Mangroves on the Brazilian Amazon Coast: Uses and Rehabilitation

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Abstract

Mangroves are enormously important for the survival of traditional communities found in coastal zones around the world. This is typical of many areas in Brazil, in particular on the Amazon coast, which encompasses the largest continuous tract of mangrove forest found anywhere in the world. A multidisciplinary approach was used to describe the patterns of appropriation and uses of the resources available in this ecosystem, through the investigation of the local ecological knowledge of the traditional mangrove dwellers. Semi-structured interviews based on a set of specially formulated questions were used to better understand the knowledge of the local populations and their practices in relation to the mangrove. These people fish, harvest shellfish, and extract timber for both domestic and productive uses (e.g. construction of fishing weirs). In this region, the natural resources harvested by estuarine-coastal extractivists are used for both subsistence and sale. The principal problems in this region are the increase in the population, overfishing, predatory fishing practices, and the degradation of the mangroves. The initiative of the local community for reforesting degraded mangroves sites stimulated projects for the rehabilitation of the mangrove ecosystem in the surroundings of the communities. The establishment of new forest stands and return of invertebrate species, as *Ucides cordatus*, marked this rehabilitation. Ultimately, it is important to understand that the participative rehabilitation of the mangrove not only guarantees its productivity and the extractive activities, but also contributes to the development of the social, economic, political, and cultural dimensions of local communities, by reinforcing their perception of the need for measures to guarantee the sustainability and conservation of this ecosystem.

Keywords

Mangrove uses and appropriation · Replantation · Rehabilitation · Brazilian Amazon Coast

29.1 Introduction

The Mangrove is an ecosystem of vital importance for many species of marine and terrestrial animals (Hogarth 1999), bringing together a diverse biota that is very useful in the extractivist social context. It is well known that for a long time the extractivism has been important, and it is still up to the present day, for the great majority of people and traditional communities (Rodrigues and Cajueiro 2003; Passos and Di Beneditto 2005). There are records that identify the mangroves as an ecological unit, of which at least two thirds of the world fishery population depend directly on this ecosystem (Spalding et al. 2010). These records provide other indicators, among which the importance of various animals from mangroves are stressed (Pannier and Pannier 1980). Consequently, this importance triggers a process of economic valuation of environmental resources incorporated in this ecosystem.

In Brazil, there are seventeen coastal capitals, where most of the population is distributed in a narrow strip of land near the coast (IBGE 2007). In addition, ecosystems located in this coastal region eventually become the target of the pressure exerted by the anthropic action,[1] resulting from an intense and disorderly occupation (Rossi and Mattos 2002). In fact,

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[1] It is understood, in the present work, by anthropic action any human activity that, somehow, interferes in the natural mechanisms of operation of an ecological unit or ecosystem. The anthropic action, therefore, is an activity that causes some kind of impact on the environment or in an ecosystem, interfering in their natural functioning (Mellanby 1982). In addition to direct human action on the natural environment, there is the presence of the so-called anthropic elements, such as buildings and objects, which act as agents of degradation and modification of the environment (CETESB 1985).

C. Makowski, C. W. Finkl (eds.), *Threats to Mangrove Forests*, Coastal Research Library 25,
https://doi.org/10.1007/978-3-319-73016-5_29

coastal dwellers use and explore several ecosystems. In the case of the Brazilian Amazon coast, the natural fields, rivers and streams, the beaches and mangroves are the target of this exploitation, being that the latter stands out for having economic, cultural, social and environmental meanings. In addition, the mangroves, in most cases, represent the main income and food source in this region (Maneschy 1993, 1995).

The mangrove ecosystem receives pressure from all sides, either through natural events or through anthropogenic activities. These, in turn, have their economic, social, cultural, and environmental basis supported in natural resources that this system offers local mangrove dwellers. These people who take ownership, use and live in the mangroves and its surroundings are considered estuarine-coastal extractivist workers (Oliveira 2015), and therefore have local ecological knowledge that allow them ownership and the use of these existing resources along the coast.

Among the most exploited resources in the Amazon mangroves are the mangrove crab (*Ucides cordatus*), and the mangrove trees (*Rhizophora mangle* L., *Avicennia germinans* (L.) L. and *Laguncularia racemosa* (L.) c.f. Gaertn., shrimps, mussels, oysters, crabs, and others.

In an ecological panorama, *U. cordatus* has a keystone role in nutrients cycling in the mangroves, being responsible, for example, for the consumption and degradation of more than half of the senescent leaves in this environment (Schories et al. 2003). In addition, this crustacean represents about 80% of the epifauna biomass of mangroves, serving as food resource for many groups of animals that inhabit or regularly visit the mangroves (Koch and Wolff 2002).

The mangrove forests are related to the importance of the knowledge and practice of the peoples who developed through observation and experimentation, a thorough knowledge about the natural processes. This knowledge is considered, currently, practices of land use and management adapted to tropical forests (Meggers 1997; Anderson and Posey 1989; Descola 1990; Glaser et al. 2005).

The appropriate resources by traditional communities are diverse and used for multiple functions, such as: (i) income generation for families; (ii) operations of the local, regional and extra-regional market; (iii) social reproduction of peoples and their cultures of the environment and the surrounding ecosystems and (iv) production practices from the use of environmental resources. Thus, the profile of appropriation and use of natural resources of mangroves has been described in accordance with the local estuarine-coastal extractivists. Considering the different uses and impacts on the resources of the mangroves, the various aspects of the rehabilitation process of impacted mangrove areas were also presented. Thus, an interdisciplinary approach is used, adding ecological, social, economic, and conservationist aspects, in order to present the coexistence and the productive practices of the estuarine-coastal extractivists on the Ajuruteua Peninsula, Bragança, Brazilian Amazon coast.

