcanic island chain in the Gulf of Guinea (Equatorial Atlantic), surrounded by deep-sea trenches and host one of the world's biodiversity hotspots (Fig. 27.1), with several terrestrial endemisms (Gillespie and Clague 2009), whereas its marine biota start to be investigated. Both islands are within the wet tropical belt, with annual rainfall ranges from 1000 to over 4000 mm with a raining season running from October to May; average annual temperatures range from 18–21 °C minimums to 30–35 °C maximums. In general, the islands are very steep, covered with lush tropical forests and with lowlands along the coastlines as the only flat areas.

Mangroves forest thrive in saline coastal sediments in the Western Central Africa (UNEP 2016a). They may occur in intertidal zones of sheltered or low exposed coasts, gulfs and inlets, coastal lagoons, marshes and estuaries or river mouths, covered with soft bottoms (of sands, silts or clays, never rocky). Mangroves habitats are found only along the coasts of the islands of São Tomé and Príncipe, not in the islets, in estuarine and scattered sheltered areas.

27.2 Biological Characteristics

The current knowledge about the main biological characteristics of the mangroves habitats encountered in this insular country will be described in the following sections,

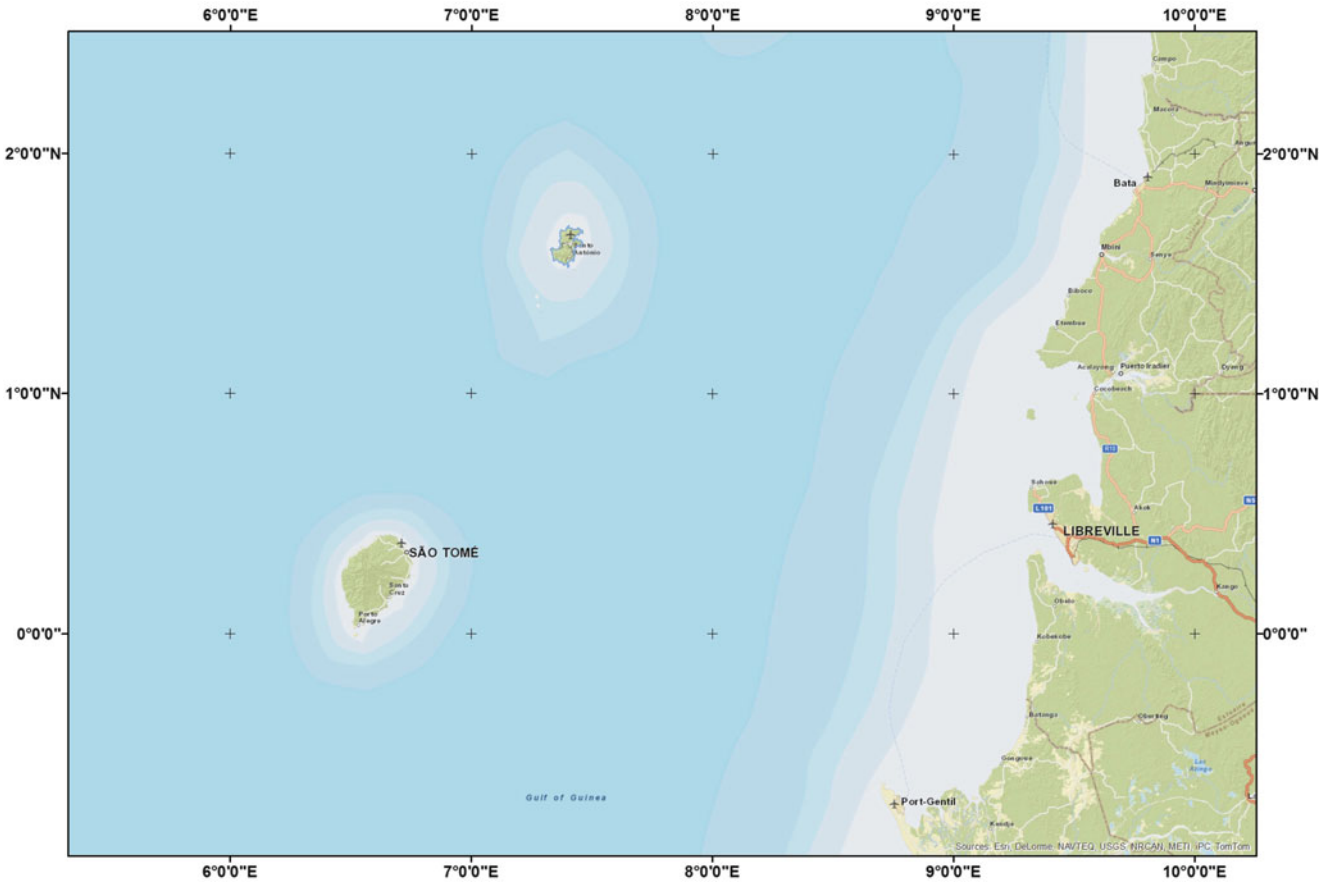

Fig. 27.1 Location of São Tome and Príncipe Islands in the Gulf of Guinea, Equatorial Africa (Modified from ESRI, 9 June 2017)

