# 12 Interrelations among Mangroves, the Local Economy and Social Sustainability: a Review from a Case Study in North Brazil

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## Abstract

The littoral region of coastal Pará in northeastern Brazil is part of the world's second-largest continuous mangrove region. The Bragança peninsula is the specific study area of the currently ongoing joint German/Brazilian interdisciplinary project 'Mangrove Dynamics and Management', which began in 1995. Human use in this mangrove ecosystem is characterized by about 15 important natural resources, which have either subsistence value or otherwise generate monetary income for the local rural population. The significance of these functions for the rural households increases with distance from the urban centre. In the primary production sector, agriculture and artisanal fisheries are the main source of income in the wider Bragantinian region. Both sectors are characterized by many small operators. The industrial sector is very under-represented throughout the region. The control of the allocation of resources within this region currently rests predominantly in the hands of local individuals. This chapter examines the conditions for the successful co-management of diverse species, resource-use patterns and household income portfolios in a mangrove environment. Therefore, stakeholders have been incorporated directly, for example, by participation in workshops. This is a feature introduced by RESEX (*reservas extrativistas*), a Brazilian model of co-management for natural resources.

## Introduction

Only minimal research had been carried out in north Brazil until the joint German/Brazilian project on 'Mangrove Dynamics and Management' (MADAM) began in 1995 (Berger *et al.*, 1999). Moreover, although – judging by the sheer number of botanical, zoological and ecological studies – mangroves must be among the most intensely studied tropical ecosystems (Twilley, 1996), progress has been insufficient in the integration of the various studies that would allow for a better understanding of any mangrove system as a whole and of its key processes. As a result, application of the research results obtained by other projects to a new study area is problematic. However, such an integration is clearly imperative for an ecosystem research approach, which intends on the one hand to create the capacity to assess the implications of human resource-use dynamics, or of changes in hydrographic, geomorphological

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or climatic conditions for the ecosystem, and on the other hand to explore the possible effects of natural or regulative changes on the relevant socio-economic structures. It is also assumed that, if recommendations for ecosystem management are to be elaborated, the socio-economic value of the ecosystem needs to be determined as a guide to decision-making.

The possible scenarios for future mangrove use, as derived from various management approaches and variables such as population growth and employment trends, must be linked in such a way that the scope for activities and decision-making pertaining to the ecosystem becomes evident. To do this, it is necessary in the first place to achieve a minimum interdisciplinary consensus on the precise local meaning of key management goals, such as sustainability. In the identification of management problems and solutions, the involvement of system users and other key stakeholders is considered essential (see Özhan, 1998).

About 15–20 different natural resources that have either subsistence value or generate monetary income for the rural population are derived from mangroves (Fig. 12.1). The first socio-economic surveys showed that approximately 80% of the households live from the diverse products of the mangrove estuary, whereas approximately 68% derive income from the mangrove ecosystem (Glaser, 2003). The economically most important mangrove productive resource is the large, semiterrestrial ocypodid crab (*Ucides cordatus*). Fish, shrimp and other invertebrates, as well as mangrove timber, are also used, the latter predominantly to fire brickwork kilns. Although the ecology of the Caeté ecosystem is considered to be relatively undisturbed by human activities, there are visible trends of expanding tourism, intensification of the fishery industry and urban growth in this area, which further point to the necessity of studying the interrelationship between mangroves and the local populace.

This chapter provides an overview of the resource-related research of MADAM and how management implications are defined under stakeholder participation.

## Research Area

The mangrove estuary of the Caeté River is located 150 km southeast of the Amazon delta in northern Brazil. It forms part of the world's second-largest continuous mangrove region, estimated to cover a total area of 1.38 million ha along a coastline of about 6800 km (Kjerfve and Lacerda, 1993). The study area includes the mangrove-covered peninsula on the northwest side of the estuary (Fig. 12.2). It consists of 180 $km^2$ of mangrove forests and the adjacent 130 $km^2$ of rural area. The human population consists of the urban area of the city of Bragança, with about 48,000 people, and a rural area of 21 villages with a combined population of about 13,000 people who live and derive their livelihood mainly from this peninsula. Krause *et al*. (2001) give a general and detailed geographic characterization of the region.

