Chapter 7
Community-Based Management of Amazonian Biodiversity Assets

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7.1 The Amazon Socioecological System

The Amazon basin hosts about half of the remaining tropical forests on Earth (Hansen et al. 2013) and a huge diversity of freshwater and terrestrial biodiversity. In addition, it also sustains a multiplicity of human societies, with an impressive linguistic and cultural diversity that evolved in a complex landscape pervaded by an extensive network of rivers (Arias et al. 2018). In parallel, the Amazon forest also represents a great temptation to the governments of nine South American

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countries in terms of industrial development, due to immeasurable high-value natural resources occurring within their boundaries. Therefore, reconciling sustainable pathways for biodiversity conservation, poverty alleviation, social insurance of traditional communities and economic growth, will determine the fate of the largest tropical forest on Earth.

The socioecology of the Amazon is highly diverse, formed not only by a variety of indigenous groups but also by small farmers, extractivists, and artisanal fishers, each with different cultures and relations with the forest and its natural resources (Lima and Pozzobon 2005). Biodiversity and ecosystem services represent the cornerstone of Amazonian cultural maintenance, which is intertwined with traditional activities such as fishing, hunting, and harvesting of forest products (Sunderlin et al. 2005). In this context, effective management of natural resources is one of the most imperative local demands, but also a challenging task, due to severe shortages of research funding and human resources (Campos-Silva et al. 2015; Magnusson et al. 2018), and often unrealistic expectations about what can be defined as demographically sustainable exploitation (Peres 2011; Terborgh and Peres 2017).

Protected Areas (PAs) represent the main existing strategy to protect natural resources, biodiversity, and traditional livelihoods (Bruner et al. 2001; Coetzee et al. 2014; Watson et al. 2014). However, tropical PA systems in developing countries, such as Brazil, face particular challenges, which strongly compromise their effectiveness against the powerful drivers of deforestation, overexploitation, and habitat destruction from mining, dams and other developments (Bruner et al. 2004). A clear example is the PA system in State of Amazonas (Brazilian Amazon), where only three staff are designated to manage all 42 state PAs, which corresponds to one park manager for every 6.3 Mha of PAs (Campos-Silva et al. 2017). This current PA system is evidently not enough to ensure the conservation of the Brazilian Amazon, and new strategies should be urgently designed.

Formal partnership with local communities, such as community-based management (CBM) or co-management arrangements, represent a promising alternative to increase local governance, decentralize decision making, strengthen surveillance systems, and reduce conservation costs (Somanathan et al. 2009). There are positive examples worldwide, where local communities play a central role in local resource management (e.g., Gibson and Marks 1995; Cinner et al. 2012a, b). CBM has been particularly successful in the Amazon, promoting strong ecological benefits, ensuring the conservation of a large set of taxonomic groups and the population recovery of overexploited species (Castello et al. 2009; Campos-Silva and Peres 2016; Petersen et al. 2016; Campos-Silva et al. 2017, 2018). At the same time, CBM initiatives have strongly contributed to the development of rural communities, improving many mainstream and unconventional socioeconomic indicators, including income generation, community pride, and maintenance of cultural capital (Campos-Silva and Peres 2016).

7.2 CBM of Biodiversity Assets as Bright Spots in the Amazon

Biodiversity assets can be understood as any resource or relationship that can be managed or protected, generating forms of values for individuals, communities, or institutions (Jepson et al. 2017). Beyond the material value, represented by income generation, food security and resources used on a daily basis, the assets concept also incorporates immaterial values that add emotion, pride, sense of justice, and different cosmologies that are not necessarily aligned with a hegemonic neoliberal paradigm. These subjective values are important to strengthen collective actions capable of shaping the social dynamic within broad socioecological systems (Jepson et al. 2017).

The Amazon basin hosts at least two successful CBM initiatives that have led to positive outcomes for both biodiversity conservation and local well-being. These examples can be considered as "bright spots" able to inspire new pathways where biodiversity conservation and local needs are truly aligned. Focusing on these bright spots is a powerful ingredient to build conservation optimism, which can strongly influence decision makers and stakeholders (Cvitanovic and Hobday 2018). These positive examples have high potential for being scaled up throughout Amazonian floodplains and to become an effective and decentralized conservation tool at vast spatial scales. Here, we elucidate how two examples of CBM have been working to date along the Juruá River, a major tributary of the Amazon River. We describe the operational mechanisms of these impressive examples, identifying the main ingredients to consolidate a robust CBM program, which can be applied in different contexts to achieve strong social and ecological outcomes elsewhere.