covering both the botanical and faunal aspects. Part of these descriptions comes from specialized works done, for example with birds or marine turtles, whereas other scientific data were gathered by a concerted effort of the co-authors partially supported by the UNESCO Reserve of Biosphere of Principe Island. It is important to mention that an exhaustive account of the biodiversity associated to mangroves are not yet available and many taxonomic groups are still unknown to the science.

27.2.1 Flora

27.2.1.1 Species Composition

In Table 27.1 is included the catalogue of botanical species encountered in the mangrove habitats, both in São Tomé and Príncipe islands. Inside that table are included several useful plants, such crop, fruit or timber species originated from historical human interventions in those mangrove areas.

The most characteristic botanical species of the mangroves hábitats in São Tomé and Príncipe are the following ones:

- Red Mangrove: *Rhizhopora harrisonii Leechman/R. racemosa* G. Mey/*R. mangle* Linnaeus. Aside from its characteristic arched prop reddish aerial roots and shinning spatulate leaves, the species of red mangrove trees have tiny yellow flowers. The main taxonomic differences among the reported species in the area are related to some morphological characters in the flowers. After fertilization, red mangroves develops distinguished pencil-shaped long fruits, which turns into propagules (= embryonic root structures). When ripe, the young seedlings detach from the parent tree and float until reaching a suitable substratum to root.
- Black Mangrove: *Avicennia germinans* (L.) Linnaeus. This species is widespread in coastal and estuarine areas of the tropics and subtropics to about 28° in both the northern and southern hemispheres. The tree is characterized by long horizontal roots and root-like projections known as pneumatophores, protruding from the soil and providing oxygen to the underground and underwater root systems (Figs. 27.2 and 27.3).
- Golden Leather Fern: *Acrostichum aureum*. This species is a large understory fern that occurs worldwide in mangrove forests and other wetlands.

Table 27.1 Catalogue of major botanical species observed in São Tomé and Príncipe mangroves

Common local name	Common English name	Scientific name
Amoreira	Iroko	*Milicia excelsa*
Bambú	Bamboo	*Bambusa vulgaris*
Bananeira	Banana	*Musa* sp.
Bolinha	–	*Xylopia staudtii*
Cacaouero	Cocoa tree	*Theobroma cacao*
Café	Coffee	*Coffea* spp.
Cajamangueira	Golden apple	*Spondias cytherea,*
Candeia	–	*Hernandia beninensis*
Carozeiro	Indian almond tree	*Terminalia catappa*
Colma	–	*Milettia thonningii*
Coqueiro	Coconut palm	*Cocos nucifera*
Eritrineira	Coral tree	*Erytrina poeppigiana*
Figueira	Common fig	*Ficus carica*
Fruteira	Breadfruit	*Artocarpus altilis*
Gofe	Trumpet tree	*Cecropia peltata*
Goiabeira	Common guava	*Psidium guajava*
Guêguê	Yellow mombin tree	*Spondias mombin*
Grigô	Brimstone tree	*Morinda lucida*
Isaquinteiro	African breadfruit	*Treculia africana*
Jaqueira	Jackfruit	*Artocarpus heterophyllus*
Lemba-lemba	–	*Turraea thonningii*
Lima	Lime	*Citrus* spp.
Mamoeiro	Papaya	*Carica papaya*
Mangue	Red mangrove	*Rhizophora racemosa/R. hardisonii/R. mangle*
Mangue	Black mangrove	*Avicennia germinans*
Mangueira	Mangoo tree	*Mangifera indica*
Marapinhao	Satinwood	*Fagara macrophylla*
Moandí	African oil bean	*Pentaclethra macrophylla*
Mucumbli	–	*Lannea welwitschii*
Oká pequeño	Kapok	*Ceiba pentandra*
Palmeira	African oil palm	*Elaeis guineensis*
Pau-caixão	African nutmeg	*Pycnanthus angolensis*
Pau-esteira	Endemic screwpine	*Pandanus thomensis*
Pau-ferro	Pheasant-berry tree	*Margaritaria discoidea*
Pau-leite	False rubber tree	*Funtumia africana*
Pau-lisha	Sandpaper fig	*Ficus exasperata*
Safu d'Óbô	African grape	*Pseudospondias microcarpa*
Sap-sap	Soursop	*Annona muricata*
–	Golden leather fern	*Acrostichum aureum*

