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Effects of Urbanization and the Sustainability of Marine Artisanal Fishing: A Study on Tropical Fishing Communities in Brazil

Simone F. Teixeira, Daniele Mariz,
Anna Carla F. F. de Souza and Susmara S. Campos

Additional information is available at the end of the chapter

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Abstract

Marine fishing occurs along the coast and oceanic islands within the Exclusive Economic Zone of Brazil and is practiced mainly in an industrial fashion in the southern and southeastern regions of the country as well as in an artisanal fashion in the northern and northeastern regions. Artisanal marine fishing is practiced by fishermen who use sailing rafts or mid-size motorboats in daily fishing activities or activities that surpass 20 days at sea. To face the ocean and extract sustenance and income, the majority of artisanal fishermen do not have advanced fishing technologies, but rather empirical knowledge passed from one generation to another, which has allowed fishermen to maintain their activities for hundreds of years. The shared knowledge with regard to fishing and gear as well as fishing territories and the discovery of new territories allows artisanal fishermen to maintain catches while resources have become scarce. However, different factors in urban areas have been contributing to changes in artisanal marine fishing, such as the facility to education and jobs in other sectors of the economy. The aim of the present study was to investigate the experiences of artisanal fishermen in traditional communities of northeastern Brazil in the occurrence of urbanization. Traditionally in artisanal fishing, the transmission of knowledge occurs in the family, generally from father to son. However, this traditional transmission of knowledge is being lost in urban fishing communities. The urban environment facilitates access to formal education and provides opportunities for both formal and informal jobs, leading to income in more attractive sectors to the sons of fishermen than the activity of fishing. This is caused by changes in schooling and has triggered the avoidance of youths with regard to fishing activities. Moreover, urban pressures, such as the loss of areas of embarkation and landing, further hinder the maintenance of fishing in such areas. Thus, issues related to urbanization have been changing the structure of fishing communi-

ties and compromising the maintenance and sustainability of marine artisanal fishing activities in urban areas.

Keywords: Fishermen, traditional knowledge, artisanal fisheries, urban pressures, sustainable fisheries

1. Introduction

The coast of Brazil is considered a national heritage in the constitution passed in 1988 (Article 225, Section 4) [1] and corresponds to the geographic space of the interaction among the air, ocean and land, including renewable and non-renewable resources as well as the terrestrial area that encompasses municipalities under the direct influence of phenomena that occur in this zone and a marine area that extends for 12 nautical miles (Decree 5300, Article 3, 2004) [2]. The Brazilian Exclusive Economic Zone (EEZ) starts at the end of this marine area and extends an additional 200 nautical miles, in which, according to Article 7 of Law n° 8617 [3], “Brazil has sovereign rights for the exploitation, use, conservation and management of living and non-living natural resources of the waters over the ocean floor and its subsoil as well as other activities directed at the exploration and use of this zone for economic purposes.” The zone extends from the tropical region at the mouth of the Oiapoque River in the state of Amapá (north of the equator) to the temperate region at the mouth of the Chuí Stream in the state of Rio Grande do Sul (southern Brazil), spanning 17 states and more than 8500 km.

The EEZ is a marine area of approximately 3.6 million km². However, adding the approximately 900 thousand km² that Brazil has formally requested from the United Nations, the total will be approximately 4.5 million km², corresponding to 52% of the mainland area. Due to this oceanic territory, the strategic importance and riches of living and non-living resources, the Brazilian Navy denominates this area the “Blue Amazon” [4]. The EEZ of the northeastern region of the country (EEZ/NE) extends from the mouth of the Parnaíba River in the state of Piauí to the city of Salvador in the state of Bahia.

The coast of Brazil is on the Atlantic Plate being characterized by three well-developed provinces: the continental shelf, continental slope and continental rise [5]. The continental shelf of the EEZ/NE is divided into two distinct stretches: (1) from the mouth of the Parnaíba River in the state of Piauí to Ponta do Calcanhar in the state of Rio Grande do Norte; and (2) from Ponta do Calcanhar to the city of Salvador in the state of Bahia [6]. In the first stretch, the continental shelf has a mean width of 63 Km and various platforms on the outer portion, which are well individualized between 23 and 30 m, 40 and 50 m as well as 60 and 70 m [6]. After Ponta do Calcanhar to Belmonte in the state of Bahia, the continental shelf gradually becomes narrower, with a maximum width of 42 km, depths down to 60 m, a quite irregular topography and typical bio-constructional occurrences (beach rocks), which are parallel to the coast and more developed from Cape Calcanhar southwards [5]. The North Brazilian Chain and volcanic Fernando de Noronha Chain, which is a line of underwater mounts, are also found off the

northeastern continental shelf; only the Fernando de Noronha archipelago and Rocas atoll reach the surface [5].

The surface currents that traverse the northeastern continental shelf originate from the South Equatorial Current, which runs westward and splits at Cape Calcanhar to form the North Brazil Current, which passes over the Equator, whereas the larger part, the Brazil Current, runs in the southerly direction [7–8]. The South Equatorial Current and its two offshoots (North Brazil Current and Brazil Current) are warm and oligotrophic [9], but small-scale, highly transitory topographic resurgent phenomena occur around the chains of the EEZ/NE [10], which enrich the surface with nutrients from deep waters and enhance both primary and secondary productivity [11].

Small estuaries lined by mangroves are found on the northeastern coast of Brazil [12] and only the Parnaíba and São Francisco Rivers have large enough mouths to provide nutrients for the outer continental shelf [9]. The lack of large rivers and the occurrence of warm waters have led to the formation of coral reefs that extend approximately 3000 km from the state of Maranhão to the south of the state of Bahia. These ecosystems are home to the greatest diversity of fish fauna in marine environments [13], which have considerable ecological, economic and social importance to the region [14], sheltering important fish stocks and contributing to the subsistence of traditional coastal communities [15].

In this extensive stretch of ocean in off northeastern Brazil, with its geological, oceanographic and biological diversity, an enormous contingent of fishermen that mainly practice artisanal fishing operations exploit living resources, facing the ocean on a daily basis to extract their sustenance. Fisheries in the northeastern region are characterized by a wide variety of species with low abundance [12], but high commercial value [16] and multi-species catches. These fisheries are essentially artisanal (96.3%) and target pelagic (anchovies, halfbeaks and sardines), demersal and benthic (spotted goatfish, parrotfishes, tomtate grunt, drums, mutton snapper and white grunt) fish species as well as crustaceans (lobsters and shrimps) and mollusks [12].