## Mangrove Products

Multiple income sources at the household level are common in rural areas of Amazonia, especially where occupational specialization at the household level is less viable because of low population densities and limited market size. Dependence on the mangrove by the rural population is also very diverse as specialization in one single target commonly does not meet the subsistence demands of a family (Tables 12.1 and 12.2). Therefore, in the following, the different mangrove products are listed separately.

### Crab

The most heavily exploited resource in Brazilian mangroves is the leaf litter-consuming semiterrestrial crab *U. cordatus*. More than 60% of rural subsistence fisher households and over half of the rural commercial fisher households collect crabs for sale (Diele, 2000; Glaser and Diele, 2004).

*Ucides cordatus* is a relatively large and slow-growing crab living in burrows. In the Caeté estuary, it reaches a size of up to 9 cm

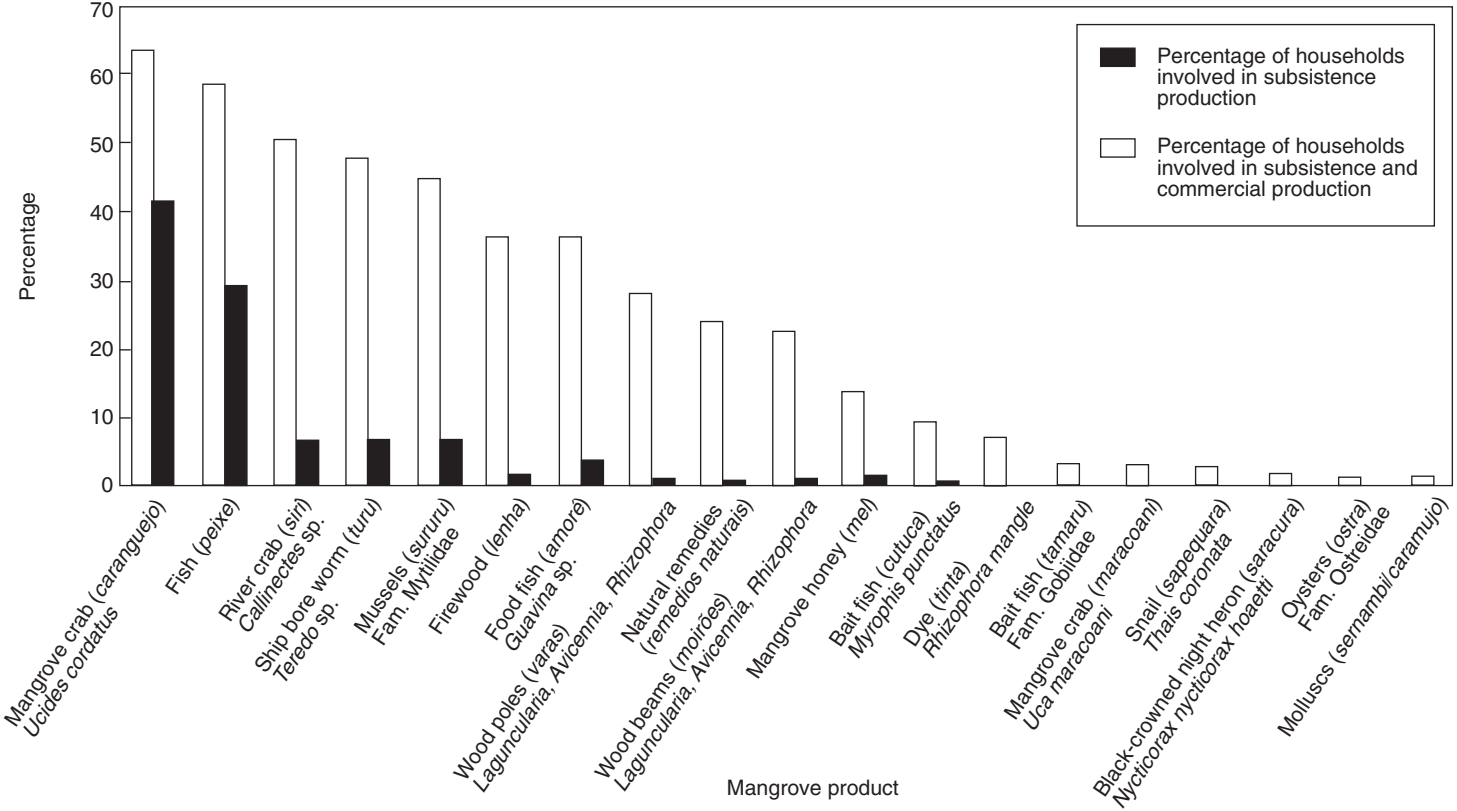


**Fig. 12.1.** The use of mangrove products in Caeté estuary villages. Local mangrove product categories not corresponding to one specific family, genus or species in biological taxonomy were described by only the local Portuguese expression and an English translation (after Glaser, 2003).

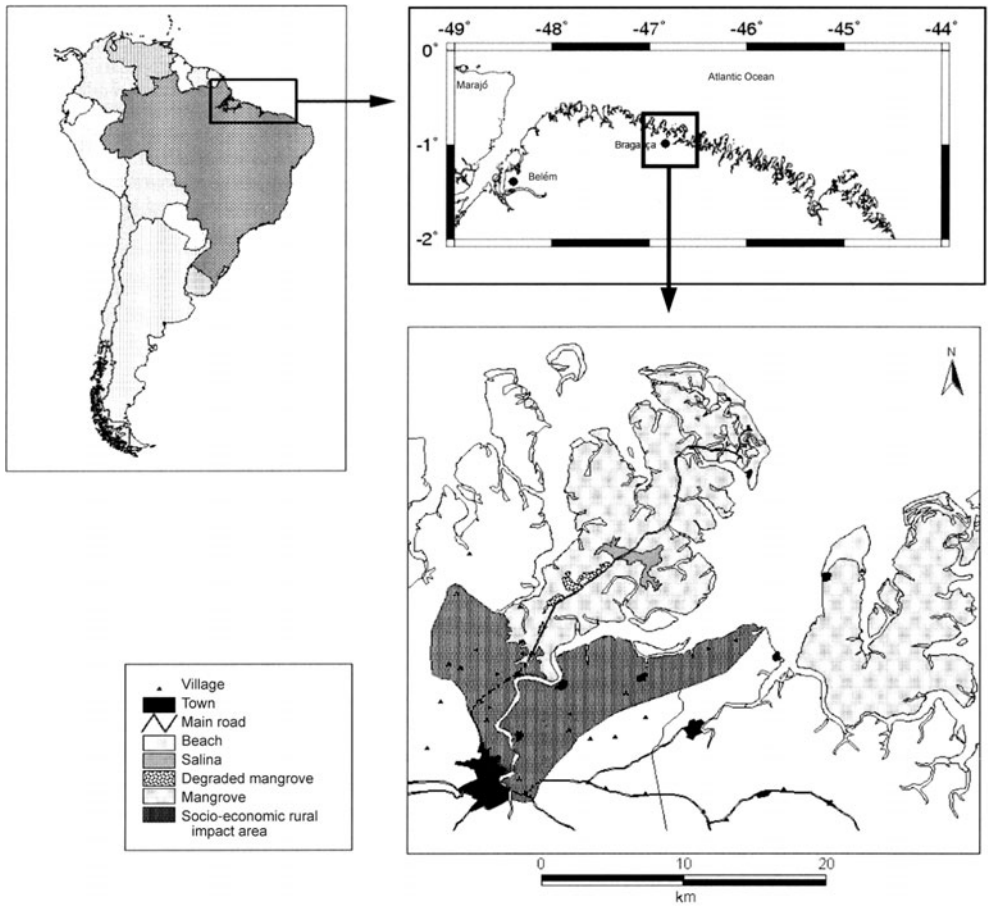


**Fig. 12.2.** The Bragança peninsula under investigation. In the lower figure, the darker shaded area represents coastal villages where residents derive income directly from the mangroves (after Krause *et al*., 2001).

in carapace width. Males are approximately 7.1 to 8.7 years old when they reach the commercial size of 6.5 cm carapace width. As *U. cordatus* feed primarily on leaf litter, they play an important role in the nutrient dynamics of the mangrove ecosystem (Koch and Wolff, 2002) and could be a keystone species for the ecosystem.