The White Mangrove: *Laguncularia racemosa* (L.) Gaertn., which is reported in West Africa from Senegal to Angola, appears cited in some national reports, but its presence needs to be confirmed in the mangrove habitats of these islands. The same situation applies to the Buttonwood Mangrove (*Conocarpus erectus* L.) that is a tree or shruh, somehow similar to the White mangrove, but with dense flower heads that grow in branched clusters, forming cone-like fruit. A potential explanation of their absence in the nature is either both species have never been found in these

Fig. 27.2 Black Mangrove (*Avicennia germinans*) and Red Mangrove (*Rhizophora*) trees at the water edge in Malanza mangrove

Fig. 27.3 Flowers of Red Mangrove (*Rhizophora*) and Black Mangrove (*Avicennia germinans*) trees

islands or historically they have been extirpated from the corresponding mangrove forest during the agro-transformation process of the mangrove habitat.

27.2.1.2 Reproductive Anual Cycle

Preliminary observations on the reproductive stages of mangroves trees, allow us to define a broad reproductive anual cycle inside the mangrove forest, at least for the Red Mangrove species and Black Mangrove tree (Fig. 27.3). The buds of the flowers start to develop from late September and October, whereas the fruits are seen in late November, becoming ripe in February–March, almost at the end of the raining season. The propagules detaches from the parent trees mainly in April and may act as long-range and short-range

dispersion mechanism for the species. In the case of the *Avicennia germinans* tree, the flowers are mainly observed between March and May, a bit latter than the previous species, while the fruits could be found during a longer period.

27.2.2 Fauna

27.2.2.1 Marine Invertebrates

In Table 27.2 are listed a preliminary number of marine mollusks and crustaceans species that could be found in the soft bottoms as well as in the arched roots of red mangroves trees. These species were mainly identified between September–November 2016 in Principe Island (Fig. 27.4).

Table 27.2 List of invertebrates observed in the mangrove habitats of Príncipe

Taxa	Family	Species	Local common name
Mollusca	Archatinidae	*Archachatina marginata*	Buzio de terra
	Neritidae	*Clypeolum owenianum* (*W. Wood, 1828*)	–
		Gastropoda sp.	–
	Hipponicidae	*Hipponix antiquatus* (L.1767)	–
	Mactridae	*Leptospisula nívea* (Gmelin, 1791)	–
	Littorininae	*Littorina* sp.	–
	Muricidae	*Tympanotonus fuscatus* (Linnaeus, 1758)	–
	Ostreidae	*Saccostrea cucullata* (Born, 1778)	Ostra
	Arcidae	*Senilia senilis* (Linnaeus, 1758)	–
	Solecurtidae	*Tagelus adansonii* (Bosc, 1801)	Almexa
Crustacea	Ocypodidae	*Afruca tangeri* (Eydoux, 1835)	Caranguejo violinista
	Portunidae	*Callinectes* sp.	Caranguejo tartaruga
		Crab sp. 1	–
		Crab sp. 2	–
	Gecarcinidae	*Cardisoma armatum* Herklots, 1851	Caranguejo de mangle
	Coenobitidae	*Coenobita rubescens* Greeff, 1884	Eremita terrestre
	Grapsidae	*Goniopsis pelii* (Herklots, 1851)	Caranguejo negro
	Grapsidae	*Grapsus adscensionis* (Osbeck, 1765)	Caranguejo de roca
	Gecarcinidae	*Johngarthia weileri* (Sendler, 1912)	Cracke
	Ocypodidae	*Ocypode cursor* (Linnaeus, 1758)	Caranguejo fantasma
	Palaemonidae	*Palaemon concinnus* Dana 1852	Camaron de mangle

Few records, such the blue crab *Callinectis* or the arch shell *Senilia senilis*, have been reported by other authors for Malanza mangrove in São Tomé (Pisoni et al. 2015). Besides, in one ocasion a large crustacean specimen resembling *Atya gabonensis*, commonly known as Giant African Fan Shrimp, was collected in Praia Grande mangrove, but this record still needs some extra sampling and more research to confirm its taxonomic identification (Cumberlidge 1999; Rossignon 1999).

This list represents the first account of marine invertebrates species for mangrove habitats in São Tomé and Príncipe, although some mollusks and crustacean specimens as well as other marine invertebrates taxonomic groups were not yet fully identified.