29.1.1 Site Selection and Procedures

The state of Pará is part of the Brazilian Amazon coast that extends from the mouth of the Oiapoque River, in the state of Amapá, until the eastern part of the state of Maranhão. This region is located on the Bragança coastal Plain, between Ponta do Maiaú and the mouth of the Caeté River, featuring a coastline of approximately 40 km (Wolff et al. 1999).

The estuarine and coastal area of the city of Bragança has circa of 180 km^2 of mangroves (Souza Filho 2005), with its characteristic biotic and abiotic components. The area that is around the mangroves, especially that occupied by traditional communities are here called “surroundings” (Fig. 29.1). It is worth pointing out that the mangrove forests of the Ajuruteua Peninsula are part of the Caeté-Taperaçu Marine Extractive Reserve (MER), as well as two communities: Castelo and Bonifácio (Fig. 29.1).

Based on the criterion of concentration of mangrove crabbers, whose information was obtained through direct contact with mangrove dwellers on the peninsula, the main estuarine-coastal communities inhabited by these people were identified and georreferenced: Acarajó, Bacuriteua, Bonifácio, Caratateua, Castelo, Tamatateua, and Treme.

The number of estuarine-coastal extractivists interviewed was 80, who have as their main activity the extraction of mangrove crabs in the mangroves of MER, besides being residents from different communities distributed throughout the Ajuruteua Peninsula.

The criterion to define the sample number s (i) the main productive practice, (ii) knowledge about the resources extracted from mangroves, (iii) access to zones of extraction for commercial production and (iv) permission to the researcher to accompany them in their productive practice. The implicit knowledge of the users was determinant in the location of the main extraction zones. Since then, their activities started to be monitored in order to: (a) georeferentiate the extraction zones and (b) describe each resource extracted.

29.1.2 Environmental Perception of Estuarine-Coastal Extractivists

In order to describe the profile of estuarine-coastal extractivists, data collection described by means of a questionnaire was performed. It is a set of questions systematically articulated that are intended to raise written information from the respondents (Severino 2007). The questionnaire presented semi-structured questions, which allow not only

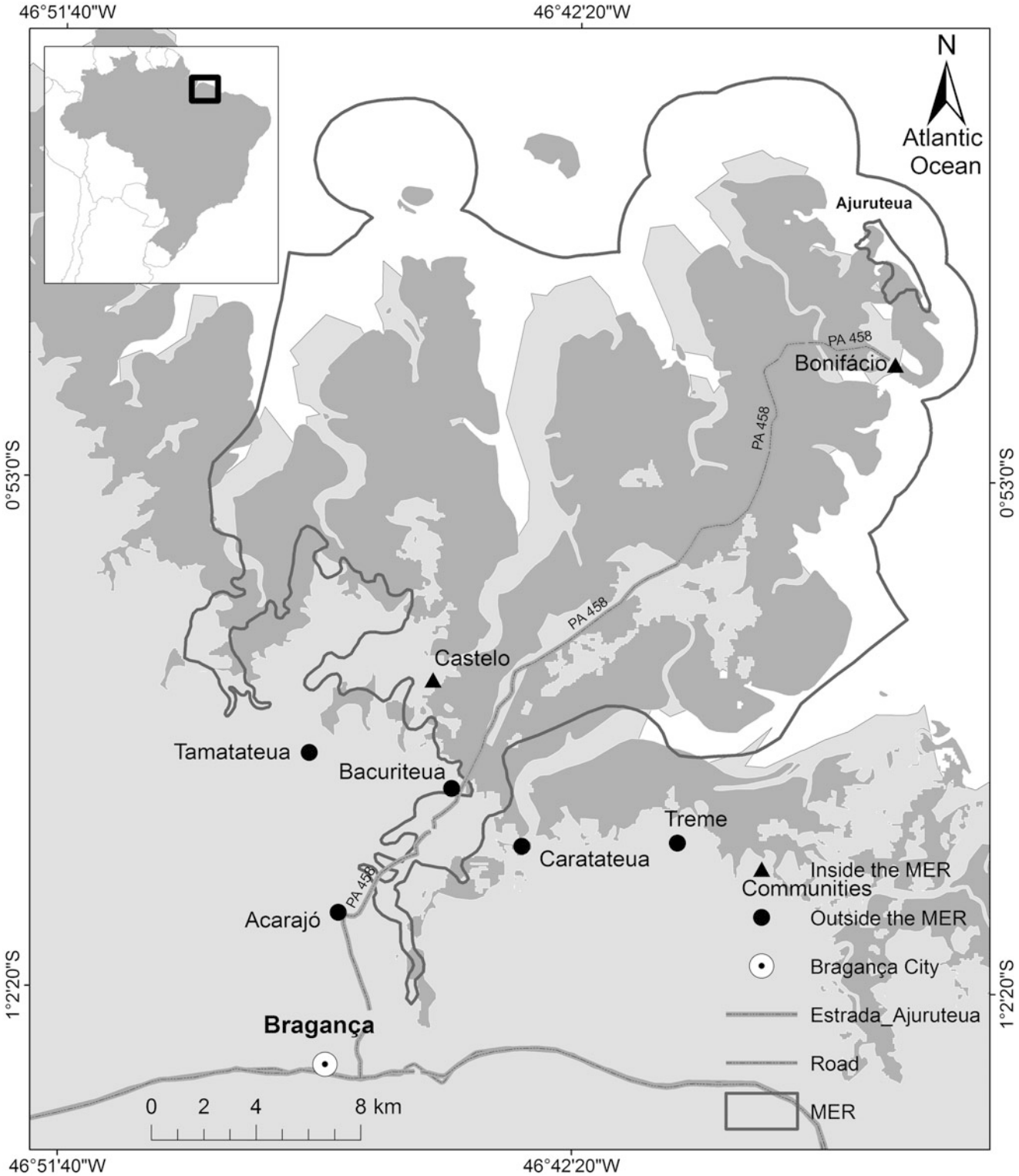

Fig. 29.1 Location of the Caeté-Taperaçu Marine Extractive Reserve on the Ajuruteua Peninsula, Bragança, State of Pará, Brazilian Amazon coast