7.3 Socioecological Context of the Juruá River

The Juruá River is characterized by its large highly productive floodplains, sustaining hundreds of indigenous and nonindigenous human settlements (Fig. 7.1). The landscape is comprised of seasonally flooded (*várzea*) forests across the whole floodplain and adjacent upland (*terra firme*) forests (Hawes et al. 2012). The Juruá, especially the middle section of this river, played an important role during the rubber boom, where thousands of people from northeast Brazil migrated to the Amazon to work as rubber tappers. These people lived under conditions that almost amount to slavery, without social rights, and often suffering from severe destitution, debt patronage, tropical diseases, and lack of access to health and education (Almeida 2002). With the help of the Catholic Church and the environmental movement that took shape around the public figure of the social activist Chico Mendes, these local communities started a process of self-organization to ensure essential social and land rights (Fearnside 1989). In this context, two large sustainable-use PAs were created in this region. The federally managed Médio Juruá Extractive Reserve

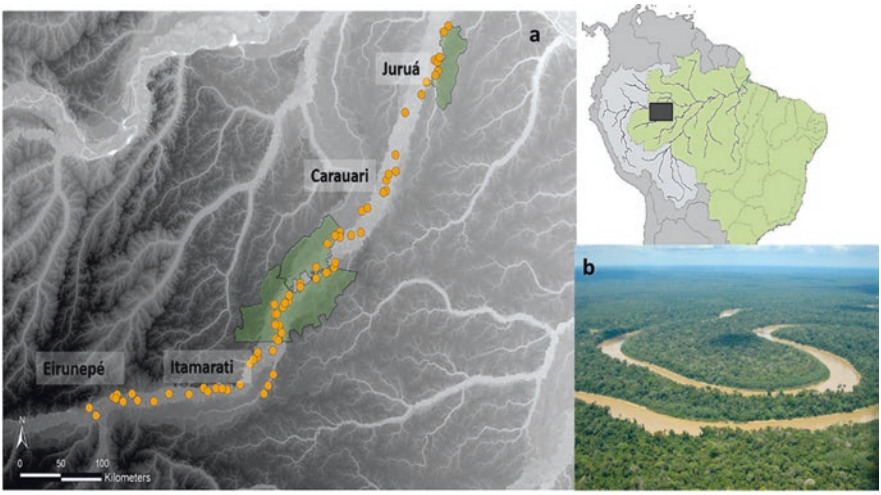

Fig. 7.1 (**a**) Distribution of protected areas across the Juruá River in western Brazilian Amazonia. The orange circles represent the rural communities. Green polygons represent three sustainable-use forest reserves. (**b**) The meanders of Juruá River

(ResEx Médio Juruá; 5°33′54″S, 67°42′47″W) was created in 1997 and hosts some 700 people distributed across 13 villages in its 253,227 hectares. The state-managed Uacari Sustainable Development Reserve (RDS de Uacari; 5°43′58″S, 67°46′53″W) hosts about 1200 villagers living in 32 communities within its 632,949 hectares. The local economy in both reserves is sustained by fisheries, slash-and-burn agriculture, and nontimber forest products, such as oil seeds and palm fruits (Newton et al. 2011), and supported by payments for environmental services (Alves-Pinto et al. 2018), but two examples of CBM stand out for generating broad social and economic benefits for rural communities: the CBM of arapaima and freshwater turtles.

7.4 Community-Based Management of Arapaima

Arapaima (*Arapaima gigas*), also referred to as pirarucu or paiche, is the largest freshwater scaled fish on Earth, reaching up to 3 m in length and over 200 kg in weight (Nelson 1994). This iconic species has played a central subsistence role in the Amazon since pre-Columbian times (Prestes-Carneiro et al. 2016). However, over the last century arapaima populations suffered a dramatic decline due to intensive commercial pressure, and were extirpated in many areas (Castello et al. 2015). Arapaima fishery was then banned by the Brazilian government, yet such measure was not enough to ensure recovery due to widespread high levels of illegal fishing (Castello and Stewart 2010; Cavole et al. 2015). In an attempt to reverse the arapaima population collapse, local communities, experienced fishers, and researchers

first started a CBM model in 1999 at the Mamirauá Sustainable Development Reserve (Castello et al. 2009, 2011).

Arapaima evolved in an anoxic lake environment, and natural selection led to changes in the swim bladder, which became adapted for breathing (Brauner 2004). As a result, arapaima regularly comes to the surface to capture oxygen directly from the air, and individuals can therefore be visually counted by trained fishers following a standardized protocol (Castello 2004). This natural feature has broad implications for harvesting management; it allows the population size of arapaima to be reliably estimated, and from these estimates the government assigns an undifferentiated harvest quota of up to 30% of adult individuals in each CBM unit (Castello et al. 2011). Another important feature of the CBM scheme is that local communities need to zone their water bodies, including areas for protection (protected no-take lakes), and to ensure full-time local surveillance against poaching. This initiative proved to be highly successful (Castello et al. 2009), and as a consequence arapaima CBM schemes have since spread to other areas across the Amazon.