27.2.2.2 Fishes

In the Table 27.3 is presented the 22 fish species reported for the mangrove habitats of São Tomé and Príncipe. Species were taxonomically ranked according to Nelson (2006) and fish identification was performed using the relevant fish guides and available checklists (Afonso et al. 1999; Lévêque et al. 1990; Quéro et al. 1990; Schneider 1990; Stiassny et al. 2007; Wirtz et al. 2007; Vasco-Rodriguez et al. 2016). This catalogue of extant species have been compiled by two different approaches: review of the pubished data for this geographical area as well as the samples obtained during recent fisheries surveys done in the mangrove hábitats of Príncipe island (September–December 2016), using diverse fishing gears. One of the common species is the mudskipper (Fig. 27.5) that could be found easily moving outside the water in soft bottoms at the mangrove edges.

In a recent survey of fish population of mangroves in São Tomé, Félix and collaborators (2016) finds out that the highest number of both juveniles and adults (inshore and residents) was observed at Malanza, the largest mangrove forest in both islands and presenting the highest hábitat heterogeneity. These authors concluded that the species richness found in São Tomé mangroves, particularly in Malanza, is similar to that of other insular mangroves of equivalent size or of continental mangroves in the Gulf of Guinea. Félix and collaborators (2016) also mentioned the presence of introduced Nile Tilapia specimens in the Malanza mangrove (*Oreochromis mossambicus*), with some question marks about its potential effects on authoctonous fish species.

27.2.2.3 Birds

The avifauna is another important vertebrate group that can be encountered inside the mangrove habitats (Fig. 27.6). During the surveys done by one of the authors between September and December 2016 in the mangrove habitats of Príncipe island, a total number of 1533 birds were observed, belonging to 26 species, 10 of them endemics (Christy 2001; Birlife International 2017). In the case of São Tome, Pisoni

Fig. 27.4 Bivalve shells of hooded oyster (*Saccostrea cucullata*) and clams (*Tagelus adansonii*) in the soft bottom of Praia Salgada mangrove, Príncipe Island

Table 27.3 List of fish species reported in the mangrove habitats of São Tomé and Príncipe

Family	Species	Local common name
Elopidae	*Elops senegalensis* Regan, 1909	Colepinha balabo
Megalopidae	*Megalops atlanticus* Valenciennes, 1847	Tainha congo
Ophichthidae	*Dalophis cephalopeltis* (Bleeker, 1863)	–
Mugilidae	*Liza grandisquamis* (Valenciennes, 1836)	Tainha tarrafa
	Liza dumerili Steindachner, 1870	Tainha tarrafa
Lutjanidae	*Lutjanus agennes* Bleeker, 1863	Corvina preta
	Lutjanus endecacanthus Bleeker, 1863	Corvina
	Lutjanus goreensis (Valenciennes, 1830)	Corvina vermelha
Gerreidae	*Eucinostomus melanopterus* (Bleeker, 1863)	Parente
Haemulidae	*Plectorhinchus macrolepis* (Boulenger, 1899)	Peixe-porco
	Pomadasys jubelini (Cuvier, 1830)	Roncador
Polynemidae	*Galeoides decadactylus* (Bloch, 1795)	Barbudo
Monodactylidae	*Monodactylus sebae* (Cuvier, 1829)	Cozinheiro
Kyphosidae	*Kyphosus incisor* (Cuvier, 1831)	Sopa
Cichlidae	*Oreochromis mossambicus* (Peters, 1852)	Papé
Eleotridae	*Bostrychus africanus* (Steindachner, 1879)	Xarroco-cherne
Gobiidae	*Awaous lateristriga* (Duméril, 1861)	Xarroco
	Awaous bustamantei (Greeff, 1882)	Xarroco
	Bathygobius burtoni (O'Shaughnessy, 1875)	Xarroco
	Periophthalmus barbarus (L., 1766)	Cocumba
	Porogobius schlegelii (Günther, 1861)	Xarroco-blabo
Poeciliidae	*Aplocheilichthys spilauchen* (Duméril, 1861)	Tose tose

and collaborators (2015) did some bird census in Praia das Conchas counting 239 birds, belonging to 26 species, whereas in the case of Malanza mangrove the number of birds counted raised towards 1942 individuals belonging to 29 species. Moreover, the only species of endangered birds identified during that field work were the São Tomé Green Pigeon (*Treron sanctithomae*) and São Tomé White Eye (*Zosterops feae*), both with vulnerable status and observed only in the Malanza mangrove.