The technology is unsophisticated, landings are decentralized and there is a lack of technical assistance and infrastructure from production through to sales [16]. Besides these problems related directly to fisheries, fishermen are affected by anthropogenic pressure on ecosystems, live resources and fishing territories. Fishermen in urban areas also face the difficulty or even impossibility of passing down their traditional knowledge regarding the environment and the resources they exploit, as the urban setting offers more attractive opportunities to the younger generation, making youths disinterested in fishery activities.

The object of the present study was marine artisanal fishermen on the northeastern coast of Brazil, who traditionally pass on knowledge regarding their occupation orally within the nuclear family. As urban fishing communities have been experiencing the breakdown of this tradition due to opportunities offered to youths to seek other ways of life as well as urban pressures that further hinder the perpetuation of fishing practices in such areas, the aim of the present investigation was to analyze the effects of urbanization on the main traditional fishing

communities in northeastern Brazil (**Figure 1**) that can compromise the continuity and sustainability of marine artisanal fishing.

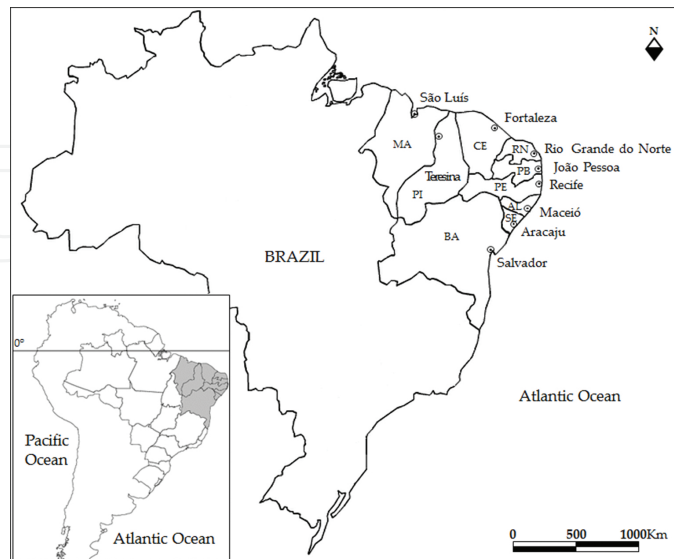


Figure 1. Map of the Brazil showing northeast region and sites described in the text.

2. Marine artisanal fisheries and fishermen in northeastern Brazil

2.1. Artisanal fishing

Fishing was an activity practiced by indigenous peoples prior to the arrival of the Portuguese. In the colonial period, European fishing practices were combined with native fishing practices, giving rise to different coastal cultures, such as the “*jangadeiros*” in the northeastern region, the “*caiçaras*” on the coast of the states of Rio de Janeiro and São Paulo in the southeastern region and the “*açorianos*” on the coast of the states of Santa Catarina and Rio Grande do Sul in the southern region [17].

In the 1960s, the Brazilian government implanted fishing industries mainly on the central-southern coast, which reached a peak in the 1970s, followed by a severe crisis the next decade, when the majority of these industries shut down [17]. In this period, industrial fisheries accounted for 64.5% of Brazilian fishery production [18]. However, this situation changed over the years. In 2006, artisanal fisheries accounted for 65.2% of the fishery production in the country and industrial fisheries accounted for 34.8% [19]. In northeastern Brazil, artisanal fisheries alone accounted for 96.3% of fishery production in the region in 2007 [12].

According to Brazilian Law n° 11959 issued on June 29th, 2009, artisanal fishing is defined as “any fishing activity practiced directly by a professional fisher in a self-employed fashion or in a familial economic regimen, using one’s own means of production or landing through a partnership contract, which may involve the use of small watercraft” [20]. However, this definition does not consider the historic, social and cultural context of each community.

Artisanal fishing goes beyond a mere work activity and constitutes a way of life corresponding to social aspects that follow a behavioral pattern in traditional communities [21].

The artisanal fleet in the northeastern region is mainly comprised of sailboats (70.9%) due to the low production and maintenance costs as well as adaptation to the climate of the region, which has strong winds throughout nearly the entire year. Fishing operations are conducted in shallow waters near the coast and estuaries. However, motorboats account for the largest portion of fishery production (60.4%) due mainly to the greater autonomy, which allows longer fishing trips and consequently greater production [16].

Fishermen use a gamut of methods for exploiting the aquatic environment, as different species are targeted using a variety of technologies, which reflect local knowledge on the different environments in which these individuals live [22]. The gear is crafted artisanally using both local raw materials and industrial equipment, such as hooks and nylon nets [18, 23]. The type of fishing may be active (when the boat or gear is in motion) or passive (when the gear remains still throughout the duration of the practice) [16].

The main fishing gears used to catch fishes are gillnets, handlines and traps. Three types of gillnets are used: (1) a purse seine that encircles the school at the subsurface of the water; (2) a set gillnet, which is used to capture fish on the bottom or in the middle of the water column; and (3) a flying fish net, used to capture flying fish on the surface, which is only found in the state of Rio Grande do Norte. These fisheries occur in areas of shallow depths near the coast and involve trips of 0.5 to eight days. For fisheries targeting flying fish, however, distances of up to 35 miles and depths of approximately 1000 m have been recorded [16, 24].

Three types of handlines are used: (1) a bottom line with one to five hooks, weight and length adjustable to the depth, which can be as much as 250 m, with operations conducted 20 miles from the coast; (2) a surface line, on which secondary lines with hooks are attached to the main line above the fishing grounds; and (3) “corso” or “corrisco”, which is similar to a surface line, but generally two lines (each with a one hook) are dragged as the boat moves across the water. This gear has the longest duration on the open ocean, with trips lasting 0.5 to 22 days and operations conducted 35 miles from the coast at depths as much as 1000 m [16, 24].

The use of a semi-fixed bottom trap has only been recorded in the state of Pernambuco. This type of trap has a hexagonal shape. It has a wood frame and is lined with mesh. The entrance is in the shape of a funnel. The fish enter the trap and cannot get out. This type of fishery is restricted to areas near the coast with a maximum depth of 80 m [16, 24].