The spawning season starts at the beginning of the rainy season, with considerable differences in larval output between years. Reproduction follows a strict lunar rhythm. Females spawn in the flooded mangroves around slack spring high tide, from where they are washed out into the tidal channels. From there, they are exported to the estuary and offshore waters. During their 3–4 weeks of development, they remain in coastal waters and it is the postlarva that returns to the estuarine environment (Diele, 2000).

Crab collectors capture mainly the largest males, whereas smaller specimens, including females, are generally rejected because of a lack of market demand. This sex and size selectivity is typical for crab capture aiming for livestock market sales and carries a high potential for sustainability. Collectors catch the crabs by pulling them out of their burrows by hand or with a hooked stick (*gancho*). Crabs are tied to so-called *cambadas*, which are strings of 14 living animals (Diele, 2000).

**Table 12.1.** Percentage of rural households according to their occupation and income source.

| Occupation/income source | Percentage of rural households |
|---|---|
| Farming | 42 |
| Crab collection (*Ucides cordatus*) | 42 |
| Fishing (commercial) | 31 |
| Retirement pension | 19 |
| Fish and/or crab trade | 9 |
| Crab processing | 9 |
| Other commerce | 11 |
| Other occupations (not related to mangroves) | 16 |
| Other occupations (related to mangroves) | 1 |

**Table 12.2.** Percentage of rural households and their linkage to the mangrove ecosystem (after Glaser, 2003).

| Linkage to mangrove ecosystem | Percentage of rural households |
|---|---|
| Overall mangrove dependence (subsistence and/or commercial mangrove production and/or other mangrove-dependent profession) | 83 |
| Commercial mangrove dependence (commercial crab collection and fishing, sale of charcoal, wood, fish, crabs and other mangrove products (Fig. 12.1) and crab processing) | 68 |
| Fishing (subsistence and commercial) | 54 |
| Commercial fishers | 32 |
| Subsistence fishers | 31 |
| Crab collection (subsistence and commercial) | 64 |
| Crab collection (commercial only) | 43 |

The fishery shows seasonal and annual differences in terms of labour input, capture volume and productivity. During the rainy season, more crab collectors work than during the dry season. The number of crabs captured from 1997 to 2001 varied from 500,000 to 789,000 per year. The CPUE (number of crabs collected per person-day) is from 130 to 176. Income declined from 1998 to 2001 by 20%, leading to an average income of 176 R$ (*reais*)/month in 2001, corresponding to 98% of the officially stipulated existence minimum in Brazil at that time (Glaser and Diele, 2004).

The crab population does not seem to be endangered yet. As crab collectors apply only very simple capture techniques and fail in areas with patches of dense *Rhizophora mangle* roots, these patches thus act as a refuge that prevents a total exploitation and consequently rapid depletion of the targeted large males (Diele, 2000).

The regulation of crab collection is the responsibility of the Brazilian Federal Environmental Agency (IBAMA). Crab collection is illegal during the crabs' annual mating days, when crabs walk on the surface rather than hide in their burrows. However, the crab fishery currently operates under a de facto open-access system, under which entry to the mangroves and use of their resources within the valid management laws cannot legally be denied to the many aspirants. Crab collectors are self-employed, many operating within a classic patron–client dependence relation to a crab trader, depending on the latter for production and emergency loans in exchange for the sale of their crab production at lower than market prices (Glaser and Diele, 2004).

### Fish

The fishery structure in Bragança is divided into two branches, industrial and small-scale. The highly commercial, long-distance

fishing industry contributes significantly to the regional economy; however, it is not linked directly to mangroves. Steel boats usually longer than 12 m are used for fishing trips lasting 20 to 45 days, targeting the more remote areas. Species caught include Pargo (*Lutjanus purpureus*), Pescada amarela (*Cynoscion acoupa*) and pink shrimp (*Penaeus subtilis*), which are sold on both the national and international market.