Fig. 27.5 An adult mudskipper *Periophthalmus barbarus* (Linnaeus, 1766), locally know as cocumba (Praia Salgada, Príncipe Island), a conspicuous species in Central Africa mangroves

Fig. 27.6 Common bird species: Water duck (*Phalocrocorax africanus*) and White heron (*Egretta intermedia*) associated with mangrove habitats in São Tomé and Príncipe

27.2.3 Mangrove Habitat Distribution

27.2.3.1 São Tomé

The current distribution of main mangrove habitats along the coastline of São Tomé island are represented in Fig. 27.7. Specially mangroves sites located in the northen and western side of the islands have a more reduced surface coverage compared to historical records (Corcoran et al. 2007; Spalding 2010), probably as these areas were partially transformed into agriculture lands (Pisoni et al. 2015) and affected by coastal road construction.

27.2.3.2 Malanza

The mangrove of Malanza is located in the south (0.8°02′04.6″N, 0.6°83′10.48″E), occupies an area of 0.7 km^2 and the maximm depth is 3.5 m. This site has the most extensive mangrove forest in the all country (Fig. 27.8). Of the total

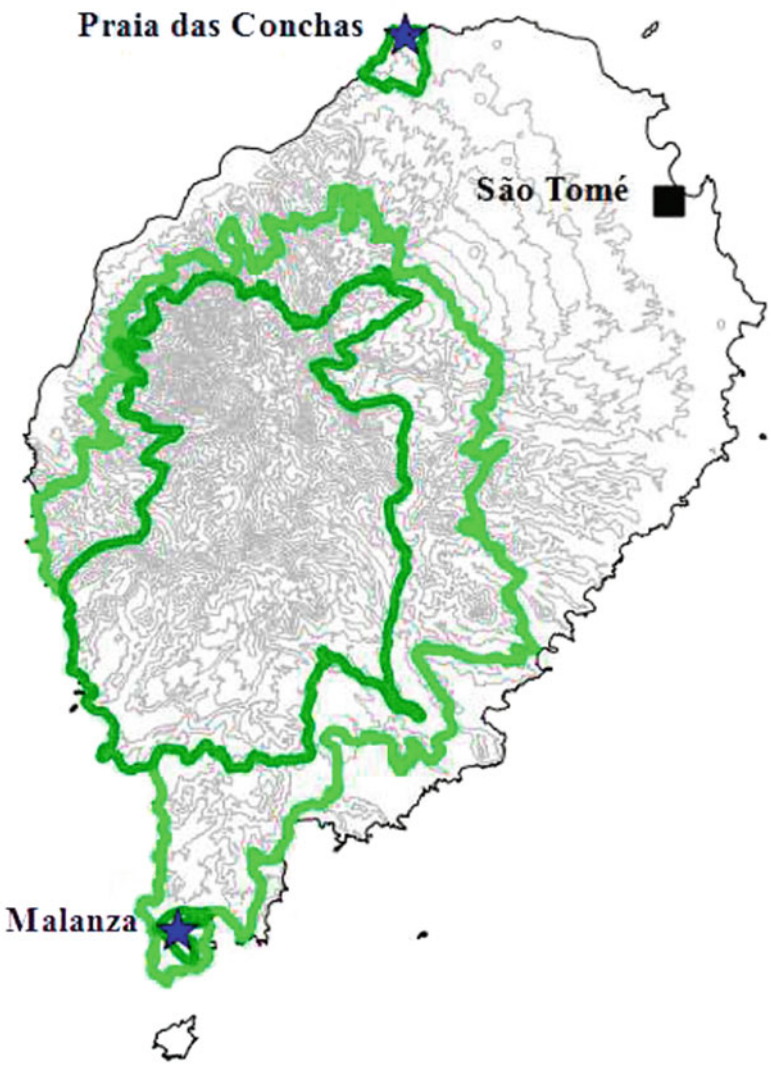

Fig. 27.7 Locations of the two main mangrove hábitats identified in the coast of São Tomé Island: Praia das Conchas in the Northwest and Malanza in the South (Modified from Pisoni et al. 2015)

339 ha of Malanza area is estimated to exist 68.6 ha of mangrove.

27.2.3.3 Praia das Conchas

The mangrove of Praia das Conchas is located in the north of the island (0.8° 24′02.1″N, 0.6°83′70.2″E), covers an area of 0.01 km^2 and is a shallow system (maximum depth 0.5 m). There are about 0.8 ha of mangrove, divided between the beach of the same name (0.5 ha) and Praia Quinze (0.3). Its historical distribution have been reduced as consequence of the construction of the coastal road.