Among all fishing gear, the handline accounts for the greatest fishery production due to the greater number and size of the catches. During the accompaniment of landings at 79 locations in seven states of northeastern Brazil between 1991 and 2001, handline operations accounted for 34.6% of the total production, followed by gillnets (27.3%) and trawl nets (10.8%) [16]. At landings in 16 locations in six states of the northeastern region between 1998 and 2000, 170 species from 52 families were identified, among which 149 species from 44 families were bony fishes and 21 species from eight families were cartilaginous fishes. The following are the main species targets in the different fisheries: *Seriola dumerili* (12.9%), *Mycteroperca bonaci* (11.6%) and *Lutjanus jocu* (7.4%) in bottom line operations; *Coryphaena hippurus* (10.3%), *Scomberomorus*

cavalla (9.9%) and *Thunnus albacares* (3.1%) in surface line and “corrisco” operations; *Opisthonema oglinum* (23.1%), *Scomberomorus brasiliensis* (14.1%) and *Euthynnus alleteratus* (6.3%) in mid-water gillnet operations; *Carangoides bartholomaei* (5.6%), *Ocyurus chrysurus* (5.3%) and *Rhizoprionodon porosus* (5.3%) in bottom net operations; *Hemiramphus brasiliensis* (78.2%) and *Hyporhamphus unifasciatus* (21.1%) in set gillnet operations; only *Hirundichthys affinis* in flying fish net operations; and *Pseudupeneus maculatus* in trap operations (45.6%) [24].

Corral fishing has also been recorded in the region, which involves a fixed trap made of stakes and wire similar to a fence, which imprisons fishes inside until their removal at low tide. These traps are deployed in regions where the continental shelf is wide and has a low incline. This practice is mainly found in the states of Ceará (91.1%) and Pernambuco (8.0%). In the state of Maranhão, only 10% of fishery production comes from corral fishing due to the high cost and need for constant maintenance. Fifty-seven species distributed among 26 families and 13 orders have been recorded, among which 22 species have commercial value in the region, such as *Scomberomorus brasiliensis*, *Centropomus parallelus*, *Cynoscion acoupa*, *Mugil curema* and *Megalops atlanticus* [16, 25].

The trawl net is bottom gear for catching shrimp that has structures, denominated otter boards, to maintain the net open. *Farfantepenaeus brasiliensis*, *Penaeus schmitti* and *Xiphopenaeus kroyeri* are the main species targeted in such operations [16]. The use of this gear is restricted to the mouths of important rivers due to the occurrence of reefs throughout nearly the entire coastal region [18], which impede trawling. The state of Alagoas accounted for the largest production of shrimp in the region between 1991 and 2001, followed by the states of Ceará and Sergipe [16].

Lobster fishing is performed over bottoms with calcareous algae on the continental shelf using three catch methods: (1) traps (locally denominated “covo” or “manzuá”), very similar to the fish traps employed in the state of Pernambuco, at depths of 10 to 40 m; this was the first method developed for catching lobster, but is currently little used due to its low degree of productivity; (2) dive fishing, in which the fisher dives with an air tank, catching lobsters in an active fashion; and (3) a gillnet made with multi-filament nylon 0.3 to 0.4 mm in diameter, buoys on the upper section and lead sinkers on the lower section at depths of 20 to 70 m [16]. Despite the fact that dive fishing and gillnet fishing are widely employed in the northeastern region, Brazilian law n 11.959 issued on June 29th, 2009 [20] prohibits these practices, which are considered predatory methods. In one community in the state of Rio Grande do Norte, 53.2% of the interviewees caught lobster using a gillnet, 20.6% performed dive fishing and only 9.5% deployed traps [21]. The same has been found in a community in the state of Ceará [26], demonstrating that illegal lobster fishing practices continue to be employed in the region due to the greater yields leading to overexploitation and unsustainability of this fishing.

The state of Ceará was the largest national lobster producer between 1991 and 2001, followed by the state of Rio Grande do Norte, with *Panulirus argus* and *Panulirus laeviscauda* the main species targeted [16]. In recent decades, lobster stocks have suffered from overfishing due to the large number of vessels, illegal catch methods and catches of juveniles smaller than the permitted size [26]. Thus, this type of fishery has a defense period in the breeding season (December to May), when lobster fishing is prohibited by Law n 11959/2009 [20] and Norma-

tive Instructions n 138/2006 [27] and 206/2008 [28], with the fishing, transportation and sales of catches from illegal fishing practices considered an environmental crime (Law n 9605, Art. 34) [29].

The aforementioned characteristics of artisanal fisheries have been found in many locations of northeastern Brazil, such as one community in Pernambuco studied by the authors since 2006, one community in Rio Grande do Norte [30], two communities in Alagoas [31–32] as well as communities in the states of Bahia [21, 33] and Ceará [23, 26]. This demonstrates that, regardless of the location of the fishing community, the fishery characteristics in the northeastern region of the country are very similar, with no considerable operational differences. The variety of fishing gear and methods reflect the diversity of living resources found in different habitats as well as different types of bottoms and the currents that affect the region. This results in various multispecies fishing resources, which is the main characteristic of artisanal fisheries in the region.

2.2. Artisanal fishermen

Coastal areas in Brazil have very productive ecosystems, in which fishery and forest resources are important, as such environments ensure the survival of different human populations [34], including artisanal fishermen. Fishermen need to have empirical knowledge regarding natural environments, which was constructed through the process of appropriation of the environment during the practice of fishery activities both materially in the form of technologies and symbolically in the form of cognitive systems created in society [35]. Such knowledge involves understanding the environmental variables that affect fishing practices, such as tidal patterns, winds and seasonality, knowing how to manage fishing equipment as well as identifying the different forms of use and ecology of the targeted species, which constitutes vital information to the success of the activity. These characteristics have led to the denomination of artisanal fishermen as traditional peoples. According to Brazilian decree n° 6040 issued on February 7th, 2007 [36], “traditional peoples and communities are culturally differentiated groups that recognize themselves as such, have their own forms of social organization, occupy and utilize territories and natural resources as a condition for their cultural, social, religious, ancestral and economic reproduction, using knowledge, innovations and practices generated and transmitted through tradition.” Communities such as artisanal fishing communities constitute an inestimable cultural heritage [37], but generally reside on the margins of society, overlooked by the government and public policies.

