

# ROLE OF PORTS IN AMAZONIAN CITIES FOR SUSTAINABLE URBAN DEVELOPMENT: THE CASE OF BELEM, BRAZIL

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## ABSTRACT

Over time, ports in the Amazon constituted the first input vectors and occupation of the territory, defining locations and greatly interfering with the flow of cargo and passengers, either in the catching process, or even in the distribution of flows over the region. However, as cities have developed, very little has taken advantage of the potential of ports to support urban development; in many cases, conflicts arise between port and urban activities. In other words, there is a need to review the role of ports, with models of urban interventions in the port cities, in a more comprehensive and complete way, in order to consider the socioeconomic and spatial dynamics existing in the city and the port. This work has undertaken an analysis in ports along the waterfront in Belem, Brazil, in an urban context of sustainable development, in order to qualify the role of each port within an assignment division function with other ports and, also, in an urban planning context, searching for balanced development between city and port. The study was started with the bibliographic review, with the characterization of port relationships, in the urban environment of mainland and islands. In the methodology, a survey was undertaken in order to obtain the origin-destination matrix, port infrastructure conditions and accessibility. After the database was built, it proceeded to analyze the data, with geo-referencing of information and discussion of results. Among the results, it was observed that port functionalities, generally influence the social, economic and spatial dynamics existing in the city-port context and even in the islands, being important for the production and transportation flows. In addition, the potential of integrating water transportation with urban transport was evidenced, as a way of increasing mobility in transportation and possible environmental savings, since it is ecologically more suitable.

*Keywords: ports, urban development, cities, waterfront interactions.*

## 1 BACKGROUND

Rivers and seas act as natural paths of occupation, contributing to the spatial and social integration of cities, due to the creation of opportunities in less accessible regions, making transportation a more democratic means of access to the territory available in the urban environments [1]. Ports have been connecting equipment between land and water, that is, driven by social and trade relations, since the formation of the first cities. A successful development of a city is usually associated with an increasing population, migration rate, land use development and increased demand for infrastructure. Establishment of strong connections between urban development and port functions shall drastically improve urban quality of life. Port is recognized as a major component of an urban setting in that it contributes to the form and identity of a city, with port city interfaces having sensitive and controversial demands and requiring adequate planning solutions [2]–[3]. Conflicts arise in the waterfront as port attempt to expand in an area or other lands that also have competing demands on the same available land. It observes in the urban spatial theory a lack or little to say about the role of port activities in shaping the spatial structure of cities [4]. In spite of, considers that planning for the physical development of a port city is different, compared to planning for conventional city.

Port cities are characterized by harboring a kind of urban equipment that is both local infrastructure and an integral part of production distribution networks at different scales.



Regarding the physical aspect, these devices act as a set of urban structures with undefined boundaries that influence relationship between the urban structure and its inland and the rest of the world. In this sense, port cities play a key role in regional development, as one of the main mechanisms to promote the flow of people, goods and information, by the role of circulation [5]. Whereas no good just producing, we need to move this production, because as said Santos [6] is no longer the production who heads the movement, but it is this one that shapes the production.

Changing development pattern of port area influences the growth in the city area as whole and surrounding urban areas, requiring appropriate spatial development strategies to these cities. This is especially since processes of urbanization in many countries were spurred by the rapid growth of port cities. On the other hand, rapid growths of urban areas that support activities of ports, also, have impacted the growth potential of port due to competing demands for scarce land. Without integrated and sensitive spatial planning that considers the needs of both competing uses, the quality of life of the people in the area may be affected. Relationship between port and its city could be seen clearly through some elements and models [7]–[8].

Recently, coastal cities have undergone physical and conceptual transformations that have been worried the relationship between the city and the port. The seaport is an expression of this change (in planning, architecture, technologies), and it is a place where citizens memory is preserved and historical legacy is protected. It is a space for interaction and connectivity between two different systems: land and water. Connectivity term is mentioned by planners in the scientific literature under different terms, for example: city and port linkage, dependency, relation, whereas mentioned it directly by saying that it is important to plan for a sustainable connectivity between the cities and their ports [9]. The new pattern of urban functions is emphasized by local conditions, like population distributions and modifying accessibility. The original port waterfront often determines the general coastal city layout. The linkage between city and port growth influenced by form and function varies from one place to another, but in all coastal cities, a common denominator is the port function or the role of port on urban space development, which explains the settlement origin and its physical and socioeconomic expansion [10].