The small-scale fishery employs simple and traditional technologies. About half of the rural population is engaged in local fisheries. These are subsistence fishermen, who only occasionally sell part of their catch to the local markets. They account for about half of the small-scale fishers (Glaser and Grasso, 1998). They use different types of fishing gear, which can be distinguished by size, type of equipment used and fishing areas. Traditional fishing devices are traps (*corralais*), cast nets (*tarrafas*), a long line (*espinhel*) and harpoons (*arpão*). Captured fish are normally salted in so-called *ranchos*, pile-work barracks located along the bay where fishermen can also stay overnight (Barletta *et al*., 1998).

The other small-scale fishermen work on commercial fishing boats, equipped with low-power engines (42%), sails (26%) or oars (32%). The catch is normally sold through a network of marketing intermediaries to the local markets. As the Caeté estuary and adjacent coastal waters are principally influenced by marine and fresh waters without any notable impact from the Amazon River, Bragança fishing stocks are dominated by marine or brackish-water species throughout the year: gó (*Macrodon ancylodon*), bagre (*Arius hertzbergii*), uricica (*Cathrops* sp.), amoré (*Eleotiedae guavina*) and pratiqueira (*Mugil* spp.) (Barletta *et al*., 1998).

Regarding fish, the mangroves play an important role as nursery habitats and tidal-induced fish migration channels between the estuary and tidal creeks. Detailed descriptions and findings regarding the above processes have been discussed in Barletta-Bergan *et al.* (2002), Barletta *et al.* (2003), Krumme and Saint-Paul (2003) and Krumme *et al.* (2004). These studies demonstrate the ecological importance of mangroves for fish populations, and show that a sustainable exploitation depends on an undisturbed and entire ecosystem.

### Molluscs

The small bivalves *'sururu'* (*Mytella falcata* and *M. guyanensis*) occur on the large banks that appear during low tide in the rivers and tidal channels. The mussel banks themselves vary from 30 to 3000 $m^2$. The density can be from 18 to >100 individuals/$m^2$ (Colin, Bragança, 1999, personal communication). They measure around 35 mm in length as adults.

It is from these banks that the fishermen exhume the *sururu* from the mud using their hands, placing the mussels in vegetable fibre baskets known as *caçuá*. Grasso (2000) assigns market prices to mangrove subsistence values for products such as mussels at US$35/month. However, this activity is more important for household consumption than for commercialization. *Sururu* is not always exploited. Glaser and Grasso (1998) reported that once a *mina de sururu* (which is the local expression for a mussel accumulation) is found, rural producers abandon crab collection to exploit them.

The mangrove oyster (*Crassostrea rhizophorae*) is not commonly found in this research area as generally the mangrove is inundated only during spring tides on average about 9 days/month. However, in other more coastal areas, oysters are found frequently and are enjoyed by the tourists. Attempts to cultivate oysters have been reported to be successful. For cultivation, larvae are captured from mangrove roots and are placed in special devices (rafts) for 3–4 months with periodical immersion during low tides. Commercially viable size (6–8 cm) of the oysters is reached in 16–18 months.

The ship bore worm *turu* (*Teredo* sp.) is also collected by families dependent on mangroves. The worm is collected from the dead wood of fallen mangrove trees for domestic use and not for commercial purposes. *Teredo* is usually consumed alive. Occurrence numbers are not yet available.

### Wood

Although mangroves are protected by law, extensive deforestation in the research area, an increase of leather tannin manufacturing that uses mangrove tree bark (mainly *R. mangle*) and the burning of mangrove wood in brick kilns and bakery ovens are widespread and well known (Glaser *et al*., 2003). Commercial brick kilns burn the largest quantity of mangrove wood in the research area. Wood is also used for house and boat construction and for cooking purposes. *Avicennia* is preferred for burning purposes as it is able to keep the fire alight for longer (Grasso, 2000).

It is estimated that more than 90% of the rural households collect mangrove wood as domestic cooking fuel (Glaser *et al*., 2003). Villages engaged in industrial crab production also use timber as fuel for cooking. Another common use of mangrove wood is to build fish traps and wires. When used for this purpose, the wood is called poles and posts. Poles used for this purpose must be at least 10 cm in diameter.