Marine artisanal fishing in Brazil is predominantly a male occupation [21–23, 38–43], which is mainly related to characteristics that favor men, such as the need for physical strength and long periods on the high sea. Women are culturally responsible for other tasks, such as household chores and raising children, which render marine fishing impossible. When women participate in artisanal fishing, they are more involved in shellfish gathering, which is an important activity in the estuaries of northeastern Brazil.

Marine artisanal fishing involves individuals of all ages, from youths to the elderly. In the city of Recife (state of Pernambuco), 80.5% of fishermen are adults [43]. In the community of Itacaré in the state of Bahia, 68% of fishermen are between 26 and 45 years of age [33]. In a rural

community in the state of Rio Grande do Norte, 54% of fishermen are between 31 and 50 years of age [21]. The striking presence of adults in fishing communities in the economically active age range confirms the importance of fishery activities to the local economy.

Fishermen generally have a low degree of schooling [43–46]. However, advances in schooling between generations have been found in a community in the city of Recife, where most fishermen have incomplete elementary (26.1%) or high school (25.0%) educations, 61.1% of their parents are illiterate and 25.4% of their descendants have a complete high school education [43]. However, this is not the case in the state of Bahia, where 40.0% of fishermen remain illiterate [44], or the state of Rio Grande do Norte, where 78.8% have an incomplete elementary or middle school education and only 4.7% have a complete high school education [21]. With the reduction in the illiteracy rate in Brazil [47], some urban fishing communities have a higher level of education, which may be related to the proximity to large cities, where schools are more accessible. The low degree of schooling among fishermen exerts a direct effect on the social organization of this class of laborers [42], which may result in the unawareness of workers' rights, thereby weakening this category of professionals and causing both disadvantages and negative repercussions regarding the negotiation of the price of the catch.

Artisanal fishermen generally have ties with the community in which they live and a longer period of time spent in such communities leads to a greater feeling of belonging [48]. This characteristic is fundamental to strengthening the activity, as a united community faces difficulties with greater ease. In the state of Bahia, fishermen reside an average of 40 years in the rural community [44]. In a community in the city of Recife, a large portion of fishermen have resided in the location since birth (42.0%) or since the creation of the neighborhood (10.2%) [43], which demonstrates that, even in an urban community, the influence of urbanization has not yet changed this important aspect of artisanal fishing.

The type of residence varies considerably with the socioeconomic status of each community. For fishermen in an urban area of the city of Recife, most homes are made with bricks and mortar [43, 45]. In a rural community in the state of Paraíba, a large portion of residences are made of wood and clay [48], but this form of home is being replaced by the practicality and durability of bricks and mortar in the capital of the state [49]. In a rural community in the state of Rio Grande do Norte, the majority of homes were made with sticks and mud. However, the municipal authorities benefitted the residents by constructing homes made of bricks and mortar, thereby changing the face of the community [30].

Sanitation is another factor that varies with the characteristics of the location. Rural fishing communities are generally isolated, with inadequate living conditions, such as the coastline or areas near mangroves, where sanitation conditions are often precarious [46, 48]. For the urban fishermen in the city of Recife [43] and the state of Paraíba [49], the conditions might be considered better. However, a similar situation is reported. Even with more frequent trash collection, most urban waste is dumped into rivers and estuaries near fishing communities, which does not differ from many large cities in Brazil with a sewage system, the treatment of which is incomplete and precarious [50], demonstrating that the deficiency in sanitary conditions is not only found within fishing communities.

Fisheries are important to coastal communities due to the large number of direct and indirect occupations created in the different sectors of the productive chain [37]. In one community in the state of Pernambuco, mean monthly income was higher than the minimum wage at the time, with higher salaries for those with their own fishing vessels. However, 20.9% exerted other activities to complement their income [43]. In communities in the state of Bahia, 55% of fishermen exercise other activities to increase their income [33]. The same is reported for communities in the state of Ceará [21, 26]. Despite the economic importance of fishery activities, income varies based on the yield and many fishermen seek other activities to complement their income, which demonstrates the low yields and economic under-valuation of artisanal fishing practices in northeastern Brazil.

3. Transmission of traditional knowledge and urban pressure

Artisanal fishermen reveal complex knowledge acquired through tradition inherited from older fishermen and contribute to the maintenance and sustainable use of natural ecosystems [51]. Such knowledge is generally transmitted orally from father to son and carefully guarded by fishermen [51] as a precious inheritance to ensure family survival and the continuation of the activity. The family is an important source of the transmission and maintenance of traditional knowledge and practices. Indeed, family ties constitute the main transmission route of knowledge regarding fishing in artisanal communities. The empirical knowledge of fishermen involves information of considerable cultural and ecological value that is essential to the continuation of local customs and the investigation of natural resources. This traditional knowledge can be used as a source of data for the establishment of species management and conservation plans, as it generally corresponds to scientific knowledge. In some countries, social ecology has used the knowledge of traditional communities for conservation purposes, as the strong dependence on natural resources, symbolic structure, management systems developed over long periods of time and often isolation make traditional fishing communities partners in conservation efforts [51].

The knowledge of fishermen involves navigation and the identification of fishing grounds through triangulation systems as well as the diversity, seasonality, migration habits and feeding habits of fish, fishing methods, depths and types of ocean bottoms [51]. Knowledge on the feeding habits of fish is evident in the community of Brasília Teimosa in the city of Recife (state of Pernambuco), where fishermen know which type of gear to use to enhance the success of fishery production [52].

In the community of Itapissuma near the coast in the state of Pernambuco, fishermen have precise knowledge of the estuary-mangrove complex, which allows social production and reproduction, maintaining a cultural heritage in which fishing practices are transmitted orally between generations and through both observations and practical learning [53]. In the rural community of Itacaré in the state of Bahia, most fishermen learned their craft in childhood, especially from fathers and family members. This demonstrates that knowledge regarding fishing practices and the use of natural resources can still be transmitted from generation to generation, thereby maintaining the characteristics of artisanal fishing [33].

Although rooted in tradition, artisanal fishermen have also been transformed by internal and external dynamics, but at a slower pace than that found in urban societies [51]. Traditional communities customarily maintain local knowledge accumulated and constructed over the years, which allows close contact with nature and the use of natural resources, even in communities located in urban areas, where the environment, albeit changed, allows sustaining modes of living based on the use of natural resources. However, this knowledge undergoes constant pressure from the urban way of life and can become lost over time due to the characteristic of the oral transmission as well as the contrast between traditional management practices and technologies available in the urban environment [54].

