Received 25 September 2023
Revised 15 December 2023
Accepted 30 January 2024

Managing circular ecosystems in imperfect contexts – the case of extractive fishing in the Brazilian Amazon region

Neuzaí Marreiros-Barbosa,[a,*] Pedro Ibrahim Hellmeister,[a] Adriana Marotti De Mello[a] and Antonio Carlos Braz[a]
[a]*School of Economics, Business Administration and Accounting, University of São Paulo (FEA-USP), Sao Paulo, Brazil*

Abstract

Purpose – This study aims to answer the question of how to structure a circular ecosystem for extractive fishing in the Amazon region. It explores possibilities for implementing a circular ecosystem management model in an imperfect market with low technological availability, high informality and limited public assistance.

Design/methodology/approach – Qualitative approach was adopted for this paper, with a case study on extractive fishing in the state of Amazonas. Data was collected through 35 interviews and direct observation of the processes of collecting, storing and transporting fish on two routes: Tapauá-Manaus and Manacapuru-Manaus.

Findings – Through the data collected, it was possible to observe the importance of an orchestrating agent – such as an association or even a public authority – for the establishment and development of a circular ecosystem for extractive fishing in the region.

Research limitations/implications – The paper makes theoretical contributions by presenting how a circular ecosystem management model could be implemented for an imperfect market in the Global South, as well as contributing to the literature on how the circular economy contributes to mitigate the threat to biodiversity posed by the linear economy.

Practical implications – It contributes to the management practice of structuring circular ecosystems.

Social implications – The role of public authorities and the collective organization of fishermen as orchestrators connecting the network of actors that develop the extractive fishing ecosystem is fundamental, guaranteeing effective social participation in solving local problems.

Originality/value – The idea of circular ecosystems was applied to imperfect contexts, with high informality, weak institutions and bioeconomy, topics still little explored in the literature.

Keywords Amazon, Bioeconomy, Circular economy, Circular ecosystems

Paper type Research paper

RAUSP Manag. J.
Vol. 59 No. 2, 2024
pp. 154-170
Emerald Publishing Limited
2531-0488
DOI 10.1108/RAUSP-09-2023-0187

1. Introduction

Fishing plays an important role in food security and the local and regional economy of the rural Amazon region (Costa et al., 2021; Tregidgo, Barlow, Pompeu, & Parry, 2020). Abramovay et al. (2021) argued that the lack of storage, processing and transport infrastructure limits the economic growth of fishing and the lack of access to reliable energy sources subjects fishermen to the demands of local agents who own ice factories or are forced to sell their products to intermediaries at very low prices.

Costa et al. (2022) and Abramovay et al. (2021) pointed out that most of the existing proposals for a sustainable bioeconomy for the tropical regions of the Global South, of which the Amazon is a part, are inadequate, taking into account the biological, cultural and social diversity of the region, while still preserving the integrity of the biome and incorporating the traditional knowledge of the peoples who have maintained it for millennia. Bugge, Hansen, and Klitkou (2016) proposed an economic system that associates surpluses with the promotion of biodiversity and the conservation of ecosystems. The authors emphasize local solutions based on diversity, the reuse of matter and energy and the management of species and their interactions. As Costa et al. (2022) emphasize, solutions should be sought that promote the circular use of materials and energy, as well as reducing inputs and energy sources external to the system in question. At the same time, ensuring greater social participation and the distribution of benefits between different participants in a given value chain is crucial (Bastos Lima & Palme, 2022).

Although the factor of circularity in solutions is emphasized by authors either directly (Abramovay et al., 2021; Costa et al., 2022) or indirectly (Bugge et al., 2016), with solutions that dialogue with the circular economy principles of reduction, reuse and chain closure (Ellen MacArthur Foundation, 2015), so far the focus of the circular economy has been on technological reconfiguration and on saving resources and energy circulation, with limited attention to social and ecological factors, including the reduction in biodiversity (Desing et al., 2020; Hobson & Lynch, 2016; O'Gorman, 2016; Sauvé, Bernard, & Sloan, 2016; Geissdoerfer, Savaget, Bocken, & Hultink, 2017; Kirchherr et al., 2017).

It is discussed in the literature that the transition to a circular economy must take place through the orchestration of a circular ecosystem (Gomes et al., 2023). For the transition to happen, a circular value proposition must be identified and circular configuration management practices must be established (Gomes et al., 2023). The concept of a circular ecosystem appears as an option to address the interdependent relationship between various actors (Thomas & Autio, 2020), its complementary nature (Shipilov & Gawer, 2020) and the governance aspects of this ecosystem (Jacobides, Cennamo, & Gawer, 2018). In addition, a circular ecosystem is characterized by the absence of hierarchical and contractual relationships between the actors that are part of it, in which their roles, activities and positions tend to be fluid and unstable (Adner, 2017; Micheli & Muctor, 2021; Trevisan, Castro, Gomes, & Mascarenhas, 2022). These characteristics are common to the context of extractive fishing in the Amazon, marked by unstable relationships between agents, a lack of governance mechanisms (Costa et al., 2021) and unequal power relations (Abramovay et al., 2021), in which the structuring of a circular ecosystem could contribute to generate circular value in the region promoting sustainable economic growth for the region's population.

Therefore, in light of the above, this article will seek to answer the following question: how can we structure a circular ecosystem for extractive fishing in the Amazon? In this sense, the main objective of this article is to analyze possibilities for the development of a circular ecosystem in extractive fishing, bearing in mind the imperfect market context of fishing activity, with low technological availability and little support from public authorities

(Abramovay et al., 2021). The article makes theoretical contributions by presenting a circular ecosystem management model for an imperfect market in the Global South, as well as contributing to the academic literature on how the circular economy contributes to mitigating the threat to biodiversity posed by the linear economy (Buchmann-Duck and Beazley, 2020). It also contributes to the management practice of structuring circular ecosystems, which can be considered as a basis for drawing up public policies aimed at benefiting communities that live off extractive fishing in the region.