the completion of questions that are necessary for the survey, but it may also give rise to other questions that can lead to a better understanding about their activities (Oliveira 2009). Additionally, the environmental perception of these respondents about the natural resources was used, since the planning for the extraction until the commercialization process. At first sight, one may think that the concept of environmental perception goes from physiology to semiotics,

passing by the social representations or the functionalism (Del Rio and Oliveira 1996; Fernandes et al. 2004). However, the environmental perception is defined here as the operation that exposes the logic of language that organizes the expressive signs of uses and practices of a place. It is an expression of the image of a place, conveyed in signs that a community builds around itself. In this sense, the environmental perception is revealed through a semiotics reading of discursive, artistic, architectural, etc. production of the community (Ferrara 1993).

29.1.3 Appropriation and Use of Mangroves Resources

There are circa of 700 crabbers along the Ajuruteua Peninsula in Bragança. They live in communities in the surroundings of mangroves and have the mangrove crab extraction and the logging as primary activities. The communities that extract these resources the most are: Acarajó, América, Bacuriteua, Bonifácio, Caratateua, Castelo, Enseada Funda, Patalino, Porto da Mangueira, Praia de Ajuruteua, Retiro, São Benedito (Acarajozinho), São Domingos, São Pedro, Tamatateua, Tapreval, Taperaçu-Campo, Taperaçu-Porto, Treme, and Vila do Meio. Table 29.1 presents the main activities (Fig. 29.2) carried out by the estuarine-coastal extractivists on the Ajuruteua Peninsula and shows that they live on the fisheries extractivism (95.0%). Thus, it is evident that the practice of fishing, the plant extractivism and agriculture overlap with other activities, such as extraction of clay, recreation and leisure. The majority of respondents (82.5%; n = 66) reported they practice extractivism during the entire year, while 17.5% (n = 14) engage in only one of the seasons of the year (Table 29.2). Whereas the results in Table 29.3 show that the activities carried out by mangrove crabbers combined with other productive activities, namely: (i) fishing for crab and fish (95%), (ii) fishing for crab and other shellfish (85%) and (iii) fishing for crab and extract mangrove wood (55%).

Table 29.1 Description of activities practiced by estuarine-coastal extractivists (n = 80) in the mangrove forests of the peninsula of Ajuruteua, Bragança, Pará, Brazilian Amazon coast. n = number of respondents. Each respondent can engage in more than one activity

Activities	n (%)
Fish (fishing weir)	38 (47.5)
Crab (catch handling)	36 (45.0)
Shellfish (catch handling)	36 (45.0)
Agriculture	26 (32.5)
Firewood domestic uses	15 (18.8)
Medicinal plants	12 (15.0)
Wood for construction	09 (11.3)
Firewood for selling	05 (06.3)
Clay extraction	04 (05.0)
Tourism	03 (03.8)
Recreation and leisure	02 (02.5)

In parallel to the information on the production of all the resources extracted, it was sought for the destination given to the products. The majority of fishermen (70.0%; n = 56) reported use for sale, while the remainder (30.0%, n = 24) said they use for their own consumption and both (consumption and sale) (Table 29.4).

Considering both production and destination of different resources extracted from the mangroves, it was possible to reveal the key factors that may affect their productive activities in the mangroves, and hence those that adversely affect the availability of these resources in mangroves. The results pointed out, according to the scale of importance, that: (i) predatory activities, (ii) increase of people using mangroves, (iii) logging, (iv) over-exploitation of mangrove products, are the most relevant factors (Table 29.5).

Few respondents (5%) said they were satisfied with the professionalization of fishermen in the age range from 15 to 55 years, while from 56 years old on the number of respondents satisfied was three times higher (20%) (Table 29.6). Out of the factors that led to this professionalization, the class from 18 to 55 years' points as the main factor (45%) the "*lack of opportunity for formal work*", while the older ones claim to have "*inherited the occupation from their families*" (35%). The "*low educational level*" also appears as a relevant factor to the class of younger (25%), while the group above 56 years of age "*They do not know or do not intend to perform another activity*" (25%) (Table 29.6).

Considering the typical mangrove trees, it was asked which species they used the most and how. The results showed, in an order of importance, that the majority (66%) of the respondents used the white mangrove (*L. racemosa*), circa of 20% and 14% the black mangrove (*A. germinans*) and red mangrove (*R. mangle*), respectively. Respondents justified their appropriation due to the fact that this species have size and shape suitable for the manufacture of fish weirs. In addition, they report that is the kind that presents greater abundance at the edges of the mangroves, being the species that has more durability in direct contact with water.

The respondents also showed that the mangrove wood has different uses for the estuarine-coastal extractivists. One of the main utilities is for domestic uses, such as charcoal and firewood for cooking. The firewood from mangrove wood is widely used for cooking the mangrove crab (*U. cordatus*) in the crustacean processing. This process starts with the capture of the crustacean (*catch handling*) in the mangroves, passing by cooking with water and salt (*brine*). Then, the crabmeat is removed from the crab and stored in plastic bags for sale. For the meat removal it is required some skills so that pieces of the exoskeleton are not crushed and mixed to the meat losing its quality (Machado 2007).