27.2.4 Príncipe

In the case of the island of Principe, the Fig. 27.9 pointed out the three locations of mangrove habitats that can be recognized at present time along its coasts: Praia Caixão, Praia Grande and Praia Salgada. There are not historical records about the former extension of these unique forests (Corcoran 2007; FAO 2007; Spalding et al. 2010), but some local people are familiar with uses and products extracted from them, therefore, it is presumed that these three areas represent the remnants of more extensive mangrove forests.

27.2.4.1 Praia Grande

The mangrove habitat of Praia Grande, in the Northeast side of the island (1°40′01.5″N 7°26′43.1″E), occupies the borderline of a coastal lagoon. The mangrove trees develops fringing the inner side of the lagoon whereas the sandbar that separates the freshwater body from the sea is still holding many specimens of a historical coconut plantation (Fig. 27.10). This location is an important nesting site for marine turtles, with nests of different endangered species.

27.2.4.2 Praia Salgada

This mangrove hábitat is located in the East side of the island (1°37′57.1″N 7°27′14.1″E), inside the Bay of Abades. The mangrove hábitat was mainly transformed in a coconut plantation, which is at present time abandoned (Fig. 27.11).

Fig. 27.8 General view of main water course inside the Malanza mangrove, São Tomé

Nevertheless, the main botanical species encountered in the area is still the Coconut palm (47%), whereas the Red Mangrove is the second most observed species occupying 15% of the area, with the Golden Leather Fern also quite common as understore species. Aside from the coconut palms, there are still several botanical useful species planted in the sandy bottoms occurring in the seafront.

27.2.4.3 Praia Caixão

In this case, the mangrove habitat is located in the estuary of the Caixão river, in the West side of the island (1°37′08.3″N 7°22′09.6″E). This river mouth has a permanent flow of freshwater and its mouth is open directly to the sea. The transition of tree zonation from the mangrove riverine habitat to the secondary tropical forest is very quick and only the Golden Leather Fern is recognized few meters inside the forest from the water edge.

27.3 Uses

At international level, mangrove forests are mainly recognized for their ecological role in coastal protection and nursery habitat for commercially valuable marine species (either fish or shrimps) (Rönnbäck et al. 1999; Blasco et al. 2005; Nagelkerken et al. 2008). They also play important functions in terms of wood and food supply (both fishing and hunting). These habitats have been used as indicators of environmental risk, to avoid or reduce coastal erosion, and as a keystone carbon sink areas (FAO 2007; Spalding et al. 2010; UNEP 2016b).

27.3.1 Tradicional Use

Mangroves provide various traditional products and services to the population of São Tomé and Príncipe; more recently, new and innovative uses of the mangrove are been developed. The large Malanza mangrove, in the South of São Tomé island, has important ecosystem services at the level of food supply (fish, crabs and shrimps) and coastal protection; more recently, its aesthetic value couple with the possibility to encounter some bird species is underpinning the development of ecotourism activities by some local companies (Pisoni et al. 2015). Its role as nursery area for commercial demersal fish species have recently been evaluated (Félix et al. 2016). Other ecological services, such as aquatic bioremediation and pollution regulation as

Fig. 27.9 Locations of the mangrove hábitats identified in the coast of Principe Island. Praia Caixão in the West, Praia Grande in the Northeast and Praia Salgada in the East

well as carbon sequestration are not yet evaluated. In the same island, the main services provided by the mangrove located at Praia das Conchas are the supply of wood, sand and charcoal (energy source) and has potential to improve its ecosystem service delivery in coastal protection and carbon sequestration.

Another traditional product delivered by mangroves, which is still operational in Príncipe's mangroves, is the application of the pigments (tannins) extracted from the leaves as staining product to dye natural fiber fishnets of a purple colour (Fig. 27.12). Nowadays, this activity is becoming more and more rare, due to the import of synthetic coloured fishnets.

27.4 Threats

The islands of São Tomé and Príncipe were uninhabited prior to their discovery in 1470–1471. Since then, they were quickly populated by the Portuguese and subsequent transformation of the authoctonous vegetation and landscapes have been reported mainly in the lowlands and coastal areas. As already pointed out by Corcoran and collaborators (2007), there are indications that much of the coastal mangrove forests were destroyed just before 1990 mainly for agriculture land.

27.4.1 Deforestation

Before the arrival of human beings, both islands were covered by lush tropical forests and along the coastline mangrove habitats were probably more common and widespread in estuarine areas that at present time. Sugar cane was the first agricultural activity and very soon became the dominant crop. Coffee and cocoa were introduced later, in the nineteenth, and extensive shade plantations of these crops were developed until nowadays. In recent decades, deforestation process concentrated in the coastal habitats,

Fig. 27.10 Aerial view of the coastal lagoon, coconut plantation and mangrove habitat at Praía Grande, Príncipe Island

Fig. 27.11 Red mangrove, coconut palms and other plants in Praia Salgada area

Fig. 27.12 Cuttings of Red Mangrove leaves used to stain traditional fishing nets

Fig. 27.13 Mangrove trees and Coconut palms mixed at Praia Salgada mangrove, Príncipe Island

and oil palm and coconut plantations are dominant crops in the lowlands areas.