The urban community of Poti Velho in the city of Teresina (state of Piauí) continues to preserve its own culture, in which traditional knowledge is passed on from generation to generation, transferred within the family, but undergoes constant pressure from the urban way of life [54]. The community of Vila Velha in the state of Pernambuco entered into a stage of the transformation of habits in 1999 due to the increase in tourism and real estate speculation. Knowledge related to fishing was passed on from generation to generation by family members and more experienced fishermen. However, the continuity of these practices is rather doubtful, as the increase in the level of schooling of the descendants offers different professional opportunities to future generations [55].

The community of Brasília Teimosa, which is located in an urban area in the city of Recife (state of Pernambuco), has been the object of study of the authors of the present investigation for several years and changes have been observed in this community. In studies conducted since 2006, the family constituted an important source for the transmission and maintenance of knowledge and traditional practices, as most fishermen report having learned this knowledge from fathers, uncles and brothers, with the constant presence of relatives in the activity. However, a small number of the descendants of fishermen become involved in fishing practices, which suggests that the descendants may not give continuity to the fishing tradition. This situation is aggravated, as the relationship between father and son was the most important form of the transmission of knowledge regarding fishing practices in Brasília Teimosa [52]. Thus, the community may be losing the traditional form of knowledge transmission within the family, which can change the face of its traditional nature. As this community is situated in an urban area in the city of Recife, residence in Brasília Teimosa allows a set of job opportunities in other sectors, which may be more attractive to young people due to the advantages offered as well as social benefits. As a result, artisanal fishing is currently being threatened as an economic and social activity in this area.

Porto de Galinhas Beach in the city of Ipojuca is the most visited touristic point in the state of Pernambuco and was a community decades ago in which artisanal fishing was an important activity. This community has been undergoing constant change due to the economic growth stemming from tourism. The authors of a study conducted in the community found that most fishermen had descendants who worked in local stores or in the tourism industry, whereas only 12% practiced fishing with local traditional gear [56]. Besides the disorderly human occupation on the coast due to tourism, the destruction of mangroves and riparian forests due to real estate speculation and agricultural activities has also contributed to a reduction in fish

stocks [56], further leading to the avoidance of fishery activities on the part of youths. Thus, there is no renewal of the group with the inclusion the descendants of fishermen, which constitutes a barrier to the transmission of traditional knowledge, leading to the risk of this community not surviving another generation [56].

In urban fishing communities in the state of Paraíba, the disbelief among fishermen regarding improvements in working conditions and quality of life has led these traditional laborers to not want their descendants to enter the fishing profession, explaining that it would be better for them to study and become qualified for professions available in the urban setting in which they live [57]. This demonstrates a degree of disinterest among these fishermen in passing on knowledge of the activity to the next generation. In such urban communities, with the diminished fish stocks in recent decades, fishing is no longer advantageous in comparison to other urban opportunities and has become a secondary activity [57] that does not attract the interest of younger generations.

In São Francisco do Conde, which is an urban area in the city of Salvador (state of Bahia), studies report that the descendants of fishermen prefer to study and learn a different profession, with the encouragement of their parents and government assistance in the form of scholarships, thereby becoming unaware of fishing knowledge and leaving this activity as an option for those who have no other opportunities [58]. In Fernão Velho, which is an urban community in the city of Maceió (state of Alagoas), 30% of interviewees learned to fish from family members, but do not want their descendants to be fishermen, which demonstrates that cultural components are no longer being transmitted to younger generations. The intensive changes in the natural landscape due mainly to urbanization and industrialization have led to a reduction in native vegetation and fish stocks, with a direct reflection on socioeconomic aspects. While many traditional fishermen and their descendants no longer consider fishing an attractive profession, unemployed individuals enter into this activity, which indicates a likely marginalization of fishery practices and the risk of the extinction of the artisanal nature of this community [59].

In the municipality of Cabo de Santo Agostinho (state of Pernambuco), the Suape region has also been undergoing changes due to industrialization and tourism. This region has been the object of studies conducted by the authors of the present investigation since 1997. Suape Bay was a native coastal region in past decades and considered one of the most important marine and estuarine areas on the coast of northeastern Brazil. Moreover, one of the main artisanal communities in the state is situated in this area. With the implantation of the Suape Port and Industrial Complex beginning in 1979 and the subsequent creation of a large resort on the bay, changes have occurred in local geomorphology and hydrodynamics. In studies conducted in 1997 and 1998, local fishermen reported that the implantation of these two enterprises was causing a reduction in local fishery production, thereby compromising the income of fishermen and leading to the avoidance of the profession on the part of younger generations. This fishing community is currently much smaller, as most descendants of fishermen are not interested in the activity and have entered other professions, indicating the likely extinction of this traditional community in upcoming generations.

The urbanization process may not initially affect the traditional nature of fishing communities, but exerts an influence on ways of thinking as well as the very characteristics of fishery activities, compromising the maintenance and continuity of such activities by impeding the transmission of knowledge. As the perpetuation of fishery knowledge occurs orally, with no records to ensure the practice of operations, catch techniques, knowledge regarding fishing grounds and fish species, the maintenance and sustainability of marine artisanal fisheries in urban areas as well as the communities themselves are seriously affected due to the pressures imposed by the new developmentalism.

4. Territoriality and urban pressures

The immense socio-cultural diversity of Brazil has been accompanied by an extraordinary land diversity that includes different forms of territoriality maintained by traditional communities and populations [60]. Thus, the term “territoriality” is defined as a collective effort of a social group to occupy, use, control and identify itself with a specific portion of its biophysical environment, converting it into the group’s “territory” or homeland [61]. However, a three-dimensional concept of space is found in the cultural tradition of artisanal fishermen, which encompasses distinct domains of life (ocean, land and sky) imbued with meaning [62], giving such populations a broader notion of territory.

Although artisanal fisheries involve extractist activities conducted in a family economy regimen with specific means of production and striking characteristics in the profile of the laborers, urban growth has been affecting these traditional communities and transforming their forms and functions, which requires new models for understanding the changes imposed by urbanization [57], such as real estate speculation, a reduction in living and working space, disorderly tourism practices, pollution and social exclusion. Rapid urbanization along coastal areas also results in the emission of effluents. The implementation of industrial centers has led to a breakdown of the natural productivity of ecosystems and fishing practices [63], with consequent environmental degradation and the loss of quality of life in traditional communities [64].