2. Theoretical background

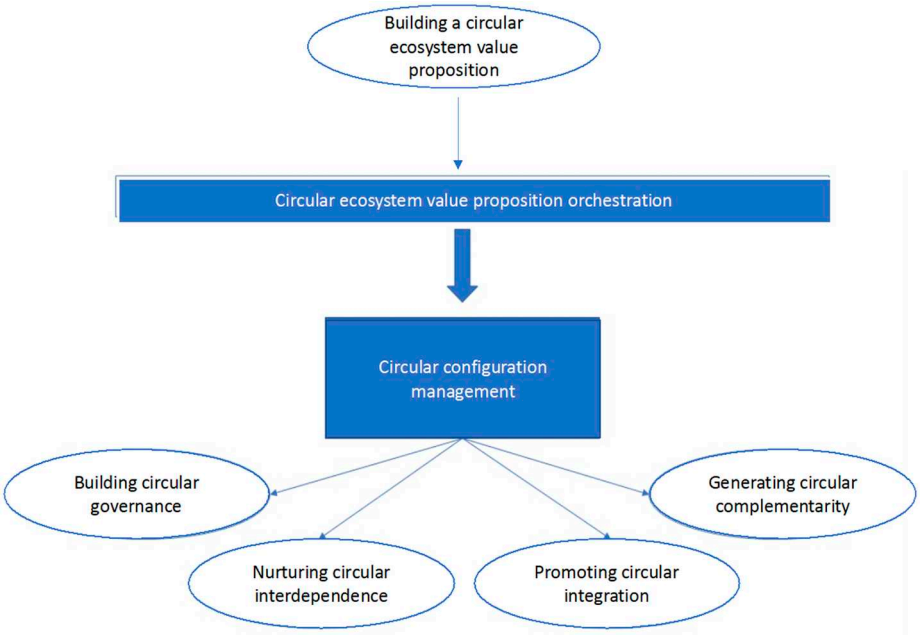
2.1 Circular ecosystems

A circular ecosystem consists of a group of autonomous and interdependent actors that collectively generate a circular value proposition (Gomes et al., 2023; Trevisan et al., 2022; Kanda, Geissdoerfer, & Hjelm, 2021). Gomes et al. (2023) defined the value proposition of a circular ecosystem as an arrangement of benefits for a given audience, which involves principles and requirements for a circular economy. In this way, the value proposition is structured based on the composition of the ecosystem, the definition of the objectives and how the actors contribute to achieving them (Thomas & Autio, 2020). From this description, the value proposition can only be delivered if there are collective efforts (Thomas & Autio, 2020).

The value proposition of the circular ecosystem directs the management of circular configurations, a process in which organizations define or redefine the roles, activities, interrelationships and flows between actors to materialize this proposition (Gomes et al., 2023; Kanda et al., 2021). Based on the framework developed by Gomes et al. (2023), the authors highlight the following processes related to circular configuration management (shown in Figure 1): "building circular governance", "fostering circular interdependence", "promoting circular integration" and "generating circular complementarity". The following paragraphs will describe each of these processes and their respective subprocesses for managing the circular configuration.

"Building circular governance" represents the set of activities related to coordination, collaboration and alignment of efforts to materialize the ecosystem's circular value proposition (Gomes et al., 2023). In a circular ecosystem, the types of actors are not restricted to suppliers but also involve complementary agents who, in turn, tend to have relative autonomy from the focal companies, as Gomes et al. (2023) point out. For example, relations between fishermen and intermediaries are not contractual (as will be shown in the case description). Also, according to the authors, a subprocess for building circular governance consists of "defining the rules of participation", i.e. a set of policies, incentives and regulations that establish the inclusion, permanence or exclusion of an actor in a given circular ecosystem. The same authors also emphasize that the focal company depends on how other agents generate value that complements the circular ecosystem's value proposition and it is up to the focal companies to define governance to specify roles and results relating to collaboration in value creation processes. Gomes et al. (2023) called this subprocess "defining the rules for value creation".

A fundamental characteristic of ecosystems is the interdependence between actors (Adner, 2017; Hou and Shi, 2021; Jacobides et al., 2018). Gomes et al. (2023) identify the process of "fostering circular interdependence" to consolidate the ecosystem and materialize the value proposition, which depends on the performance and actions of different actors. This mechanism is made up of the subprocesses of "identifying interdependencies between actors in the ecosystem", marked by the mapping of opportunities and dependencies in the interrelationship between actors; "developing interdependencies", a set of mechanisms used by the focal company to make it possible for a complementary agent to offer solutions; and



Source: Adapted from Gomes et al. (2023)

Figure 1.
Circular ecosystem management theoretical framework

"reinforcing interdependencies" between the actors in the ecosystem, involving the continuous development of solutions and training to guarantee continuity in the relationship of dependency between the actors. For example, the authors cite the joint development of technologies that enable the services that complementary agents provide to a focal organization.

Multilateral relationships, the relative autonomy of complementary agents and the absence of hierarchical control in ecosystems (Adner, 2017) require constant alignment between ecosystem actors to generate a coherent circular ecosystem value proposition (Gomes et al., 2023). The authors highlight the "promotion of circular integration" as processes through which organizations map, incorporate and align the different aspects of the circular ecosystem configuration to materialize the proposition. According to the researchers, the "incorporation of new objects, roles, actors and links" and the "alignment of different aspects of a circular ecosystem" are key subprocesses for generating circular integration. In the first subprocess, there is a search for candidates, including universities and start-ups, to develop new production processes. In the second subprocess, the authors cite as an example an initiative by the focal company that made collection points available to reduce production bottlenecks related to the low volume of waste.

Extending the notion of complementarity (for example, in Granstrand and Holgersson, 2020; Jacobides et al., 2018; Teece, 2018), Gomes et al. (2023) proposed that circular complementarity occurs when the benefit of a solution offered by one actor is greater when used in conjunction with another solution from another actor so that, together, both develop circularity in the ecosystem. The authors highlight this process in which an orchestrating

agent must promote the "Generation of Circular Complementarity" and indicate the subprocesses of "mapping opportunities to enable circular complementarity" to create partnerships that result in benefits and the "facilitation of circular complementarity", defined by the creation of mechanisms to enable this partnership.

2.2 Extractive fishing in the Amazon – an imperfect market

Fishing plays an important role in food security and rural Amazon's local and regional economy (Costa et al., 2021; Tregidgo et al., 2020). In some areas of the lower Solimões River and the upper Amazon River, it is the main source of protein for the human population (Eloy & Lasmar, 2012). Despite its importance, extractive fishing is a highly imperfect market – it has problems with infrastructure and technological availability, as well as a lack of regulation and little support from public authorities, high level of information and power asymmetry among its players (Abramovay et al., 2021; Abramovay, Massunari, Uemura, & Matsumoto, 2022).