Studies have shown that arapaima CBM has been generating impressive outcomes in several sites across the Amazon, for both biodiversity conservation and the well-being of rural communities (Castello et al. 2009; Campos-Silva and Peres 2016; Petersen et al. 2016). Along the Juruá River, in western Brazilian Amazonia, community-based protection of lakes has induced a huge recovery of arapaima populations, with an increase of 425.2% within 11 years of CBM (Campos-Silva et al. 2019). Even outside PAs, arapaima population trends show the same pattern, increasing 397.5% per year (Campos-Silva et al. 2019). A single protected lake can host more than 2800 individuals, while unprotected lakes on average only support nine individuals (Campos-Silva and Peres 2016; Campos-Silva et al. 2019), which underlines the high success of this model. The same pattern was found in other river basins, where arapaima has also been brought back from the brink (Castello et al. 2009; Petersen et al. 2016). In addition to conservation gains for arapaima, community-based protection of lakes also benefits a large set of co-occurring species, including caimans, freshwater turtles, and other fish species (Miorando et al. 2013; Campos-Silva and Peres 2016; Arantes and Freitas 2016).

Furthermore, beyond these ecological outcomes, arapaima CBM has also triggered a substantial social transformation in Amazonia, through improvements in rural well-being. First, protected lakes ensure an annual income to rural people typically short on other options for earning cash. The social security that this provides allows revenues to be saved and used in cases of emergency, for example, urgent health care (Campos-Silva and Peres 2016). Second, profits secured from the harvest can also help improve basic infrastructure and living conditions in households and communities (Campos-Silva and Peres 2016). Other important social outputs perceived by people actively participating in arapaima CBM are improved food security, community pride, cultural maintenance, and a more equitable distribution of profits from fisheries (Campos-Silva and Peres 2016).

7.5 Community-Based Management of Amazonian Freshwater Turtles

Freshwater turtles, particularly those from the genus *Podocnemis*, including *P. expansa, P. unifilis* and *P. sextuberculata*, also show a high cultural value throughout Amazonian history by both indigenous and nonindigenous dwellers (Prestes-Carneiro et al. 2016). Recorded uses other than the consumption of meat and eggs, include fat to produce oil for fuel, medicine (e.g., fat and bone), and the carapace for ritual purposes and as a tool (Smith 1979; Rebêlo and Pezzuti 2000; Pezzuti et al. 2010). As for arapaima, many freshwater turtles and especially the Giant South American turtle (*P. expansa*) experienced huge population declines over a large geographic scale due to historical commercial overexploitation (Schneider et al. 2011).

In an attempt to reverse the imminent population collapse in turtle stocks and to safeguard the high-value resource they potentially provide, the Brazilian government in partnership with local communities started a process of CBM in the early 1970s, focused on the protection of fluvial beaches which *P. expansa* (and other *Podocnemis* species) use to nest (Andrade 2007; Cantarelli et al. 2014). Freshwater turtles are still considered a high-value delicacy among rural and urban people (Rebêlo and Pezzuti 2000), and their conservation strongly depends on local support in about 390 protected beaches across Brazilian Amazonia. At each of these beaches, beach guards ensure local surveillance throughout the breeding season, which results in reduced poaching of nesting females and their eggs (Campos-Silva et al. 2018).

Similarly to arapaima CBM, community-based beach protection has led to strong ecological outcomes. For example, after 40 years of CBM along the Juruá River, populations of freshwater turtles are in a recovery process (Campos-Silva et al. 2018). The number of Giant South American turtles nesting there is 58-fold higher on protected beaches compared to unprotected beaches, and nest poaching is about 2% and 99% in the protected and unprotected beaches, respectively (Campos-Silva et al. 2018). Collateral benefits from beach protection are also widespread across other taxonomic groups, including caimans, birds, iguanas, fishes, and even invertebrates (Campos-Silva et al. 2018), reinforcing the role of freshwater turtles as an umbrella species through beach protection.

An important difference between the CBM of arapaima and freshwater turtles is the current lack of economic returns in the latter. In our study region along the Juruá River, beaches are guarded 24/7 throughout the entire breeding season (5 months), yet beach guards receive only around U$ 110 in the form of a food hamper (Campos-Silva et al. 2018). Considering the high personal life risk undertaken, and the physical and mental effort required for effective protection, it is clear that beach guards are severely underpaid for their services. Despite their dedication to the cause, dissatisfaction among beach guards is increasing, threatening the continuity of this successful program over the long term (Campos-Silva et al. 2018).