Fig. 29.2 Uses and products from the mangrove ecosystem on the Ajuruteua Peninsula, Bragança, Brazilian Amazon coast. Fresh fish (A) and salted fish (B), live mangrove crab (C) and cooked mangrove crab (D), swimming crab (E), shrimp (F), cassava (G), firewood (H), leaves of tobacco (I), clay sculpture (J), recreation and leisure (K), and handicraft (L)

The "wood for construction" is in the scenario of making fixed fishing traps, which can be divided into two types: weir and *fuzarca* net (Fig. 29.3). They are structures built with woods from the mangroves (*R. mangle*, *A. germinans*, and *L. racemosa*) or other stems as the bacuri tree (*Platonia insignis* Mart.). Both have entries in the form of "V", called

Table 29.2 Productive periods for crab fishing and wood extraction in the mangrove swamps of the peninsula of Ajuruteua, Brazilian Amazon coast

Period	n (%)
Rainy (December to May)	06 (07.5)
Dry (June to November)	08 (10.0)
During entire year (January to December)	66 (82.5)
Total	80 (100)

n = number of respondents

Table 29.3 Resources extracted by estuarine-coastal extractivists (n = 80) of mangrove crabs and mangrove wood in the peninsula of Ajuruteua, Bragança, Brazilian Amazon coast

Resources	n (%)
Mangrove crab and fish	76 (95.0)
Mangrove crab and Shellfish	68 (85.0)
Mangrove crab and wood	44 (55.0)
Mangrove crab and shrimp	12 (15.0)
Mangrove crab and others	04 (05.0)

n = number of respondents

Table 29.4 Destination of mangrove crab's production and wood extracted by esturarine-coastal extractivists (n = 80) on the Ajuruteua Peninsula, Bragança, Brazilian Amazon coast

Destination	n (%)
Sale	56 (70.0)
Own consumption	13 (16.3)
Both (consumption and sale)	11 (13.7)
Total	80 (100)

n = number of respondents

Table 29.5 Factors affecting productive activities of resources extracted from mangroves on the Ajuruteua Peninsula, Bragança, Brazilian Amazon coast

Factor	n (%)
Predatory activities	38 (47.5)
Increase of people using mangroves	36 (45.0)
Logging	32 (40.0)
Over-exploitation of mangrove products	30 (37.5)
Overfishing	24 (30.0)
Tides elevation	12 (15.0)
Pollution	12 (15.0)
Agriculture	05 (06.3)
Dunes advance	05 (06.3)
Oil spill (boats)	04 (05.0)

n = number of respondents

"*espias*", which directs the fish inside the trap. In the case of *fuzarca* net, the tunnel entrance leads to a conic net, and the weirs, directs to an area called sty where fish are caught. Both fisheries do not have target species, considering that they are characterized as generalist fisheries. The harvest is performed usually twice per day during the low tide.

In this same scenario, mangrove tree species (*L. racemosa* and *A. germinans*) are used by local people as a pen for rearing pigs in the communities surrounding mangroves, such as: Castelo, Porto da Mangueira, and Tamatateua (Fig. 29.4).

The "commercialization of mangrove woods" follows the parameters ruled out by the commerce demanded by brickyards, bakeries, and fishing traps, because according to the respondents, for the brickyards and the bakeries the three species of mangroves are used. However, for the fishing traps, the respondents claim to use more *L. racemosa*, followed by *A. germinans*, and as a third option, *R. mangle*. Similarly, it was possible to identify the use of mangroves wood for other activities such as production of firewood for manufacturing cassava flour (Fig. 29.5). This productive activity is common among the estuarine-coastal extractivists, because 32.5% of the respondents practice agriculture and, among the most cultured, the planting of cassava (*Manihot esculenta* Crantz) and manufacture of the cassava flour. In a scale of importance such activities are always in the first place. From this production, one part is for the families' own consumption and the other for commercialization. The main species used for firewood are *R. mangle* and *L. racemosa*. However, it is emphasized that this use is sporadic and occurs only when the wood is dry, which was reported by only 10% of respondents.

According to the respondents, the manufacturing of charcoal for domestic use and commercialization has emerged as the main goals in the production of this activity (Fig. 29.6), which in turn is common among almost all the families on the Ajuruteua Peninsula. The main mangrove wood used for this purpose is *R. mangle* and *L. racemosa* representing 31%, while *A. germinans* is used to a lesser extent (13%).

The dying of fishing nets by using stain of vegetable origin was also singled out as a common activity among the estuarine-coastal extractivists. This process takes place so that the fishing net durability is prolonged. The raw material (tannin) used in this process comes from the bark of *R. mangle*. In addition, a more detailed description of uses of mangrove products, based on the respondents' speech, showed that the use of mangrove tree species is ample and common on the Ajuruteua Peninsula (Table 29.7). *Laguncularia recemosa*, for example, was present in all the speeches (100%), followed by *A. germinans* (62%) and *R. mangle* that reached 18%.