Abramovay et al. (2021) argued that the lack of storage, processing and transport infrastructure limits the economic growth of fishing and the lack of access to reliable energy sources subjects fishermen to the demands of local agents who own ice factories or are forced to sell their products to middlemen at very low prices. The result is an unequal distribution of income for extractivists and producers, as well as financial dependence on middlemen, known as "aviadores", who have made up this local commercial relationship for decades and represent one of the most difficult paradigms to break (Freitas & Schor, 2020). As Conexsus (2020) has shown, this market structure is an obstacle for cooperatives and associations to identify commercial opportunities generated by different products of extractive origin. At the same time, companies interested in the market are unaware of the variety of these products and miss out on promising opportunities related to new products (Abramovay et al., 2021). Most of the time, as confirmed by the work of Conexsus (2020), companies interested in biodiversity products buy them from intermediaries in value chains, which hinders the emergence of dynamic and competitive markets.

The market for many products of the Amazon bioeconomy is also often marked by technical limitations in industrial processing and obstacles to meeting minimum health and safety standards required by importing markets (Valli, Russo, & Bolzani, 2018), as well as strong clientelism and unequal power relations in the region (Abramovay et al., 2021). This market structure, coupled with the illegality and obscurity of land rights, leads to corruption and predatory resource extraction practices, which reduce the competitiveness of these products on the legal market due to their lower quality and lack of transparency, regularity and repeatability of supply (Abramovay et al., 2021; Abramovay et al., 2022).

However, there are cases in which technological development has been applied to transform fish skin into various products, including handbags and wallets, as well as using the skin and spines to produce collagen for food, cosmetics and pharmaceuticals (Costa et al., 2021). Fish processing waste can be used to produce biogas, bio-jewelry, handicrafts, animal feed and food for human consumption (e.g. hamburgers, sausages and nuggets), reducing the environmental impact of the waste and generating even more income (Jimenez et al., 2020). These examples of reprocessing of fish demonstrate that a circular economy could generate value for the communities, by using the sale of fish waste by fisherman.

3. Research methodology

A qualitative approach was adopted for this article, using strategies for theorizing from process data (Langley, 1999), with a case study on the extractive fishing ecosystem in the state of Amazonas. Data collection is described in the next subsection.

3.1 Data collection

The data was collected from August to November 2019. This period corresponds to the fish harvest. Therefore, there was a large quantity of fish of various sizes and species. Despite the high demand often seen at this time, a large volume of product loss was observed in the river where the Fishing Terminal is located and at the stalls, as well as being recognized by the interviewees themselves. The municipalities of Tapauá and Manacapuru were chosen because of the need to monitor the transport of the fish to Manaus, taking into account the different distances, storage methods and types of boats. The fish from Tapauá were transported in a large pleasure boat, while those from Manacapuru were transported in the same small boat used for fishing. Both stored the fish in batches. The municipality of Manacapuru is located to the west of Manaus, about 68 km from Manaus as the crow flies and 88 km by the river (IDAM, 2021). Tapauá is located to the south of Manaus, in the Purus Region, around 1,228 km away by river (IDAM, 2021). The fish collecting, storing and transportation processes from two boats coming from the municipalities of Tapauá and Manacapuru were monitored all the way to Manaus. They also monitored the commercialization and disposal of fish waste at the Manaus fishing terminal and at the Panair and Manaus Moderna markets.

Data was collected from different sources, primary data through semistructured interviews (detailed in Table 1), with questions related to the extractive fishing chain and waste management. Of the 35 interviews, 33 were conducted in person. The other two were conducted via WhatsApp, with representatives from the handbag and accessories factory in the city of São Paulo and the tannery in the municipality of Três Rio in Rio de Janeiro.

The interviews were audio-recorded or recorded on WhatsApp, with the respondents' permission and then transcribed. As the interviews were conducted with different people, the questions were adapted iteratively to each person's participation in the extractive fishing chain. In the case of the government representatives, the questions were adapted to their organization's activities. Table 1 below shows the list of interviewees, the location and time of each interview, as well as the communication channel used. The purpose of the interviews was to elicit the opinions of the participants.

Primary data were also collected by direct observation of the fish collecting, storing and transportation processes on two routes: Tapauá-Manaus and Manacapuru-Manaus. Through visits made to the fishing terminal, Feira da Panair and Feira da Manaus Moderna, to observe the behavior and activities of the extractive fishing chain, from the fishing grounds to the trading points in Manaus.

Secondary data was collected by consulting public documents and the organization's websites linked to the fishing sector in Brazil.

3.2 Data analysis

Despite the primary focus on events, process data analysis tends to draw in phenomena such as changing relationships, thoughts, feelings and interpretations of activities and choices (Langley, 1999). We have used the circular ecosystem management theoretical framework proposed by Gomes et al. (2023) to analyze the proposed circular value for the extractive fishing ecosystem in the case in question, focusing our analysis on theory elaboration (Ketokivi & Choi, 2014).

The descriptive data analysis began with the State Secretariat for Rural Production (SEPROR) website, to map the state government's initiatives in the area of fishing, especially artisanal fishing. IDAM's website was used to analyze training activities for those involved in extractive fishing. As for waste management, the waste collection data available on the

No.	Interviewee	Location	Duration interview (min)	Communication
1	Fisherman from Manacapuru	Manacapuru	10:05	In-person
2			6:16	In-person
3			7:25	In-person
4			5:33	In-person
5			12:10	In-person
6	Fisherman from Tapauá	Tapauá	4:59	In-person
7			3:19	In-person
8			04:58	In-person
9			04:18	In-person
10	Boat owner	Tapauá	5:22	In-person
11		Manaus	02:36	In-person
12	Dispatcher	Fishing terminal	5:00	In-person
13		(Manaus)	10:46	In-person
14			9:27	In-person
15	Market trader	Panair fair	02:50	In-person
16		(Manaus)	2:44	In-person
17			3:38	In-person
18		Manaus modern	4:38	In-person
19		fair (Manaus)	2:40	In-person
20			2:51	In-person
21	Fish handler	Panair fair	2:46	In-person
22		(Manaus)	1:40	In-person
23	Refrigerator representative	Manacapuru	24:53	In-person
24		Iranduba	27:06	In-person
25	Tannery representative	Três Rios-RJ		WhatsApp
26	Bags and accessories factory representative	São Paulo		WhatsApp
27	Greengrocer's representative	Iranduba	08:07	In-person
28	Representative of the Manacapuru fishermen's association	Manacapuru	13:01	In-person
29	Researcher at UFAM	Manaus	42:28	In-person
30	Researcher at INPA	Manaus	39:48	In-person
31	Secretary of Tapauá City Hall	Tapauá	07:20	In-person
32	Secretary of Manacapuru City Hall	Manacapuru	25:33	In-person
33	Representative of the Municipal Department of Urban Cleaning– SEMULSP	Manaus	32:38	In-person
34	Representative of the State Secretariat for Rural Production – SEPROR	Manaus	18:30	In-person
35	Representative of the Secretariat of Aquaculture and Fisheries - SAP	Manaus	30:43	In-person