7.6 Principles Ensuring Success of Amazonian Bright Spots

The literature to date identifies a set of important principles for achieving the cohesive management of common natural resource pools at the local community level (Ostrom 2009; Cox et al. 2010, 2016). These principles often occur in successful projects that deliver positive outcomes for both biodiversity conservation and local welfare (Pinkerton and Weinstein 1995; Castello et al. 2009; Cox et al. 2010; Gutiérrez et al. 2011; Campos-Silva and Peres 2016). From a literature review of such recognized principles on common pool resource management and our own collective experience in Amazonian CBM programs, we present a model comprising the social and institutional principles, and the intrinsic values inherent in biodiversity assets, which have been used by traditional communities for centuries (Fig. 7.2). This model can help strengthen existing CBM programs in Amazonia and inspire new initiatives.

As the first principle, the presence of leadership and social capital seems to be fundamental in successful examples of CBM (Gutiérrez et al. 2011). Strong leadership, defined as an individual with entrepreneurial behavior and high motivation who is respected as a local leader, can inspire behavioral changes within the wider community, increasing local engagement, commitment, and collective compliance of other residents (Gutiérrez et al. 2011). However, it is very important that local leaders do not use their privileged condition and access to economic opportunities for self-benefits, which can erode their own legitimacy (Muehlig-Hofmann 2007). Social capital, in turn, reflects the ability of a local community to sustain a strong cohesion based on explicit norms, high levels of trust, and dynamic networks with a wide set of stakeholders (Gutiérrez et al. 2011) and can strengthen the

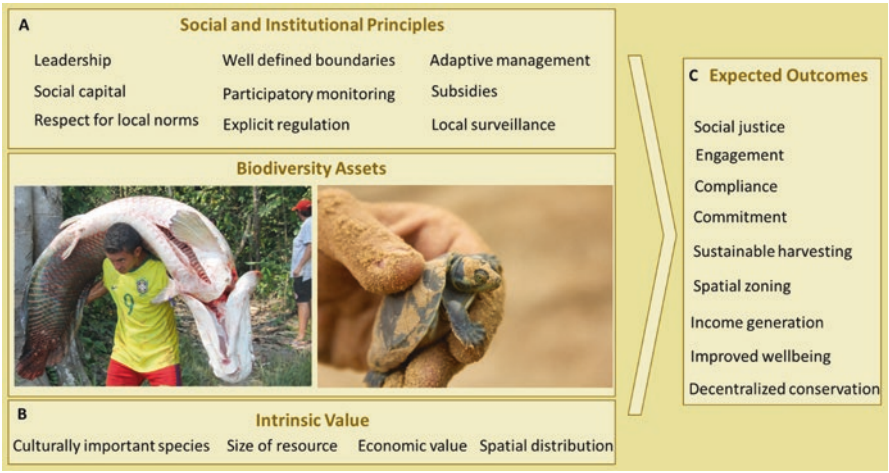

Fig. 7.2 Schematic showing (**a**) important social and institutional principles and (**b**) intrinsic values from biodiversity assets to ensure the expected outcomes (**c**) in community-based management (CBM) of biodiversity assets

management model as a whole (Pretty 2003). Therefore, identifying communities with strong local leaders and social capital should be a starting point in the process of CBM establishment.

The use of culturally noteworthy species as a flagship species is another important strategy, which can improve the engagement of local people in conservation and management initiatives (Garibaldi and Turner 2004; Freitas et al. 2020). Culturally important species play a central role in community subsistence, material acquisition, medicine, cultural identity, and/or spiritual values (Cristancho and Vining 2004; Garibaldi and Turner 2004). In Amazonia, there are a large number of species closely associated with human culture. For example, both arapaima and freshwater turtles have had a strong subsistence and cultural importance since pre-Columbian times (Prestes-Carneiro et al. 2016; Freitas et al. 2020). Besides this form of cultural importance, the economic value of the target species may also be important, in order to sustain a value chain and generate income for rural communities. Reliable economic returns can increase the likelihood of creating a cohesive management system, with high levels of engagement and compliance among users. However, to ensure sustainable harvests of a high-value species, the population size of the target species must be large enough to tolerate the harvesting dynamic (Ostrom 2009). For example, the management of arapaima, a culturally important species with high economic value and large population sizes within protected lakes, has generated substantial income at many sites across Amazonia (Campos-Silva et al. 2017). In contrast, freshwater turtles also have a high subsistence and market value, but do not currently generate a financial return, because in many localities the population size is not large enough to support a sustainable harvest and the commercial exploitation of these species is still illegal (Campos-Silva et al. 2018).