The areas of mangroves are therefore of utmost importance for the peoples from coastal communities, since a good part of the animal origin proteins is originated therein, so essential for their livelihood. In this sense, strong traces in the inhabitants of these communities are realized when it comes to the uses of resources from the mangroves and also cultivated in the surrounding areas (Table 29.8). The process of appropriation and use are due to meeting the interests of

Table 29.6 Factors leading to the professionalization of estuarine-coastal extractivists (n = 80) on the Ajuruteua Peninsula, Bragança, Brazilian Amazon coast

Age groups (years)	Factors	n (%)
18–55	Lack of opportunity for formal work	18 (45%)
	Low educational level	10 (25%)
	Inherited the occupation from their families	06 (15%)
	They do not know or do not intend to perform	04 (10%)
	Satisfied with the profession	02 (05%)
> 56	Inherited the occupation from their families	14 (35%)
	They do not know or do not intend to perform *another activity*	10 (25%)
	Satisfied with the profession	08 (20%)
	Low educational level	06 (15%)
	Lack of opportunity for formal work	02 (05%)

n = number of respondents

Fig. 29.3 Weir (A) and *Fuzarca* net (B) used at fishing artifacts in the Caeté River, Ajuruteua Peninsula, Bragança, Brazilian Amazon coast

both the estuarine-coastal community in search of their livelihood as the interests of local merchants.

29.2 Rationale for Rehabilitation of Mangrove Forests on the Ajuruteua Peninsula

According to the Federal Decree 97.632 from 1989 of Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA), the terms *Restoration*, *Recuperation*, and *Rehabilitation* are inverse paths to degradation and important to make it easier the communication when it comes to the process choice to be adopted in the degraded area. The term *Restoration* implies "mandatory return to original state of the area before the degradation", what is technically and economically questionable and an impractical process. The term *Recuperation* results in "Return of the site, reduced to a form of use, according to a pre-established plan for the use of the soil, aiming to produce a stable environment", that is, for repair of resources by establishing the composition and frequency of original species of the place. Rehabilitation, in turn, aims at the "Return of the degraded area to a suitable biological condition, which can mean the implementation of activities of (i) profitable use, but not long-term and (ii) less profitable use, such as recreation and/or aesthetic and ecological enhancement. In fact, the rehabilitation of a degraded area or a system is part of a growing approach where goals and targets should be well defined, in this way, adding the concept of environmental sustainability.

Fig. 29.4 Pens for rearing pigs in estuarine-coastal communities, with emphasis on the use of *Laguncularia racemosa* and *Avicennia germinans*

Fig. 29.5 The manufacuring process of cassava flour highlighting the place (A) and toasting, when they use firewood (B) from mangroves

The main motivation in rehabilitating the degraded mangroves on the Ajuruteua Peninsula arose from the isolated effort of the local estuarine-coastal communities in reforesting the degraded areas due to the construction of the state road PA-458, in the municipality of Bragança, State of Pará, Brazil. In 2005, it was joined to this initiative the bilateral agreement between Japan and Brazil, through the project entitled "Recuperation of degraded mangrove areas in Bragança", between the Japan International Cooperation Agency (JICA) and the Federal University of Pará (UFPA). Through the Technical Cooperation from Community Projects, which has as its purpose to contribute to the social and economic development of developing countries at the local level. The following activities were implemented: (i) establishment of partnerships between the community and the project, (ii) construction of a plant nursery with mangrove seedlings (genera: *Rhizophora, Avicennia*, and *Laguncularia*), (iii) direct performing of community monitors with the technicians and researchers, and (iv) preparation of a handbook of environmental action to explain the importance of the conservation and preservation of mangroves to the community.

In the same way, the sustainable production of mangrove resources, such as the mangrove trees that are used for a wide variety of local practice, was used as a justification for the rehabilitation of mangroves on the peninsula. *Laguncularia racemosa* is the most used mangrove tree species throughout the region, being used for the construction of large fishing

Fig. 29.6 The manufacturing process of charcoal using mangrove wood

Table 29.7 Species and uses of wood by estuarine-coastal extractivists on the Ajuruteua Peninsula, Bragança, Brazilian Amazon coast

Scientific name	Common name	Products	Uses
Avicennia germinans	*Siribeira*	Poles	Housing
	Black mangrove	Charcoal	Domestic, commercialization
		Pen	Rearing pig and cow
		Canoe for cassava	Processing cassava flour
		Firewood	Mosquito repellent, cooking
		Weir	Fishing
Laguncularia racemosa	*Tinteiro*	Weir	Fishing
	White mangrove	Fence	Housing
		Pen	Rearing pig and cattle
Rhizophora mangle	*Mangueiro*	Medicine	Fever, intestinal infections.
	Red mangrove	Firewood	Domestic, manufacturing cassava flour
		Charcoal	Domestic, commercialization
		Stain	Dying fishing nets
		Roof	Housing
		Pen	Rearing cattle
		Weir	Fishing

weir (Voigt 2011). The return of the mangrove crab (*U. cordatus*) to the rehabilitated areas is also a great benefit to local residents, who use them for consumption and commerce (Monteiro et al. 2014). In addition, it is worth mentioning that the conservation of mangrove ecosystem may imply also in the conservation of the genetic stock, the maintenance of the majority of ecological processes or simply the landscape, whose purpose can be related to recreation and the protection of coastal areas (Field 1998).

29.2.1 General Description of Replanted Mangrove Areas

The areas of replanted mangroves are located at the peninsula of Ajuruteua, in the communities of Tamatateua (00°57′12.5″S and 46°47′02.4″W) and Taperaçu-Campo (00°57′29.5″S and 46°64,5′58.7″W), about 15 km away from the city limits of the city of Bragança, State of Pará, Brazilian Amazon coast (Fig. 29.1).