Table 1.
List of interviewees

Source: Own authors, from research data

Municipal Department of Urban Cleaning website was analyzed. Research into the utilization of fish waste was examined on the Federal University of Amazonas and the National Institute of Research in Amazonia websites. Consultations were carried out on the website of the Secretariat of Fisheries – MAPA (Agriculture Ministry), relating to fishermen's activities and fish production. The main fishing and aquaculture regulations in Brazil and Amazonas were also analyzed. The results are in Section 4. The theoretical data analysis results are in Section 5, explaining and building case evidence for each construct from the theoretical framework used in section 2.2.

4. Findings

4.1 Case description: extractive fishing in the state of Amazonas

After the data collection procedures, it was possible to map the extractive fishing chain in Amazonas. According to Figure 2 (below), despite a broad network of actors, actions are almost always isolated, seeking individual benefits.

In the following sections, the sequence of fish extraction, storage and transport processes observed on two routes will be described through a narrative strategy (Langley, 1999): Tapauá-Manaus and Manacapuru-Manaus. After the boats arrive at the distribution points at the Manaus Fishing Terminal, the Panair Fair and the Manaus Moderna Fair, the activity and commercial relations between fishermen, intermediaries and final consumers will be detailed, up to the management of the waste generated by the processing and sale of fish. The last section of this topic identifies a circular value proposition for extractive fishing and the processes for managing a circular ecosystem in the region studied, in line with Gomes et al. (2023).

4.2 Extraction, storage and transport

Using waste from fishing activities can represent an opportunity to generate income for fishermen and their entire community. This waste is still discarded as ordinary rubbish, although it is an important raw material for the manufacture of bioproducts, including biofuels, animal feed, hydrolyzed protein, cosmetic and pharmaceutical products, as well as bags and accessories. However, developing a circular ecossystem requires the collaboration different actors (Trevisan et al., 2022). In addition to public authorities, acting to implement public policies and enforce environmental regulations, and members of the chain, interaction with other partners is necessary, including universities, civil organizations, companies and non-governmental organizations. Value creation and capture mechanisms must be used to produce financial gains (Teece, 2018) and, in the case of extractive fishing, contribute to the preservation of natural resources and the fair distribution of resources among the actors in the chain.

Fishing in the Amazon still uses artisanal methods to catch shoals. Production is influenced by environmental and market factors which, when combined with the great diversity of species and high consumption, make this activity quite complex. The boats used vary in size and small boats can hold up to 3 tones of fish, while medium-sized boats can hold up to 50 tones. On the other hand, large boats, which are usually also used to transport people, store much larger quantities. For a long time, only "redinhas" (small nets) were used for fishing. However, "redinhas" select species of different sizes, including fish that are still developing and generally have low commercial value. The "redinha" was banned from use in fishing by Ordinance 43 of July 26, 2004. Even so, many fishermen, especially owners of canoes or small boats, use them.

Due to the environmental damage caused by the use of "redinhas", fishermen have started using "malhadeira", made of a coarser mesh, to catch larger species. This type of net, when used correctly, ensures greater species selectivity and allows smaller fish to pass through the gaps, avoiding major impacts on local shoals. The "malhadeira" also prevents the capture of developing fish, which have no commercial value. The "escolheredeira", on the other hand, is made up of two types of nets attached: the "redinha", usually black and smaller and thinner, is used to trap the shoal. Then the fishermen use the "malhadeira", which is white and made of a coarser mesh, to catch the larger species.

When fishing for larger species such as tambaqui and pirarucu, the "malhadeira" is used. This device is attached to a pole on the river bank and stretched across to the other side. To cover the entire width required for fishing, several "malhadeiras" can be interwoven. The