The tendency toward occupying coastal areas in Brazil has substantially aggravated the impact on artisanal fishery activities. Such areas hold a strategic position in commercial exchanges, concentrating port activities, favoring the establishment of cities and industries and offering numerous recreational attractions to large urban masses [65]. This process has led to the shrinking of fishing areas and territories, with the loss of launching and landing locations as well as fishing grounds.

Northeastern Brazil accounts for 18% of the national territory and has nine coastal states, the most evident characteristic of which is the large concentration of the population along the coast, resulting from centuries-long occupation related to commercial relations with other countries [66–67]. Prior to Brazil’s incorporation into the process of globalization, native populations disputed their territorial spaces with real estate developers. Fishermen were forced to form small communities with no basic infrastructure or urban services or began to

reside in the periphery of nearby urban centers, also without infrastructure or services [67]. One such example is the real estate pressure that occurred in the 1970s on the urban beaches of Tambaú and Lucena in the city of João Pessoa (state of Paraíba) and currently occurs on Penha Beach in the same city. This is due to the peripheralization process of richer classes of society, who have exchanged residences in the center of town, which has since become more directed toward commerce, for spaces occupied by fishing communities, which are currently highly prized by the real estate industry, thereby compromising the ability of fishing communities to remain in coastal areas [57]. In the neighborhood of Brasília Teimosa in the city of Recife (state of Pernambuco), where the main office of the Z-01 Fishers' Colony is found and most artisanal fishermen of the city reside, there are longstanding reports of pressure to remove the fishing community from the area. This struggle for the right to use the land, defined as "stubbornness", coincided with the construction of the federal capital (Brasília) in the center of the country and gave rise to the name of the community: Brasília Teimosa (Stubborn Brasília) [68–69]. This community continues to face real estate pressure and other social pressures stemming from the economic growth of the state of Pernambuco [43].

Tourism and real estate speculation also exert significant pressures on fishermen in rural areas of northeastern Brazil. Rural communities, such as Prainha do Canto Verde on the coast of the state of Ceará, exhibit much greater strength and organization. Thirty years ago, a Brazilian Court granted this community the recognition of its right to land against a real estate company that declared itself the proprietor of the land. To remain, the inhabitants combined fishing with community tourism managed by the social group itself, which established operational rules, such as the prohibition of sales of land to individuals who were not part of the community [67]. This demonstrates community ties with the location and a feeling of belonging.

Besides the pressure regarding territory due to real estate speculation and tourism, the expansion of capital due to enterprises such as shrimp farming also results in a change in the land structure of rural fishing communities. In Canto do Mangue in the state of Rio Grande do Norte, lands located on the banks of the estuary, which were previously leased to fishermen for family agricultural purposes, began to be the target of private initiatives for the shrimp farming industry with the raising of the exotic species *Litopenaeus vannamei*, which besides occupying areas used by artisanal fishermen, has contributed to the reduction in fish stocks as well as the accelerated degradation of mangroves [30]. This type of activity also leads to the discharge of toxic effluents in bodies of water, the expulsion of the families of fishermen from their places of residence and the restriction of their access to traditional fishing grounds [63], thereby imposing the loss of territories.

Artisanal fisheries are also affected by offshore oil exploration, which brings serious risks to the coast of the states of Sergipe and Bahia, the severe pollution from alcohol production plants, which is released directly into estuaries, especially in the states of Pernambuco and Alagoas, and the discharge of toxic waste into lagoons and bays of high natural productivity, such as Manguaba lagoon in the rural area of Marechal Deodoro (state of Alagoas), Mandaú lagoon in the urban area of the city of Maceió (state of Alagoas) and Todos os Santos Bay in the city of Salvador (state of Bahia) [63]. Todos os Santos Bay is an environmental protection area surrounded by a metropolitan area with port and industrial activities, including an oil refinery

[70], where an important fishing community is being negatively affected by the new developmentalism.

Even with the social changes occurring in fishing communities in recent decades due to the expansion of urbanization, tourism and real estate speculation, artisanal fishermen constitute social subjects that have a form of spatiotemporal ordination that is dissonant with the urban-industrial context and have a heritage stemming from their centuries-long interaction with nature, which modernity cannot disregard [62]. Through material and immaterial cultural manifestations of fisheries, the activity may still last, as many individuals, especially tourists, enthusiasts of nautical trips and amateur fishers may pay to experience the work and way of life of traditional fishermen. Moreover, the traditional community in the urban setting may also be considered an obligatory part of social reports for environmental licenses granted to large enterprises [57], especially those that affect fishing territories.

The environmental impact report (denominated RIMA) by Brazilian environmental agencies for enterprises of the Marine Waterfront Recovery Project in the cities of Jaboatão dos Guararapes, Recife, Olinda and Paulista (state of Pernambuco) is an example of the participation of urban fishing communities in reports for environmental licenses. This report involved the participation of 50 leaders who answered questionnaires and 203 fishermen who participated in meetings and workshops to report on the impact of enterprises [71]. The fishermen were only considered in the final phase of the project, but should have been consulted during its design, as the numerous negative impacts are generally not mitigatable for artisanal fisheries.

The meaning of the surrounding environment is fundamental to artisanal fisheries, as fishermen maintain interactions with natural resources and their territory, even if the activity is threatened by different forms of pressure as well as environmental and social changes. Thus, understanding sustainability in this situation requires a new look at social practices, in which fishers should have greater participation, as these men and women struggle to maintain their identities, ways of life, territories and social visibility.

5. Public policies and the sustainability of artisanal fisheries

5.1. Public policies directed at artisanal fishing in Brazil

Historically, Brazilian public fishery policies were designed with no consideration for traditional communities and were based on the modernization of the exploitation of natural resources [72], with a position clearly in favor industrial fishing activities and large enterprises based on the dualism of the old *versus* the new, with small-scale fishermen considered reactionary, uncultured, predatory and incapable of assimilating new technological standards [73]. In the minds of the proponents of modernity, the tradition of professional artisanal fishing as work and a way of life no longer performs any efficient role in human development and is even seen as the cause of different forms of environmental degradation due to the fact that it is an activity that uses natural resources. Such an equivocal argument could be clarified if these proponents of modernity accompanied fishery routines [74].