According to Moraes et al. (2005), this region has a tropical, hot and humid climate, with annual rainfall of approximately 2300 mm and average temperature of 26 °C, due to the influence of the Inter-Tropical Convergence Zone. The driest months comprise the period from July to December, while the rainiest from January to July. The Ajuruteua Peninsula presents semidiurnal tidal cycles (DHN 2013), dominated by macrotides ranging between 4 and 6 m in height (Souza Filho 2005).

The texture of the soil in some replanted areas was classified as light or heavy clay, varying the content of organic matter between 16.3 and 23.9 g kg^{-1}. The percolation water

Table 29.8 Extracted resources, their uses and products from the mangroves of Bragança-PA, Brazilian Amazon coast

Resources	Products	Uses
Fishes	Dishes, fish flour	Food, commercialization
	Leather, swim bladder, scale	Handicraft, commercialization
Mangrove crab	Dishes	Food, commercialization
	Organic residuals	Handicraft, commercialization
Shimps	Dishes	Food, commercialization
Swimming crabs	Dishes	Food, commercialization
Oysters	Dishes	Food, commercialization
	Organic residuals	Handicraft: bijou, etc.
Mussels	Dishes	Food, commercialization
	Organic residuals	Handicraft, commercialization
Shipworm	Dishes	Food, commercialization
Scalet Ibis	Meat, feather	Food, handicraft, commercialization
Heron	Meat, bait	Food, fishing
Ducks	Meat, bait, feather	Food, fishing, handicraft, commercialization
Honey	Meat, Medicines	Food, health
Beans	Dishes	Food, commercialization
Rice	Dishes	Food, commercialization
Corn	Dishes	Food, commercialization
Cassava	Root	Food, commercialization
Tabacco	Cigarettes	Food, commercialization
Clay	Domestic utensil, handicraft	Commercialization
Reeds	Domestic utensil, handicraft	Handicraft, commercialization
Fruits	Pulp	Food, commercialization
Mangrove trees	Charcoal, firewood, medicines, stain, weir, pole	Domestic fuel, commercialization, medicine, dying

presents values that vary according to the period of the year. In the rainy period, the pH is close to 6, while in the dry period rises to 8. Salinity also varies between the dry and wet periods ranging between 2 and 80, defining a seasonal fluctuation.

29.2.2 Site Preparation and Planting Techniques

The place where the seedlings nursery was built flooded on a daily basis. Tidal creeks connected hydrologically through narrow channels ensured natural flood of the nursery. The area occupied by the nursery was 32 m^2 (8 × 4 m), with a depth of 40 cm, and wooden support to prevent collapse due to the tidal movements. Three rows were built, and each has the capacity of 800 seedlings, totaling circa of 2400 units (Fig. 29.7).

For the seedlings production the most dominant species were selected along the peninsula: *R. mangle*; *A. germinans*, and *L. racemosa*, considering also the dominant landscape closer to the replanted areas in an attempt to reproduce them. The species *A. schaueriana* Stapf and Leechman *ex* Moldenke also occurs on the peninsula but in shorter density (Abreu et al. 2016), and as no individuals next to the replanted areas were registered, this species was not used for reforestation. The collection of mature seeds were carried out during the rainy season (January to May), when there is the peak of production of reproductive phenophases in the coastal region of the Brazilian Amazon (Fernandes 1999; Nascimento et al. 2016).

The seeds collected went through a pre-treatment, except the seeds of *R. mangle*. *Avicennia germinans*, for example, were left about 8 h immersed in water brackish water, when the peels begin to loosen. In the case of *L. racemosa*, the seeds were immersed for 5–7 days. On the third day almost all seeds already presented the beginning of a primary root and should be planted during the sixth or seventh day, before the secondary roots appear by the ninth day, because the latter break very easily.

The mangrove seeds have peculiarities according to the species, which must be considered during the storage process. The seeds of *R. mangle*, for example, loses the viability over time, having to be planted as soon as possible, while *L. racemosa* can be kept for about a week, or more weeks in the case of *A. germinans*, if kept dry and in a cool and in the shade. However, it is important to bear in mind that seeds must be stored as short as possible.

In the case of *R. mangle*, one third of the seed was buried in mud, being the depth adjusted as the flood and hardness of the mud to prevent loss by tidal movements. The same procedure was performed for the other two species, but

Fig. 29.7 Nursery rows divided by narrow channels with wooden support to prevent collapse

Fig. 29.8 Direct sowing of *Rhizophora mangle* (A), *Avicennia germinans* (B), and *Laguncularia racemosa* (C) seeds into degraded mangrove soil

being up to five seeds for *R. mangle* and *A. germinans*, while *L. racemosa* from five to ten seeds per hole, since this last species has a high mortality rate in this first stage of planting (Fig. 29.8). Direct sowing provides great results regarding seeds survival due to the proximity between the seeds, thus stimulating the competition and accelerating the individuals' growth (Tsuji and Fernandes 2008).

The reforestation of mangrove patches by planting seeds or seedlings enable the recovering of degraded mangrove landscape. Planting seeds by using direct sowing is highly efficient. However, in addition of being dependent upon the period of greatest seed production, it offers higher risk of non-viability of seeds planted or mortality of those sprouted seeds. However, it is important to emphasize that growing seeds indoor presents some advantages in addition of creating a favorable environment for the development of seedlings. This method is also very efficient since it avoids or reduces the loss of seedlings (i) by tidal movements, (ii) cattle trampling and (iii) by pest attacks, thus ensuring greater quality, survival and success in the reforestation (Tsuji and Fernandes 2008). Results using the conventional method with nursery-grown seedlings in different parts of the world showed considerable variation in the percentage of survival of the plants, such as 40–60% in Australia (Saenger 1996), up to 85% in Indonesia (Soemodihardjo et al. 1996), and 90% in India (Untawale 1996). The quality of seedlings of *R. mangle*, *A. germinans*, and *L. racemosa* produced by nurseries in the amazon region was tested considering some variables, which may interfere in the seedlings survival rates, such as the type of substrate and percentage of shading.