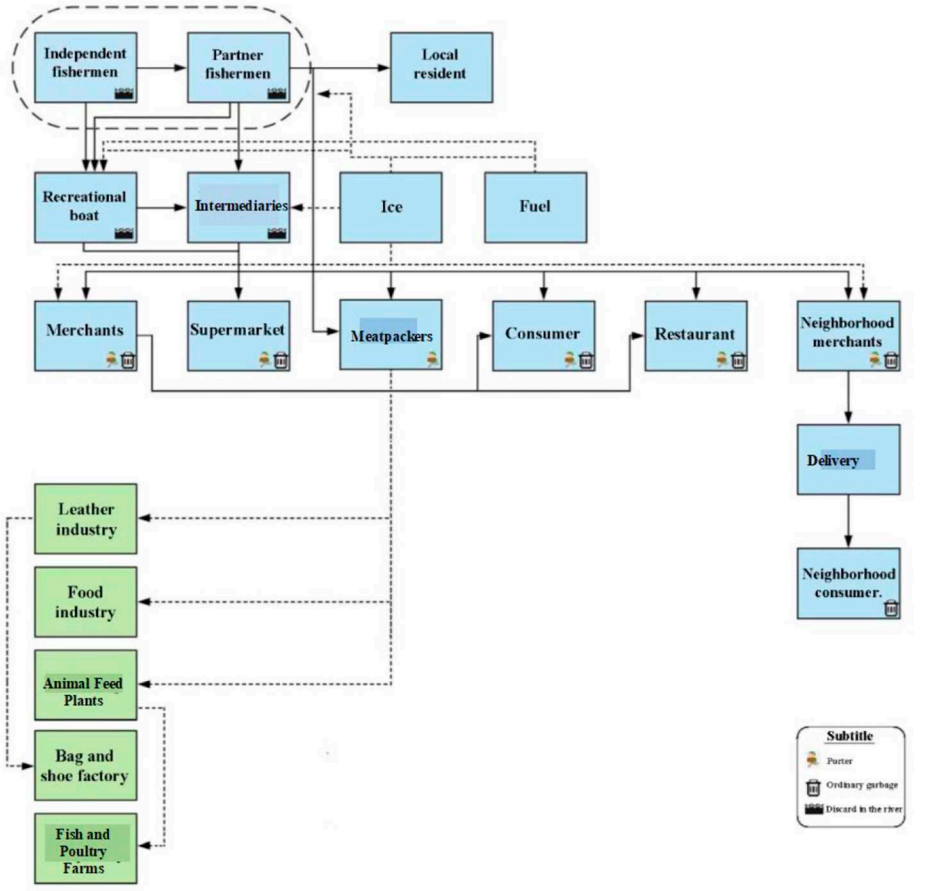


Figure 2.
Extractive fishing chain in the Amazon

Source: Own authors, from research data

process of setting the nets is done with the canoe and the fisherman places the equipment from one end to the other, at a height sufficient for the catch. Once caught, the net is lifted and the fish is removed. At this point, the smaller and larger fish are separated by hand. Only the fish suitable for trade are put into the canoe and the smaller fish are returned to the river. With the right size net, the fish pass through the slits. When this does not happen, the fish get stuck and, even if they are discarded, they die from the stress caused by trying to get rid of the net.

Larger boats can store up to 50 tones of ice and fish, while smaller boats, which usually catch smaller fish such as jaraqui and sardines, can store up to 3 tones of fish. Once sorted, the fish are transferred to the boat and stored in cool boxes installed on the boats themselves. Between 6 and 15 people usually work on the boats, all with specific roles. Each fishing trip lasts an average of 15–20 days. When the fisherman owns or works with a rented boat, he transports the fish himself. However, most of the time fishermen who live in distant communities sell their fish to middlemen who use transport boats to deliver the goods to Manaus. Both the fisherman's boat and the transport boat have places to store the

fish at the bottom of the boat, where it is stacked. These storage areas are lined with wood and fiber and have no shelves. They are stacked with a layer of ice and a layer of fish, up to a height of around 3–4 m. On fishing boats, fish are stored as they are caught. The layers at the bottom are damaged and the fish loses its quality, making it unsuitable for sale and therefore discarded.

Most of the fish harvested is sold at the Manaus Fishing Terminal or specific fairs. From there, the product is distributed to municipal fairs, neighborhood stalls or supermarkets and then sold to the final consumer. Another formal and higher-quality distribution option is through fish processing plants. As well as ensuring better payment conditions for fishermen, these factories are subject to health and environmental standards and are responsible for properly disposing of waste and maintaining the product's health requirements. After processing the fish, the remaining materials are collected by companies that treat the fish's fat and skin and turn them into various bioproducts. Fish processing plants require a constant volume of supply and high-quality standards, requirements that the precarious transport and storage infrastructure of extractive fishermen could not meet.

4.3 Distribution – Manaus Fishing Terminal

Designed with the capacity to store approximately 200 tons of fish, the Manaus Fishing Terminal was financed with funds from the Municipality of Manaus and the Federal Government. The fishing terminal was equipped with the right equipment so that fishermen could process, store and sell their fish in appropriate sanitary conditions. The administration of the site belonged to the Ministry of Agriculture (Federal Government). However, the refrigerators and other equipment in the building were stolen and the structure was compromised by leaks and cracks. Political disputes and successive crises led to the terminal being abandoned. The site entered the National Privatization Program and was auctioned off in 2022, but it remains deteriorated and unused. Rubbish, domestic animals, and vultures take over the site. Due to the abandonment of the terminal, the boats that bring in the fish line up around a ferry that is in poor condition and requires maintenance.

Fishing boats sell their product through intermediaries who receive a commission on the sale (from 10 to 15% of the value of the product, depending on the species sold). In addition to the sales commission, fishermen also pay a fee to sell their catch on the ferry. In the fishing chain, the broker is an intermediary between the fisherman and the buyer. They also finance the fishermen, guaranteeing the purchase of the product. The whole process, from fishing to selling, is done informally, without official contracts or proper labor relations. On average, the boat remains moored at the terminal ferry for up to five days or until it sells all its stock. The longer it takes to sell, the lower the price, due to the loss of quality. It is estimated that approximately 30% of the total fish caught is lost.

The fish sold in the terminal area is resold to final consumers at fairs, such as Manaus Moderna, near the city's harbor. The fish sold at the fairs is stored in styrofoam boxes covered in layers of ice. No market in Manaus has refrigeration. At the time of sale, the fish is displayed on concrete benches, and, at the end of the day, what is not sold goes back into storage boxes with ice, in precarious hygiene conditions. The fish waste (carcasses, scales and leather) is deposited in a bucket for later disposal – collected by the city's waste collection lorries or often thrown back into the river.

4.4 Fisheries waste management

The waste from the fish sold in Manaus, both at the fishing terminal and the fairs, is disposed of like ordinary rubbish. Viscera, leather and scales are dumped in rubbish trucks that pass by at set times and the fish that is not sold is left at the stalls, discarded in the

trucks or the rivers. When the volume of leftovers is high, especially during the period of greatest supply, the fishermen throw the fish into the river along the way back to their communities of origin. The pirarucu, which is a large, noble fish, is processed on the boats and the meat and carcass are sold. However, highly valued products such as the pirarucu's scales and leather are discarded in the river.

5. Case analysis – structuring a circular ecosystem in Amazonian extractive fisheries

To answer the main question of this article – how to structure a circular ecosystem for extractive fishing in the Amazon – this section aims to identify the constituent elements and the main gaps in the current extractive fishing chain through the constructs of the theoretical framework discussed in Section 2.1.

Gomes et al. (2023) theoretical framework for managing circular ecosystems is made up of autonomous but interdependent actors, to create and capture circular value, as we have identified in the case of extractive fishing in the Amazon. To create circular value, it would be necessary to build a circular value proposition, which requires the orchestration of different actors and the management of the circular configuration of the ecosystem. The results of the analysis of the case of extractive fishing are presented below, with the elements that constitute it as a circular ecosystem, as well as the gaps observed in its development.

5.1 Building a circular value proposition

Building a circular value proposition, as explained in Figure 1, involves orchestrating the circular value proposition, generally through an actor with a coordinating role – the focal firm. In the case of extractive fishing, although there are opportunities and potential for developing circular value creation (see Table 2), with the availability of waste and a high potential for utilization, the lack of a company or other focal agent that identifies, develops and manages the co-evolution of value means that a large part of the waste is not used. In comparison, when fish is sold to meatpackers, there is coordination that facilitates the collection and sale of waste to processing companies, such as tanneries and manufacturers of bags and accessories.