To ensure the sustainable harvesting of biodiversity assets, one of the most prominent characteristics of these Amazonian CBM models is the establishment of well-defined no-take zones (Campos-Silva et al. 2017), which arguably represents a cornerstone principle in common theory (Ostrom 2009). Explicit zoning of harvests, including "no-take" areas between human settlements, may ensure the successful reproduction of target species and the replenishment of wild populations through source-sink dynamics (Novaro et al. 2000; Levi et al. 2009; Antunes et al. 2016). This is highly relevant in Amazonian floodplains, where many fish species can move between aquatic environments during the flood pulse (Junk et al. 1989). In this context, it is also important to take into account the ecological requirements of the target species, such as their life cycle, habitat preferences, and migration behavior, to ensure that suitable habitats for foraging and reproduction are included in the spatial arrangement of the management zones (Campos-Silva et al. 2019). Spatial zoning appears to be best enforced, at least in the case of arapaima and freshwater turtles, through a strong surveillance system conducted by local residents, which ensures compliance and precludes poaching.

A clearly defined harvest quota is another essential component of sustainable harvest program (Costello et al. 2008). In the case of arapaima, the Brazilian government allows up to 30% of the adult population to be harvested, conditioned to some organizational requirements, including suitable infrastructure, a

well-established value chain, and appropriate community organization (Campos-Silva and Peres 2016). While freshwater turtles are currently not legally harvested to generate income, there is already a trial program to work toward a sustainable quota for harvesting hatchlings, which can then be reared in captivity and later sold in local markets (Alho 1985; Andrade 2007).

Institutional principles may also be strong predictors of effective co-management initiatives (Berkes 2007; Ostrom 2009), ensuring a high level of autonomy, decentralizing the decision-making process, and reducing the overall costs of conservation (Somanathan et al. 2009). Respecting sociocultural contexts and Local Ecological Knowledge (LEK), for example, is an important component of successfully common pool resources management (Baggio et al. 2016). In the arapaima CBM, fishers' knowledge is one of the most important attributes sustaining the entire management system (Castello et al. 2011). In particular, participatory monitoring provides an opportunity to include LEK in management arrangements, and strongly contributes to the process of empowering local communities (Constantino et al. 2012). Both case studies we presented here exemplify how important LEK is for generating relevant information, such as comprehensive population assessments (Castello et al. 2009; Campos-Silva and Peres 2016; Campos-Silva et al. 2018).

Explicit regulations are important to ensure governance transparency, which is also a very important component of an effective natural resource management (Lockwood et al. 2010). Governments can play an important role regulating the management activity, such as in the case of arapaima, where the quota and permits are authorized by the Brazilian federal government. Adaptive management, which covers many others principles, including the use of LEK to evaluate and respond to internal forcing from the environment (Berkes et al. 2000), increases the speed of local responses to unforeseen circumstances, improving the resilience of the activity (Olsson et al. 2004).

Social rights and local aspirations of indigenous and nonindigenous dwellers in rural Amazonia have been neglected for a long time by the Brazilian government, compromising local autonomy and capacity building (Schwartzman et al. 2010; Vadjunec et al. 2011). To redress this balance, multiscale partnerships and subsidies are fundamental principles for the management of Amazonian common pool resources (Berkes 2007; Ostrom 2009), and are strongly desired in the initial stage of CBM establishment. The combination of different skills from multiple institutions, aligned with funding to boost management practices, can help to break the inertia built up over the past centuries in terms of local participation in decision making and the lack of technical expertise often observed in rural Amazonia.

The Amazon has been a scenario of profound interactions between humans and wildlife for millennia (see Clement et al. Chap. 3). This strong human–nature relationship has created a rich knowledge bank, used by human civilizations to build their social–ecological systems (Odling-Smee et al. 2003; Albuquerque et al. 2019). However, over the last 30 years, industrialized Brazilian society has destroyed more than 436,000 km^2 of Amazonian forest (INPE 2019), dramatically impacting local livelihoods and biodiversity. The alignment of biodiversity conservation and local welfare is one of the most imperative needs in Brazil today, both for biodiversity

conservation and for the social justice of traditional tribal and nontribal populations still inhabiting the Amazon. Focusing on Amazonian bright spots can help us send a clear message of hope and action, which is critical to awaken the attention of local to international policymakers, and encourage both managers and stakeholders to increase their efforts to implement these successful management examples elsewhere.

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