Regarding the substrate, the mangrove seedlings in the first year of development depend on the energy contained in the cotyledon (Tamai and Iampa 1988). In addition, these cotyledon reserves sustain the production of epigeal and hypogeal parts of seedling, being extremely important for their establishment (Kitajima 2002). However, the seedling shoots growth is one of the main effects of the substrate on the roots (Hartmann et al. 1990). In fact, Araujo et al. (2014) showed that the type of substrate affects the seedling growth, which was evidenced by evaluating the quality of seedlings. According to Oliveira et al. (2008), the index of Dickson (IDQ) that uses the variable total dry weight (TDW; g); the shoot height (H; mm); the stem diameter (SD; mm); shoot dry matter (SDM; g), and root dry matter (RDM; g), can be used to express the quality of a seedling. The experiment with seeds/seedlings of *R. mangle*, *A. germinans*, and

L. racemosa carried out in Brazilian Amazon coast, after 270 days, showed that IQD values are larger for seedlings developed in yellow latosol substrate than in sandy or muddy substrates, and were confirmed in the study carried out in the same region by Costa et al. (2016). Thus, it is important to bear in mind that the use of new substrates for the production of mangrove seedlings in nursery seems not only an efficient procedure, but also an alternative measure to reduce the impact on the mangrove soil.

Some types of mangrove trees as those of the genus *Bruguiera, Heritiera*, and *Xylocarpus* can be less tolerant to light than others because their seedlings normally develop under the canopy of different tree species (Hanley et al. 2008). Although mangrove trees are pioneers and heliophilous plants, they also feature their spatial distribution influenced according to their tolerance to light, as is the case of *R. mangle* that is less tolerant to light (Smith and Lee 1999). Indeed, the seedlings of *L. racemosa* and *A. germinans* are more tolerant to brightness than *R. mangle* (Lopes et al. 2013). These authors showed that through monitoring over 9 months and the evaluation of biometric and morphologic parameters, seedlings of *A. germinans* develop better at 30% of shading and in full sun, while the seedlings of *L. racemosa* were more tolerant to 30 and 60% shade, but showed a better development in full sun. Additionally, the production of seedlings in nurseries enables reforestation outside the period of seeds production of local species.

The planting procedures applied to degraded mangroves areas are important for the rehabilitation and maintenance of the resources and landscape, but this process must achieve greater success in places where certain environmental characteristics have not been lost yet, mainly the flooding system. From this point of view, the reforestation carried out on the Ajuruteua Peninsula showed high mortality of seedlings planted in dry soils due to road construction (PA-458) that acted as a barrier, avoiding flooding from tidal waters. As a consequence of this impact on mangrove forest, several soil variables as organic matter, macro, and micronutrients increased reference values for carbon (C), ratio C: N, organic matter, iron (Fe), pH, sand, and clay.

29.2.3 Environmental, Social, and Economic Impacts of Mangrove Rehabilitation

From rehabilitation of impacted areas of mangroves, it is expected that the effect on the substrate be gradual and positive through greater retention of moisture, turning the dried soil to a muddier substrate. Therefore, a more adequate environment is obtained for the decomposition and retention of organic matter, which is essential in the process of nutrient cycling, as well as an environment for the recruitment of a new seedling generation. Likewise, this new substrate provides greater mobility for the recruitment of polychaetes that are important to the process of nutrient cycling and represent on the Ajuruteua Peninsula around 85% of the benthic fauna (Beasley et al. 2010). In addition, the new environment is also attractive to other invertebrate species, but especially the mangrove crab (*U. cordatus*) that has a high rate of larval recruitment in habitats favorable to the development of juveniles (Simith and Diele 2008). In fact, the study focused on the recruitment of *U. cordatus* in replanted mangrove sites showed that this species is able to settle down successfully in this new environment (Aviz 2016).

From a social point of view, the rehabilitation of this ecosystem is of great value and an essential tool for the recuperation and maintenance of natural resources inherent to the mangrove forests for the estuarine-coastal communities. Thus, the emergence of new propagules and seedlings in the areas of replanted mangroves reaffirms the fact that reforest impacted areas is a good practice. It is essential not only for the return of the forest per se, but the wood of mangrove trees for sustainable uses. The recruitment of fauna typical of invertebrates, especially of *U. cordatus*, in turn, clearly indicates the importance of rehabilitation of this system for the conservation of benthic macrofauna, specially the commercially relevant species. In fact, it is important to bear in mind that the actions for the maintenance of the structure and functioning of the mangroves are relevant to the social well-being, with the improvement of life through the generation of income for the estuarine-coastal extractivists worldwide. Through the implementation of new methods of management in the mangrove forests of Can Gio, in Vietnam, for example, many jobs have been created by generating income for a large number of fishermen through the reforestation, cutting firewood when thinning or pruning, and catching small crabs, oysters and clams on the forest floor (Hong 1996).