5.2 Circular configuration management

The management of circular governance, as discussed in Section 2.1, is the process that encompasses the activities that define the roles, activities, links and flows between the actors in the ecosystem, to materialize the circular value proposition, by building circular governance, fostering circular interdependence and promoting circular integration. Below we identify the main gaps and opportunities in the case studied (see Table 2).

5.2.1 Building circular governance. Circular governance is built by defining rules for coordination and collaboration, as well as aligning efforts to realize the value proposition. The centerpiece is the definition of criteria for participation in the ecosystem, which can be done through incentive policies or regulations. However, in the case studied, there are no clear rules for participation in the extractive fishing ecosystem and the actors work in isolation, in a noncontractual and informal way, with the presence of many intermediaries who are dispatchers in the commercial activity. Due to the absence of a resource management plan in the region studied, there is a decrease in the participation of extractive fishermen in the distribution of the value generated by the fish chain. There is no direct integration between self-employed fishermen and other players in the chain, such as meatpackers, processing plants, handbag and shoe factories and the food industry. As a result, the results derived from collaboration in the value-creation processes are restricted to the agents at the end of the chain, especially the meat-packing plants, which are currently able to sell the waste.

Building a circular value proposition – Availability of fish waste, including skins, carcasses, viscera, hides and scales. – Production of biofuels, animal feed, protein hydrolysates, pharmaceuticals, bags and accessories from the waste – Product research and development with public and private organizations			
Building circular governance	Encouraging circular interdependence	Promoting circular integration	Generating circular complementarity
– Isolated labor between fishermen and submission to the conditions established by intermediaries – Unequal distribution of value among the chain's agents Greater concentration at the top, especially in the meat-packing plants	– A one-off initiative by the government, which organizes the "Peixe no Prato" (fish on the plate) traveling fair, providing trucks and ice – Precarious infrastructure at the Manaus Fishing Terminal, leading to loss of goods – Exclusion of fishermen and market traders from training programs organized by the industry to reuse waste	– High collection costs and ignorance of the potential for commercial relations between actors in nearby locations – A chain marked by bottlenecks in the extraction, storage and distribution of fish, creating difficulties in achieving the minimum quality standards required by processing plants	– Precarious infrastructure for storage, processing and sale, coupled with the fact that fishermen do not perceive the value of the waste generated, creates obstacles to large-scale trade in waste – Lack of relationships between fishermen and traders in the tannery and processing plant sector. In addition, hygiene and conservation issues increase the perishability of fish

Source: Own authors, from research data, based on Gomes et al. (2023)

Table 2. Circular ecosystem management framework applied to extractive fishing in Amazonas

5.2.2 Encouraging circular interdependence. In a circular ecosystem, the flow of materials and the circular value proposition depend on the performance and interaction between different actors. Gomes et al. (2023) identified that focal companies create mechanisms of interdependence between their members. In our case (see Table 2), the "Peixe no Prato" initiative by the Amazonas SEPROR is an example of an actor developing interdependence in an ecosystem to support fishermen. The agency promotes itinerant fairs for the sale of fish, in which the state provides a truck, ice, a driver and the organization of the fair. Despite the existence of programs such as "Peixe no Prato" (fish on the plate), most of the time fish traders sell their goods on their boats due to the poor infrastructure of the Manaus Fishing Terminal. In addition, there is a great loss of merchandise due to the storage conditions on the boats. This means that there is still room for joint development of technology and structures for selling fish in the region. Fishermen and market traders are not included in any technological development and training processes promoted by the industry and meat-packing plants to reuse waste, creating a scenario in which inequality in the distribution of value in the extractive fishing chain is perpetuated.

5.2.3 Promoting circular integration. Circular integration is promoted by mapping, incorporating and aligning the different objectives of the different players in the ecosystem, aligned to produce circular value in common. For example, according to the representative of a greengrocer in the region studied, who uses fish waste to make

fishmeal, the high cost of collecting the waste is an obstacle to the company not using more of this product. This is a problem that could be solved with the help of partners. According to the Iranduba meat-packing plant representative, a company from Boa Vista collects the waste on-site, while the grease factory is located 15 min from the plant. From this example, it is clear that the performance of a chain also depends on a collaborative effort.

5.2.4 Generating circular complementarity. An important characteristic of circular ecosystems is complementarity, i.e. the fact that the actors in an ecosystem tend to make greater gains by operating together. In the case of extractive fishing, you can see that meatpackers and industries would benefit from fishermen and market traders entering the market if they had adequate processing, storage and sales infrastructure. This way, there would be more waste to sell, creating a more stable market and reducing fish losses. Today, fish from extractive fishing is delivered mainly to market traders. Delivery to the slaughterhouse almost always occurs when the fisherman (or intermediary) does not sell all the fish at the fishing terminal. This makes it difficult to map out partnerships between actors that could consolidate the circular value proposition. Similarly, there is no close relationship between fishermen and traders in the tannery sector, processing plants and other manufacturers that use fish waste. Fishermen do not recognize the waste as a valuable resource that could increase their income. In addition to the improper use of fishing equipment, the inappropriate transport and storage of fish generates losses and reduces its commercial value.

6. Discussion

Our main objective is to discuss how to structure a circular ecosystem for extractive fishing in the Brazilian Amazon region. We adopted the circular ecosystem concept has the main theoretical approach, following Kanda et al. (2021) that recognized that the ecosystem approach can help in solving issues of complexity and coordination that characterize business models for circularity. Moreover, in the case of extracting fishing, besides the complexity that characterizes circular business models, we found an imperfect market, as characterized by Abramovay et al. (2021): technological limitations, lack of regulation and little support from public authorities, high-level of information and power asymmetry among its players.