After the independence from Portugal in 1975, the agricultural activities were reduced and many plantations were abandoned, thus stimulating some forms of regeneration to secondary forests. De Lima et al. (2012, 2014) have analyzed the distributional presence and abundance of endemic birds in primary forests and shade plantations (cocoa and coffee), showing a reduction of endemisms in shade plantations.

Particular areas, such as the lowland forests, have been widely cleared for agriculture (sugar cane, African oil palm and coconuts plantations), sometimes affecting the mangrove forests, such in the case of Praia Salgada and Praia Grande mangrove areas in Príncipe (Fig. 27.13). Coconut plantations and diverse tropical trees, such as Indian almond tree, African breadfruit, Jackfruit, Common guava, Golden apple, African nutmeg, Soursop, etc. together with some medicinal shrubs were cultivated. Nowadays, some of these botanical useful species still remains in the mangrove habitat range, specially in the case of the mangrove habitats in the northern side of São Tomé and in those currently identified in Príncipe Island.

27.4.2 Habitat Transformation

In the case of São Tomé mangroves, road construction (sometimes very close or even crossing through the habitat itself) is considered as a major factor leading to the transformation of the habitat. For example, in Praia das Conchas mangrove the water flow is limited by a road that crosses the downstream area, limiting superficial intrusion of seawater; thus, the development of the road resulted in a slight increase in height in the area's topography and restricted seawater intrusion inside this mangrove mainly during spring tides. For the Malanza mangrove area, that mangrove have a constrained southeastern opening towards the sea associated to the foundations of the Malanza bridge, which halt the tidal influence; therefore, sedimentation inside the mangrove habitat is an increasing threat.

Another factor leading to habitat transformation is the introduction of exotic species. Terrestrial introduced species is probably the chief conservation concern in these tropical islands and may play a critical role in the management of primary vegetated habitats (Brown 1991; Dutton 1994). The islands have the usual mammals introductions associated with human translocations, such as rats, cats, dogs and pigs, whereas civets, weasels, and mona monkeys have been introduced on purpose to São Tomé and more recently, to Príncipe. The negative effects of these introductions may range from endemic bird reproduction disruption to reduction in primary forest seedlings. It it not posible to assess now the damage caused by agricultural activities and the introduction of various mammals (domestic and wild) and even by terrestrial gastropods, on the authoctonous vegetation distribution and structure, including mangroves.

Another threat affecting the hábitat structure and composition of these mangroves is the extraction of timber, wood and charcoal. In both islands, mangrove trees have been commonly used as a regular source of wood and charcoal for daily life for the nearby local communities. In these sense, large trees are almost absent in any of the current mangrove forests.

27.4.3 Global Change, Sea-Level Rise and Coastal Erosion

As in many other regional seas, equatorial african coasts are subject to natural erosion and sedimentation processes, including high wave energy and strong littoral transport, which are intensified by human activities such as sand mining, port construction, and mangrove deforestation (UNEP 2016a). Moreover, acording to Penhor et al. (2011), São Tomé and Príncipe will have during 2040–2060 a reduction in precipitation combined with an increase of mean temperatures, which may increase the stress of remaining mangrove forests.

Moreover, the sea-level rise projections along Africa's coastal zones by 2100 are approximately 10% higher than the global mean (World Bank 2013) meaning that the coastal lowlands including mangroves of 37 countries, many of them in the Gulf of Guinea, will be vulnerable at various spatial and temporal scales (UNEP 2016a).

Already, some coastal communities and villages both in São Tomé and in Príncipe are increasingly and more frequently submitted to flooding and erosion damage apparently due to increased storm intensity and significant shifts in the duration and intensity of the rainy seasons that have begun to overlap with the storm season (Fig. 27.14). Due in part to this overlap, a number of communities are experiencing record flooding and loss of property since 2008. Sand mining, mangrove deforestation and other human interventions are sigificantly contributing to exarcebate the impacts of extreme events. Loss of access to the sea, damage and even destruction in houses and public facilities (schools) are some of the most significant impacts leading to loss of income and fear as some communities are also forced to run from their houses (e.g. Praia das Burras in Príncipe Island and Iô Grande in São Tomé). Several adaptation projects are ongoing including the identification and adaptation interventions for reducing the vulnerability of coastal community infrastructure and productive assets related with climate change impacts.