In Brazil, fishery policies after World War II followed a worldwide tendency of growth based on industrialization that dominated the 1950s and 60s. The Superintendence of Fishery Development [Superintendência do Desenvolvimento da Pesca (SUDEPE)] was created in October 1962 for the regulation of fisheries and fishing resources. During the time when fisheries were regulated by SUDEPE, the priority was the modernization and industrialization of fishing activities and catches went from 300,000 tons in the 1960s to 900,000 tons between 1970 and 1980 [75]. However, this massive incentive for industrial fishing practices led to the decline of stocks and the failure of businesses linked to the fishery sector [75].

With the failure of the adopted public policy, SUDEPE was extinguished in 1989, passing the control of fisheries and fishing resources to the Brazilian Institute of the Environment and Renewable Resources [Instituto Brasileiro do Meio Ambiente e dos Recursos Renováveis (IBAMA)]. In 1998, the Fishery and Aquiculture Department was created (Decree n° 2.681 of June 21st), linked to the Ministry of Agriculture and Water Supply, and, together with IBAMA, served as the regulating agency of fishery activities.

To optimize the regulation of fishery operations, the Special Secretary of Aquiculture and Fisheries was formed by the Federal Presidency through Provisional Measure n° 103 (January 1st, 2003) and later became the Ministry of Fisheries and Aquiculture (MPA) through Law n° 11.958 (June 26th, 2009) issued symbolically on June 29th, 2009, which is Fishers' Day in Brazil [76]. The aim of the MPA was to "foster and develop policies directed at the fishery sector in conjunction with its aspirations. [...] founded in the marks of a new management policy, maintaining a commitment with environmental sustainability regarding the use of fishery resources" [76].

Due to the increase in domestic and industrial pollution, real estate speculation and the few possibilities of a significant increase in fishery production, except for marine fisheries, the Brazilian government proposed a credit policy for the fishery sector in 2003 to encourage the conversion of artisanal fishing to aquiculture, arguing that this would be an alternative for fishermen due to the overexploitation of wild fishes [74]. However, there was no participation on the part of artisanal fishermen in the stock evaluation process and no consideration of regarding their traditional knowledge. Thus, wishing to modernize the fishery sector, the Brazilian government ended up promoting the breakdown of fishing community traditions [74], mainly by not adopting a participative management plan that considered traditional knowledge accumulated and passed down from generation to generation.

During the existence of the SEAP and MPA, fishery management made some advances in public policies directed at the profession, with the revising or implantation of laws to ensure benefits and rights for fishers, such as (1) economic subsidies for diesel oil used for fishing vessels (Law n° 9445, March 14th, 1997) [77]; (2) the General Fishery Register related to licenses, permission and authorization granted for fisheries and aquiculture (Law n° 10683, May 28th, 2003; Normative Instruction n° 6, May 19th, 2011) [78–79]; (3) unemployment insurance during the fishery defense period (Law n° 10.779, November 25th 2003) [80]; (4) rural credit for family enterprises among small-scale farmers and artisanal fishers (Law n° 11326, July 24th, 2006) [81] through the National Family Agriculture Strengthening Program; (5) the recognition of fishery colonies as well as state and national fishers' federations as agencies of the class of laborers of

artisanal fisheries (Law n° 11699, June 13th, 2009) [82]; and (6) the New Fishery Law (Law n° 11959, June 29th, 2009) [20], which lays down the National Aquiculture and Fishery Sustainable Development Policy. Besides these policies, social programs of the government, such as the Family Grant, have assisted in improving the living conditions of a portion of fishermen [83]. However, during fishery management by the SEAP and MPA, many aspirations of fishermen were not considered, as artisanal fishermen are often impeded from using government benefits due to not meeting the required criteria or for not being part of the official Brazilian statistics regarding fisheries. As a result of current political affairs in Brazil, the MPA was extinguished on October 2nd, 2015 (Provisory Measure n° 696/2015) [84], when fisheries and aquiculture began to be regulated by a secretary linked to the Ministry of Agriculture, Livestock and Water Supply. The discontinuity of the MPA has generated uncertainties regarding the new direction of fisheries.

5.2. Sustainability of artisanal fisheries

Artisanal fisheries account for more than 90% of fishing jobs and the catches of this modality represent more than half of fishing catches throughout the world [85]. A worldwide decline in fish stocks [86–88]) as a result of unsustainable practices and an increase in fishing efforts [89–90] have been well documented in recent decades. Moreover, the global marine fisheries catches reported by FAO are underreported, being captured 30% more than is declared, with a peak catch of 130 million tons in 1996 and has been declining more strongly since [91].

In Brazil, artisanal fishing also faces a general lack of biological, socioeconomic, technological and organizational information, resulting from the dispersion and complexity of the activity. The difficulty is even greater when considering the variety of multispecies gear and the diversity of the resources captured. The insufficient information is evidenced by the lack of political attention directed at the profession, which is often a reflection of the conventional approach with a focus on biological aspects and no consideration given to the economic and institutional aspects of fishing communities, which contributes the invisibility of artisanal fisheries with regard to public policies [18] as well as the lack of sustainability of this modality.

Considering the worldwide decline in catches, efforts have been made to implement global actions directed at the sustainability of fisheries based on (1) the Code of Conduct for Responsible Fisheries [92] established in 1995 by the Food and Agriculture Organization (FAO) of the United Nations aimed at the ecological and social sustainability of fisheries; (2) the principles of the ecosystem approach to fisheries [93] aimed at planning, developing and generating fisheries to meet the different needs and desires of societies, benefiting from the complete variety of goods and services provided by marine ecosystems; and (3) the RAPFISH method, which is a multidisciplinary rapid appraisal technique for evaluating the comparative sustainability of fisheries [94–95]. In Brazil, the RAPFISH method has been used in eight states from north to south. When fisheries were compared jointly, sustainability indicators did not reveal any clear patterns, demonstrating that similar approaches will be needed in the future to assist fisheries in Brazil [96], and RAPFISH is a method that undergoes a constant improvement process.