Central element of connectivity, the transportation infrastructure brings development from coastal to inland city areas. It acts by the development of the city-port connectivity as an effective economic growth pole. Access with different transportation modes are important to the connectivity between the city and the port, so that passengers and cargo can move furthermore to the inland beyond the port area and to downtown. The human activities are the drivers of the transportation system, since activities should be done in specific facilities that are spatially distributed [11]. Land use changes also come with functional changes, as port terminals began to experience a specialization of roles based on their geographical location as well as in their location within supply chains of trade. Models show the underlying sustainable connectivity between the coastal cities and their ports, which depends mainly on transportation and land use development [12], [13].

In the context of sustainable development, in the past few decades, sustainable development was based on managing economic growth or prosperity and sharing benefits in a co-evolutionary perspective with the ecosystem. Actually, the challenge of sustainable development has, first, been about regenerating economic wealth, which has not yet been achieved, through new circuits of value creation [14]. New unconventional forms of value creation and production are based on circular processes, with circularization and synergies that are the general principles for smart city sustainable development [15]. Port cities and port areas have a particular development potential because they may take on a key role in launching a smart sustainable development model. Starting from local cultural resources for

the activation of the creative processes in a circular economy through a synergistic approach; combining the port's economic, logistic and industrial activities with a cultural heritage regeneration, with the creativity of inhabitants. Investments in the urban regeneration of waterfronts – in Rotterdam, Barcelona, Liverpool, Valencia, Vancouver, Tokyo, Hamburg, Amsterdam, Genoa, Glasgow, Antwerp, Copenhagen, etc. – are well-known experiences. They can be interpreted as transition experiments [16] and express the creativity and resilience of cities against the pressures of change, by highlighting the capability of cities to transform themselves and to maintain their identity.

The present work adds a contribution to the discussion of the theme, in a reality of South America, in Amazonia, undertaking an analysis in ports along the waterfront in Belem, Brazil. In an urban context of sustainable development, the roles of each port were qualified, within an assigned functions division with other ports and, in urban planning context, lined a view for balanced development between city and port. Belem choice is due to the fact it is a typical Amazonian city, whose foundation emerged from a port (older port) and, over time, its edge was occupied by several ports, with various activities, serving the local population and other country regions. However, nowadays, it has been observed conflicts between port operations and urban development, mainly linked to port expansion and urban mobility indicators. The hypothesis followed was there is a reciprocal influence between the role of each port and the development of the city, whose loss of harmony results in great problems for both. In specificity of case study, the work focus was centered on physical and environmental factors, in a spatial view, with emphasis in urban mobility and land use.

## 2 METHODOLOGY

This article has two main purposes: on the one hand, it strives to identify shortcomings that hinder the achievement of expected benefits on urban and regional growth linked to port activity expansion. It is not based on a comprehensive analysis of case studies but, from a literature review, study a specific case, and for that reason limiting factors mentioned in the article are not necessarily suited for any specific situations. On the other hand, the article proposes a reflection on relevant analytical and policy intervention tools with potential to tackle and – ideally – to solve shortcomings. It advocates that a wider use of such tools would enhance the efficiency of handling freight volumes through ports and onto surface transport corridors, maximizing positive spillover effects while minimizing nuisances and drawbacks.

This study was empirical and heavily based on primary data collected through on the spot visits, activity mapping at the promenade, surrounding neighborhoods, user perceptions survey and focused group discussions with the major stakeholders. Users such: tourists, daily users, street vendors, managing authorities, shopkeepers of nearby commercial area and fishing community, beside regular passenger of water transportation, were identified as part of statistical sample – the stakeholders – after preliminary on the spot visits. User's interviews have been carried out to assess profile, travel patterns, perception about ports and management aspects of the waterfront. Demand survey was conducted at the promenade in each port at various time slots of working and non-working days with 100 random samples of users in each port, assuming a standard distribution of the sample.