On the other hand, there are different types of natural threats or not, which foster the increase of mortality in the mangrove planting process. The natural threats concern the different herbivores that attack the seeds and seedlings causing some sort of damage. It can be exemplified by the action of beetles (e.g. *Poecilips Fallax* – Scolytidae) on propagules of the genus *Rhizophora* (Agaloos 1994; Hong 1994). Aquatic invertebrates (e.g. clams and oysters) also retard the growth of seedlings and damage the plumules and young leaves, respectively. Replanted mangrove sites and seedling nurseries, on the Ajuruteua Peninsula, were adversely affected by several episodes of herbivory. Records include attacks by crustaceans of the genus *Uca* (Ocypodidae) on the first leaves of seedlings of *A. germinans* (Tsuji and Fernandes 2008), as well as the presence of endoparasites (gall-inducing insects) on leaves

of *A. germinans*. Considering the region and the places chosen for the implementation of planting a higher number of threats should be expected. Interference from marine algae (Rhodophyta species) can bend and break the seedlings (Cabahug et al. 1986), until the presence of vertebrates can be felt. Wild boars (*Sus scrofa*) have already been reported by Nam (1994) in the plantation of mangroves, as the presence of long tailed macaques (*Macaca fascicularis*) that forage for crabs and mollusks in newly planted areas of *R. mucronata* (Hong 1996) are both examples of negative natural effects on the replanted mangrove sites. In addition, it is worthy highlighting that during the seedlings production, when using local tidal regime for irrigation, the spring tides took away several seeds and even the bags with seedlings, mainly, of *L. racemosa* (Tsuji and Fernandes 2008).

The anthropic effects are less harmful and worrying. Nam (1994) reported that, in Vietnam, the growth of seedlings of mangrove species (*R. apiculata* BL., *R. mucronata* Lamk., and *Ceriops tagal* (Perr.) C.B. Robinson), was inhibited by competition with *Acrostichum aureum* and *Phoenis paludosa*. It resulted from the fact that seedling were planted in higher lands that had been sprayed with herbicides. Hong (1994) also reported that the seedlings were broken due to the passage of boats through the plantations, or even by dweller trampling who gather shellfish and fish in replanted mangrove sites. On the Ajuruteua Peninsula, the loss of seedlings of *R. mangle*, *A. germinans*, and *L. racemosa* is also caused by both dweller trampling during logging and/or crabbing activities and cattle herds trampling that graze freely on the peninsula and hence invade plantations for foraging.

29.3 Final Considerations

The description and understanding of the appropriation and use of resources, as well as productive activities held in the mangroves and the participative involvement in the rehabilitation process of this environment by the estuarine-coastal extractivists is always the result of involvement of a multidisciplinary approach in a socio-environmental perspective. Thus, it was possible to identify the use, extraction, and the reason for the mangroves resources. As well as their identities in the productive practices. The productive activities are not restricting only to the economical dimension, but they are also built through social relationships. In fact, at the traditional communities, the productive activities comprise multiple dimensions (e.g. social, economic, political, cultural, and environmental) (Castro 1997). It is worth noting, on the basis of the discussion presented by this author that productive activities developed in traditional communities are associated with nature, as well as they reflect on the accumulation process of knowledge over the generations. In the same way, Diegues (2004) defines traditional community, as they emphasize that it is a socio-political space dynamic and sociocultural, but highlights the economic organization as one of the central elements. The same author points out that the economic organization is based on the use of renewable natural resources with patterns of consumption, which combine various activities dependent on the nature cycles, as well as their culture is founded on symbologies, myths, and rituals associated with production activities, such as: hunting, fishing, and several extractive activities.

The resources extracted from the mangroves are for the commercialization and this unified information to those who sell and eat (13.7%) gains amplitude, aiming more than 80% of this resource to commerce. Based on the above information, there is the conception that the mangroves natural resources of mangroves on the Arujuteua Peninsula are part of the commercial dynamics and, hence, increases the pressure towards the predatory practice of intensification in the exploitation of these resources, without considering, the negative impacts resulting from this activity. Nevertheless, the analysis of users' perception brought to light the main problems that most affect the production activities of the estuarine-coastal extractivists. It is stressed the "*employment forms of predatory production*", which is directly related to the use of instruments both for crabbing and logging. The latter activity results from the use of mangrove wood for the manufacturing of fishing weirs, fences for domestic yards, load and unload fisheries ports, stowages, huts that serve for shelter and selling to brickyards and bakeries. Another factor that stands out is the "*increase of people using the mangroves*", especially during the holiday periods (January, February, and July), when mangrove crabs is notably more consumed in bars, beaches, and restaurants in the city of Bragança, also increasing the demand for other surrounding municipalities.

Being a dweller in mangrove areas in the Amazon region is not always a choice, but a result of lack of opportunities, low educational level and family heritage. There are many causal factors influencing this reality on the Brazilian Amazon coast. This region is characterized by the lack of industries or enterprises that may promote access to formal employment. This is corroborated by elder respondents (aged 56 or over), who highlighted the continuity of the family and the community's heritage, from the learning obtained with the family members and due to, therefore, having mastered the fishing activity skills (Maneschy 1995; Castro 2000).

It is evident that there are many approaches when it comes to the mangroves forests management. Pristine mangroves need fewer interventions than the impacted ones, together with the best choice regarding the restauration, recuperation or rehabilitation process. The most important is that the users, participatively, have their roles defined in this process. The gradual transformation of soil and its properties, the recruitment of flora and fauna point out the environmental gains, so

that the environmental goods and services are rehabilitated. So, the income generation and the social well-being have guarantee in the system rehabilitation for the sustainable use by the estuarine-coastal extractivists. Surely, it reflects the reality of most communities on the Brazilian Amazon coast. It is important to emphasize that many forms of appropriation and use of the mangrove resources in this region is relevant to a better understanding of the interaction between users and the mangrove as an asset of common use. Finally, all participative activities for rehabilitation of this ecosystem becomes essential to sensitize mangrove dwellers towards sustainable use of mangrove resources.

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