Other global actions with an impact on sustainable fishing are (1) labeling and certifications for sustainable fishing products, such as the eco-labeling guidelines for fish and fishery products from marine fisheries designed by FAO [97] to certify and promote labels for products from well-managed marine fisheries and focus on issues related to the sustainable use of fishery resources; (2) the certificate from the International Social and Environmental Accreditation and Labelling Alliance (ISEAL Alliance), founded in 2002, which is an association of leaders of international organizations that establishes standards for social and environmental issues and certifies products, including fish catches, that comply with the ISEAL good practices code [98], involving open, transparent, participative processes with a proven standard of credibility and measures to ensure that even the most marginalized interested parties have something to say about the development of standards; and (3) the certification of the Marine Stewardship Council (MSC), which is an international non-profit organization aimed at contributing to the health of oceans that certifies fishery based on sustainable practices [99]; the MSC is a pioneering agency that maintains dialogs with all fishery sectors as well as a broad spectrum of stakeholders [100]. Sustainable fishing is the aim of such labeling and the MSC certification has had a positive impact on the environment, but has marginalized fisheries, especially those in low-income countries, as the council focuses on the sustainability of fish stocks and not fisheries [101].

Besides these important guidelines, fishery management must also consider the actions of the United Nations Millennium Development Goals, the aims of which are the eradication of poverty on the global scale, problems such as bycatch, habitat loss, species introductions and invasive species as well as the globalization of the fishery market [102]. Regardless of global guidelines, each nation adopts its own public policies and presents specific regulations based on its particular situation. In Brazil, the bases of fishery sustainability are founded on the National Policy for the Sustainable Development of Fishery Activities (Law no. 11959/2009) [20]. To achieve a balance between the principle of the sustainability of fishery resources and the obtainment of both economic and social results, this policy establishes access regimens, total permissible catches, sustainable fishing efforts, defense periods, fishing seasons, catch sizes, protected areas, reserves, gear, methods, fishery systems, aquiculture systems, the support capacity of the environment, fishery monitoring/control and the protection of fishes in the process of reproduction or the re-composition of stocks. Section 1 of this law declares that fishery management should consider the peculiarities and needs of artisanal fishermen, subsistence activities and family farming to ensure the continuity of these aspects and practices. In 1995, the Code of Conduct for Responsible Fisheries [92] officially recognized the need to consider the traditional knowledge of artisanal fishermen regarding fishery resources.

With the growing crisis in recent years [86, 103] and the limited capacity to predict complex systems, such as the marine ecosystem, together with the fact that fishery management should be conducted in a broad-scoped, integrated fashion to maintain the productive capacity and resilience of linked social/ecological systems [102, 104], there has been a recent increase in information, indicating the importance of including traditional knowledge in fishery management. However, despite the fact that the importance of such knowledge is frequently expressed, it has not been observed in practice in Brazil, as demonstrated in a recent study

through the reports of artisanal fishermen in the communities of Baldo do Rio and Carne de Vaca (state of Pernambuco), who state that political actions are distant from their interests [105]. Urban artisanal fishermen, in the state of Pernambuco, are also affected by the lack of attention given by institutions linked to fisheries [106].

The implantation of marine protected areas and marine extractive reserves is recognized as an important tool for fishery sustainability. The aim of such areas is to achieve the conservation and sustainability of fisheries, thereby contributing to biodiversity and habitat conservation as well as other ecological/social benefits beyond the boundaries of these areas [107]. In Brazil, such areas are considered a community-based, site-specific, multi-use, land and sea resource management approach based on claims of culturally distinct groups with longstanding livelihood ties to 'artisan-scale' production territories [108]. Thus, it is essential to consider social issues and long-term benefits for the effective management of these areas [109]. Studies conducted in Brazil indicate that such protected areas have been established without consulting artisanal fishermen and that fishery management plans are designed by scientists without incorporating the traditional knowledge of fishermen, thereby increasing social marginalization and the loss of cultural identity, whereas management involving fishermen is crucial to the success of the project [109]. Therefore, the success of this tool in Brazil remains dependent on managers willing to include all stakeholders in the implementation of protected areas.

Sustainable fishing remains a goal to be reached that should involve inclusive governance, encompassing the complexity of the ecosystem and its natural uncertainties, such as climate change, the dynamics of the market in the light of growing globalization and all stakeholders involved in fisheries, with particular inclusion of the protagonists of this activity – artisanal fishers.

6. Conclusion

Artisanal fishing is a longstanding activity responsible for numerous direct and indirect jobs and the largest portion of fishery production in northeastern Brazil. The modality is characterized by a variety of gear and techniques that reflect the diversity of living resources found in different habitats, resulting in fishery activities with multispecies resources. To exploit such resources, artisanal fishermen rely on rich traditional knowledge regarding the environment and fishery resources, which is fundamental to the maintenance of the way of life of these communities and is directly responsible for the success of fishery practices. Despite the economic importance of fisheries, many fishermen seek other activities to complement their income. This underscores the low yields and economic devaluation of artisanal fishing in northeastern Brazil, which, together with the pressure of the new developmentalism in urban areas, have been causing changes in traditional fishing communities. Pressure from real estate speculation, the reduction in fishing territories, disorderly tourism and pollution have led to a drop in the natural productivity of coastal ecosystems and fishery production, thereby compromising the quality of life and maintenance of urban fishing communities.

Moreover, the process of urbanization affects ways of seeing and thinking as well as the very characteristics of fishery activities, such as the transmission of knowledge, since younger generations are not interested in fishing and look to more attractive professions offered by large urban centers. As the perpetuation of knowledge occurs through oral practices, with no written records to ensure continuity, the maintenance and sustainability of marine artisanal fishing in urban areas as well as the communities themselves are seriously compromised in the face of the pressures imposed by the new developmentalism. Besides urban pressures and declines in fish stocks, which contribute to the discontinuity of urban fishing communities, the Brazilian federal government does not strengthen traditional fishing communities and adopts actions that fail to take traditional knowledge into consideration, thereby contributing to the breakdown of the transmission of the activity as well as the social invisibility of these laborers.

Sustainable fishing remains a goal to be reached that should involve inclusive, participatory governance, encompassing the complexity of coastal ecosystems, the sustainability of fisheries and fishery resources as well as the maintenance and continuity of traditional communities.

Author details

Simone F. Teixeira^{1,2*}, Daniele Mariz^{2,3}, Anna Carla F. F. de Souza^{2,3} and Susmara S. Campos^{2,4}

*Address all correspondence to: teixeirasf.upe@gmail.com

1 University of Pernambuco, Recife, Pernambuco, Brazil

2 Research Group on Ethnoecology and Tropical Fish Ecology Studies of University of Pernambuco, Recife, Pernambuco, Brazil

3 Federal University of Pernambuco, Recife, Pernambuco, Brazil

4 Federal Institute of Education, Science and Technology of Pernambuco, Recife, Pernambuco, Brazil

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