From analyzing the case, it can be seen that the extractive fishing chain in the region studied lacks the essential elements to be considered an actual circular ecosystem, as defined by Gomes et al. (2023). As a starting point for discussion, we note the absence of an orchestrating agent to structure a circular value proposition and manage the ecosystem's configuration. Gomes et al. (2023), in line with other authors such as Kanda et al. (2021), Adner, (2017), Hou and Shi, (2021), Jacobides et al. (2018), we stress the importance of orchestration as a fundamental aspect of ecosystem design and building. An orchestrating agent acting in extractive fishing, in the form of an assembly of fishermen or even through the direct action of a sub-national public body in the region, could consolidate this proposal and spread awareness among the agents of this ecosystem about the potential for reusing waste to produce bioproducts, bags and accessories. Even when waste is used, the value generated is restricted to the actors at the end of the fishing chain, mostly meatpackers and, to a lesser extent, intermediaries.

This orchestrating agent could develop direct commercial relations between fishermen, marketers and buyers of fishery waste, removing the need for intermediaries, as well as promoting price negotiation directly between fishermen and meatpackers, increasing the value received by self-employed fishermen. Through joint

efforts, bargaining power at the bottom of the chain would increase, as well as facilitating the control of fishing and the generation of commercial information, enabling gains in scale. By collecting information on the volume of fish caught and consumption, it would also be possible to balance supply with demand for the product, reducing any losses and establishing a minimum price.

An orchestrating agent would also be responsible for establishing partnerships with public and private bodies to develop new products from fishing waste, as well as negotiating credit lines that could be converted into improvements in transport, processing and storage infrastructure. Partnerships with other players could also promote the proper disposal of waste and its sale to the biofuel, pharmaceutical and textile industries. By creating value and increasing earnings among producers belonging to the circular ecosystem, this kind of configuration contributes to the sustainable development of the bioeconomy, as discussed by Abramovay et al. (2022) and Costa et al. (2021).

In other regions, it is possible to find structured fish management, as is the case in the Mamirauá Sustainable Development Reserve. Through the Fisheries Management Programme (PMP) (RDSM, 2014), rules were established for the use of natural resources and participation in each of the reserve's management units. One of the objectives of the PMP was to eliminate as many intermediaries as possible in the commercialization chain to increase the producer's earnings. The program also has the participation of residents and users of the Mamirauá Reserve through a representative unit, the Association of Residents and Users of the Mamirauá Antônio Martins Reserve, that acts as an orchestrator, managing the ecosystem (Gomes et al., 2023). The new practices established by the Mamirauá Sustainable Development Reserve Management Plan (2014) have required a great deal of investment in training producers in the use of more efficient production techniques and, above all, in understanding the associations' management processes. In addition, Brazilian Institute of Environmental Protection established a fishing quota for adult fish, and specific fishing tools are also used to promote the capture of larger fish only (RDSM, 2014), reducing pressure on stocks.

7. Conclusion

This research aims to propose recommendations for the development of a circular ecosystem for extractive fishing, bearing in mind the imperfect context of the reality of extractive fishing in the state of Amazonas, where there is low technological availability, a lot of informality and little support from public authorities. Through data obtained through interviews and direct observation, it was possible to observe the importance of an orchestrating agent – such as a company, an association or even a public authority – for the establishment and development of a circular ecosystem for extractive fishing in the region. Gomes et al. (2023) discussed the central role played by the focal firm or orchestrator in building and managing a circular ecosystem, as our results showed.

The case we analyzed shows that Gomes et al. (2023) framework for developing a circular ecosystem can be applied in imperfect contexts such as extractive fishing, and reinforces the importance of orchestration in building and managing circular ecosystems, especially in those imperfect contexts, where market flaws, such as asymmetry of information and bargaining power are more evident. This may indicate that the framework can be applied in similar contexts in Global South countries, which is already an important theoretical contribution of this article. In addition, the idea of circular ecosystems was applied to the bioeconomy, a topic that is still little explored in the literature on the subject.

Concerning the contribution to practice, it is clear that the role of public authorities as orchestrators connecting the network of actors that make up the extractive fishing ecosystem is fundamental, as is the collective organization of fishermen, guaranteeing effective social participation in solving local problems, especially where public authorities are unable to meet the demands of the local population efficiently.

This research has limitations, given the impossibility of generalizing its results, given the method used. However, this fact does not prevent the insights presented here from being used as a first application of the circular ecosystem management model in an imperfect environment as described by Abramovay et al. (2021), which ends up characterizing a large part of the production contexts in sectors such as agriculture and the informal economy in countries in the so-called "Global South".

References

Abramovay, R., Ferreira, J., Costa, F. D. A., Ehrlich, M., Euler, A. M. C., Young, C. E. F., . . . Villanova, L. (2021). The new bioeconomy in the Amazon: opportunities and challenges for a healthy standing forest and flowing rivers. Amazon Assessment Report 2021.

Abramovay, R., Massunari, L., Uemura, D., & Matsumoto, D. (2022). *Infraestrutura Para o desenvolvimento sustentável da Amazônia*, Brasil: Editora Elefante.

Adner, R. (2017). Ecosystem as structure: an actionable construct for strategy. *Journal of Management*, *43*(1), 39–58, doi: https://doi.org/10.1177/0149206316678451.

Bastos Lima, M. G., & Palme, U. (2022). The bioeconomy – biodiversity nexus: enhancing or undermining nature's contributions to people?. *Conservation*, *2*(1), 7–25, doi: https://doi.org/10.3390/conservation2010002.

Buchmann-Duck, J., & Beazley, K. F. (2020). An urgent call for circular economy advocates to acknowledge its limitations in conserving biodiversity. *Science of the Total Environment*, *727*, doi: https://doi.org/10.1016/j.scitotenv.2020.138602.

Bugge, M. M., Hansen, T., & Klitkou, A. (2016). What is the bioeconomy? A review of the literature. *Sustainability*, *8*(7), 691, doi: https://doi.org/10.3390/su8070691.

Conexsus. (2020). Negócios pela terra. Inteligência de mercado Para empreendimentos comunitários.

Costa, F. A., Nobre, C., Genin, C., Frasson, C., Fernandes, D. A., Silva, H., … Folhes, R. (2022). *Bioeconomy for the Amazon: Concepts, limits, and trends for a proper definition of the tropical Forest biome*, WRI Brasi.

Costa, F. A., Schmink, M., Hecht, S., Assadd, E., Bebbingtone, D. H., Brondiziof, E. S., … Pereira, H. S. (2021). Complex, diverse and changing agribusiness and livelihood systems in the Amazon. Disponível em: retrieved from www.theamazonwewant.org/wp-content/uploads/2022/05/Chapter-15-Bound-May-11.pdf

Desing, H., Brunner, D., Takacs, F., Nahrath, S., Frankenberger, K., & Hischier, R. (2020). A circular economy within the planetary boundaries: towards a resource-based, systemic approach. *Resources, Conservation & Recycling*, *155*, 104673, doi: https://doi.org/10.1016/ j.resconrec.2019.104673.