## Discussion

Federal Brazilian legislation defines forests and other areas that support dune and mangrove growth as areas of permanent protection. This implies the prohibition of all human interference except scientific, educational and ecosystem recovery work. The national coastal management plan makes all activities that lead to the degradation of ecological stations and reserves punishable by law. Glaser *et al*. (2003) provide a detailed overview on the legislation relevant to mangroves. This makes the discrepancy between legislation objectives and reality very evident.

However, an important outcome from our investigations is that the dependence of the primary producers on the natural resources of the mangrove area is clear. Even if the ecology of the system can still be considered tolerably undisturbed by human activities, there is a considerable increase in remote and local anthropogenic interference (Krause *et al*., 2001). Mangrove resources constitute subsistence food security for the poorest coastal households and the sale of fish and crabs is central to rural livelihood strategies in mangrove-adjacent areas. More than 83% of rural households harvest natural resources associated with mangroves (Glaser *et al*., 2003). Use pressure on these products is increasing because of coastward migration, a lack of alternative income options for coastal dwellers and a rising urban demand for mangrove products.

Glaser *et al*. (2003) pointed out that users are typically aware of their own long-term need to maintain mangroves and are interested in sustainable, long-term management of mangroves within their area.

Because previous attempts of centralized, state-managed conservation to achieve effective mangrove management have mostly been unsuccessful, co-management-oriented concepts are being considered as an alternative.

Extractive reserves (RESEX) have been considered as a legal option for the co-management of natural resources in Brazil since 1988 and have come into focus as a solution to coastal mangrove management problems. Brazil Federal Decree No. 98.897 of January 1990 established that RESEX are 'territorial spaces destined for the self-sustained exploration and conservation of renewable natural resources by user populations' (Glaser and Oliveira, 2004). Under the RESEX concept, rule-making authorities, resource-use rights and management duties are assigned to local associations of interested residents who, with official capacitation and training and with intermittent implementation assistance from conservation authorities, are expected to generate the control and management quality that top-down, coercive state management has been unable to provide (Glaser *et al*., 2003). RESEX were discussed for the first time in 1985 under the leadership of Chico Mendes to meet the interests of *seringueiros* in Amazonia. For aquatic resources of the Amazon flood plains (*várzea*), this concept had been applied successfully in the early 1990s. This concept proposed the transfer of fishing rights and their management to riverine communities with

the aim of guaranteeing fish supply for subsistence (McGrath *et al.*, 1994). Rather than fence people away from the mangrove, extractive reserves are supposed to permit people to manage the forest without destroying it.

According to Glaser and Oliveira (2004), the aims of RESEX can be summarized as follows:

- protection of nature through use,
- improvement in living conditions for the traditional users of natural resources,
- integration of traditional users into national development processes, and
- promotion of user cooperation, that is, collective decision-making and action.

Effective co-management depends on the active participation of local ecosystem users and must not be contrary to the current environmental legislation. If successful, RESEX may turn the current, non-viable, open-access regime into a viable form of user-regulated and use-monitored common-pool management (Glaser and Oliveira, 2004). However, no data are available so far on how many people can be supported on a sustainable basis by 1 ha of mangrove area. And, experiences from the rainforest extractive reserves show clearly that waves of migrants entering the coastal zone cannot be absorbed by such a system. Therefore, RESEX are best viewed as part of the mosaic of land-use systems in the region, rather than as a social and ecological panacea.

## Conclusions

These studies have revealed the relationship between the rural population in Caeté Bay and the mangrove ecosystem. The results make it evident that the preservation of the mangrove system in the region is fundamental to maintenance of the households' quality of life. The mangroves provide subsistence products for nutrition, housing and fuel, as well as commercial products from which income is generated. Further mangrove degradation will result in significant income loss for the locals and increase the potential for social conflicts.

It is still unclear whether the actual use of mangrove resources is sustainable. The RESEX concept is an attempt to turn the Caeté area into user-regulated and user-monitored common-pool management. A final evaluation will show the success or failure of such co-management.

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