In summary, the mangrove habitats in these islands are threatened by historical conversion to land for agriculture uses, overharvesting for firewood and charcoal, changing hydrology and coastal erosion.

Fig. 27.14 Coastal erosion at Praia Salgada mangrove (Abades Bay, Principe Island) (© Pedro Gómez)

27.5 Conservation and Sustainable Management Issues

Aside from the above mentioned traditional usage of mangroves forests, there are very few studies on the ecosystems services they may provide to local communities. These keystone coastal and estuarine ecosystems have been recognized recently as nursery and feeding grounds for resident fish species (Félix et al. 2016). Mangroves in Western Central Africa are among the most carbon-rich ecosystems in the world, with estimates that 1299 tonnes of carbon dioxide storaged in pristine mangrove habitats (Ajonina et al. 2014). Mangroves has higher primary production levels that most tropical forests, due to to very high standing and belowground biomass, with large storage capacity of blue carbon. Therefore, degradation of the mangrove ecosystem compromises its resilience and erodes its natural capacity for carbon sequestration. A recent study in Guinea-Bissau by Vasconcelos and collaborators (2015) showed that reversing mangrove deforestation could contribute to mitigation of climate change effects plus preserving the many other ecosystem services.

The ecosystem services and products derived from mangroves in São Tomé and Príncipe start to be evaluated and in near future addtional research may bring new quantitative data to valorize these habitats and contribute to its conservation at national scale.

Most of the mangrove hábitats in São Tomé are located inside the Parque Natural Obô of São Tomé; therefore they are subjected to some degree of protection. In the case of Príncipe Island, there are three main remnants of mangrove forests: Praia Salgada, close to the community of Praia Abade, Praia Caixão and Praia Grande, all of them outside the Parque Natural Obô of Principe. A preliminary assessment of these three habitats was developed in 2016–2017, by the UNESCO Biosphere Reserve of Príncipe Island aiming to identify the main existing species, to confirm their current extension and assess the potential for expansion and potential development of ecotourism activities (such as birdwatching, trails, etc.) similar to those already developed for Malanza mangrove forest in São Tomé with partial support of European funds (Fig. 27.15).

In the case of Príncipe Island, the preliminary results indicate that Praia Salgada mangrove, close to the community of Praia Abade, shows a great potential for conservation and

Fig. 27.15 Advertisement of local ecotourism activities at Malanza Mangrove, South of São Tomé Island

Fig. 27.16 New mangrove trees (*Rhizophor*a) sprouting in the edge of an abandoned coconut plantation in the historical range of the mangrove habitat (Praia Salgada, Príncipe Island)

expansion (Fig. 27.16). The restoration of the mangrove forest combined with the development of ecotourism and educational activities could support community development and job opportunities, especially for women and young people, with high relevance at local level. Recovery and expansion of this mangrove will also contribute to prevent coastal erosion and prevent potential damages to infrastructures (road, bridges) and access to natural resources such as water, beach and coastal fisheries. Praia Caixão and Praia Grande mangroves, although not having established communities, also show potential for ecotourism and educational activities in combination with other conservation (marine turtles and bird watching) and responsible fisheries activities.

Another ecosystem service that may play an important role for the conservation strategy of mangrove hábitats at a national level is related to the blue carbon financing (Herr et al. 2012), in this case under the Abidjan Convention Region. Here there are opportunities, as well as some

constraints, and issues of uncertainty associated with payments for maintaining blue carbon stocks, which needs to be overcome on improved measurement, reporting and verification. Despite the constraints, blue carbon payments have been advancing in a number of developing countries (Ajonina et al. 2014; UNEP 2016a). UNEP and CIFOR (2014) have produced a detailed guidance on planning a blue carbon project, from concept development to regulatory compliance.

In this sense, the Blue Forests Project is a powerfull conservation tool implemented by the United Nations Environment Programme (UNEP) and executed by GRID-Arendal through funds from the Global Environment Facility (GEF) and partner co-finance. The project was initiated in January 2015 and will run over the course of 4 years. The Blue Forests Project represents a milestone opportunity for sustainable financing of coastal ecosystem management through economic values associated with carbon and wider ecosystem services.

São Tomé and Príncipe mangrove habitats have suffered a tremendous impacts on historical times, reducing its potential surface coverage and modifying its structure and composition. Nevertheless, this type of ecosystem has shown its resilience in the scattered mangrove areas that can be observed along the coastlines of both islands. Nowadays, there are some research efforts, national policies and international financing tools that may contribute to foster under novel, innovative approaches the sustainable use and conservation of this magnificent habitats in the middle of the Gulf of Guinea.

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