Ellen MacArthur Foundation. (2015). *Delivering the circular economy: a toolkit for policymakers*, Ellen MacArthur Foundation. Isle of Wight.

Eloy, L., & Lasmar, C. (2012). Urbanisation and transformation of indigenous resource management: the case of upper Rio Negro (Brazil). *International Journal Sustainable Society*, *4*(4), 273–388.

Freitas, N. D., & Schor, T. (2020). Bioeconomia e a bolsa de mercadorias da amazônia. *Interesse Nacional. Ano*, *13*, 20–25.

Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The circular economy e a new sustainability paradigm? *Journal of Cleaner Production*, *143*(2017), 757–768, doi: https://doi.org/10.1016/j.jclepro.2016.12.048.

Gomes, L. A. V., de Faria, A. M., Braz, A. C., de Mello, A. M., Borini, F. M., & Ometto, A. R. (2023). Circular ecosystem management: orchestrating ecosystem value proposition and configuration. *International Journal of Production Economics*, *256*, 108725. doi: https://doi.org/10.1016/j.ijpe.2022.108725.

Granstrand, O., & Holgersson, M. (2020). Innovation ecosystems: A conceptual review and a new definition. *Technovation*, 102098, doi: https://doi.org/10.1016/j.technovation.2019.102098.90.

Hobson, K., & Lynch, N. (2016). Diversifying and de-growing the circular economy: radical social transformation in a resource-scarce world. *Futures*, *82*, 15–25, doi: https://doi.org/10.1016/j.futures.2016.05.012.

Hou, H., & Shi, Y. (2021). Ecosystem-AS-structure and ecosystem-AS-coevolution: A constructive examination. *Technovation*, *100*, 102193, doi: https://doi.org/10.1016/j.technovation.2020.102193.

Jacobides, M. G., Cennamo, C., & Gawer, A. (2018). Towards a theory of ecosystems. *Strategic Management Journal*, *39*(8), 2255–2276, doi: https://doi.org/10.1002/smj.2904.

Jimenez, E. A., Amaral, M. T., de Souza, P. L., Costa, M. D. N. F., Lira, A. S., & Fredou, F. L. (2020). Value chain dynamics and the socioeconomic drivers of small-scale fisheries on the Amazon Coast: a case study in the state of Amapá, Brazil. *Marine Policy*, *115*, 103856. doi: https://doi.org/10.1016/j.marpol.2020.103856.

Kanda, W., Geissdoerfer, M., & Hjelm, O. (2021). From circular business models to circular business ecosystems. *Business Strategy and the Environment*, *30*(6), 2814–2829. doi: https://doi.org/10.1002/bse.2895.

Ketokivi, M., & Choi, T. (2014). Renaissance of case research as a scientific method. *Journal of Operations Management*, *32*(5), 232–240, doi: https://doi.org/10.1016/j.jom.2014.03.004.

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, 221–232, doi: https://doi.org/10.1016/j.resconrec.2017.09.005.

Langley, A. (1999). Strategies for theorizing from process data. *The Academy of Management Review*, *24*(4), 691–710, doi: https://doi.org/10.2307/259349.

Micheli, P., & Muctor, G. (2021). The roles of performance measurement and management in the development and implementation of business ecosystem strategies. *International Journal of Operations & Production Management*, *41*(11), 1761–1784, doi: https://doi.org/10.1108/IJOPM-05-2021-0317/FULL/PDF.

O'Gorman, M. (2016). Taking nature out of the corner and into the spotlight: biodiversity and the circular economy. Wildlife Habitat Council. Retrieved from www.wildlifehc.org/taking-nature-out-of-the-corner-and-into-the-spotlight-biodiversityand-the-circular-economy/

Sauvé, S., Bernard, S., & Sloan, P. (2016). Environmental sciences, sustainable development, and circular economy: alternative concepts for trans-disciplinary research. *Environmental Development*, *17*, 48–56, doi: https://doi.org/10.1016/j.env.dev.2015.09.002.

Shipilov, A., & Gawer, A. (2020). Integrating research on interorganizational networks and ecosystems. *Academy of Management Annals*, *14*(1), 92–121, doi: https://doi.org/10.5465/annals.2018.0121.

Teece, D. J. (2018). Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world. *Res. Pol*, *47*(8), 1367–1387, doi: https://doi.org/10.1016/j.respol.2017.01.015.

Thomas, L. D. W., & Autio, E. (2020). Innovation ecosystems in management: an organizing typology. *Oxford research encyclopedia of business and management*, Oxford University Press, doi: https://doi.org/10.1093/acrefore/9780190224851.013.203.

Tregidgo, D., Barlow, J., Pompeu, P. S., & Parry, L. (2020). Tough fishing and severe seasonal food insecurity in Amazonian flooded forests. *People and Nature*, *2*(2), 468–482. doi: https://doi.org/10.1002/pan3.10086.

Trevisan, A. H., Castro, C. G., Gomes, L. A. V., & Mascarenhas, J. (2022). Unlocking the circular ecosystem concept: evolution, current research, and future directions. *Sustainable Production and Consumption*, *29*, 286–298, doi: https://doi.org/10.1016/J.SPC.2021.10.020.

Valli, M., Russo, H. M., & Bolzani, V. S. (2018). The potential contribution of the natural products from Brazilian biodiversity to bioeconomy. *Anais da Academia Brasileira de Ciências*, *90*(1 suppl 1), 763–778. doi: https://doi.org/10.1590/0001-3765201820170653.

Author contributions: Neuzai Barreiros Barbosa – data curation (Supporting), investigation (Lead), Methodology (equal), Writing–original draft (support). Pedro Hellmeister – Formal analysis (Supporting), Methodology (Equal), Writing–original draft (Lead). Adriana Marotti de Mello – Conceptualization (Lead), Formal analysis (Equal), Research supervision (Lead), Writing – Review and Editing (Lead). Antonio Carlos Braz – Formal analysis (Supporting), Methodology (Supporting), Validation (Lead), Writing (Review and Editing), Supporting.

***Corresponding author**
Adriana Marotti De Mello can be contacted at: adriana.marotti@usp.br

Data availability statement

Research data are not shared.