After database ready, there was georeferenced data analysis on maps that were prepared using the QGIS program [17], to each port under study, presenting the perspectives of urban development. Roles of ports were observed within principles of space sustainability; the internal division of functions and the improvement of the city's connectivity with the islands and the region as a whole. The analysis considered the following dimensions: the relation between city and port, ports functionalities and integration perspective of water transportation with urban transport.



## 2.1 Case: Belem, Brazil

Belem city, in Brazil northern region, capital of a metropolitan region of the same name, is known as the gateway of the Amazon. Capital of Para state, with 1.4 million of population; located in a peninsula at the Guajara bay, and comprises two sectors: mainland and islands. It is included other six municipalities (Ananindeua, Marituba, Benevides, Santa Barbara do Para, Santa Izabel and Castanhal) comprising two and a half million people in 1.1 thousand km<sup>2</sup> (Fig. 1). Belem has lived its most glorious days in the 2nd half of the 19th century, during the rubber boom. After a long period of stagnation, the city has recovered its growth with the construction of a highway connecting it to the Brazilian capital, Brasília. Belem Metropolitan Region (BMR) economic structure is based on the third sector (commerce/services/government) with 91% of total jobs, with one-third of all jobs concentrated at Belem's downtown and its surroundings. The average income of 50% in BMR is between US\$ 125.00 and US\$ 370.00.



Figure 1: Belem Metropolitan Region – BMR, study area.

The area around the old port (“Old City”) is still the most important trip generation area within the city. The main transport corridors leave this area towards the hinterland, but in a non-continuous form due to the existence of the “Institutional Belt” formed by large properties owned by the army and other public entities. Besides these facts, the continental areas went through a process of intense growth due to the implementation of large housing units and irregular low-income constructions. At the same time, the island population is extremely poor, living in conditions below the poverty line, needing to move to obtain the simplest things such as health and education services, drinking water and food (Fig. 2).

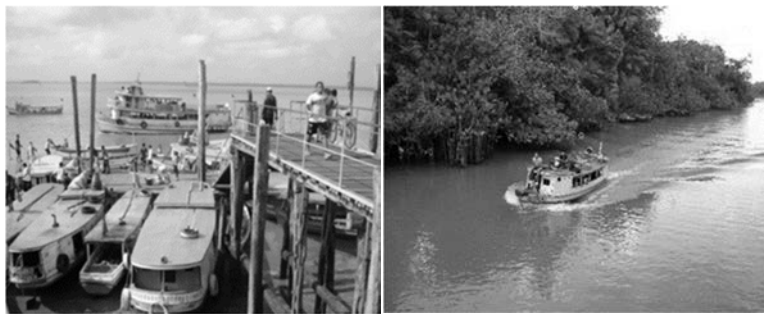


Figure 2: Scenes of Belem islands.

In the last years, deep changes in the BMR's socioeconomic structure have led to changes in urban mobility: population growth, average income downfall of population, increasing car ownership rates, increasing bus services supply in the main corridors. Occurrence of lacking in investments both new corridors as well as improvements in the existing ones and a disorganized process of urban expansion in the peripheral areas and high buildings construction on downtown.

As a result, bus trips share within the modal split has diminished, mainly because of continuous quality of services deterioration. Studies show the record of 4.0 million daily trips in the BMR and the modal split is bus: 44.6%; bicycle/on foot: 42.0%; cars: 13.4%. The bus share was 59.2% ten years ago [18].

BMR public transport services are structured according four sub-systems:

- Intermunicipal buses connecting Belem to other BMR's cities, as well as other cities to the inland;
- Belem local (municipal) buses;
- Municipal private public transport modes (taxis, moto-taxis);
- Water transportation connecting Belem to Islands.

Besides of theses transportation modes, BMR presents a case of urban intermodal network, nowadays done through little boats between its islands (around forty-four islands) and from islands to mainland part, without any government supervision or regulation. It is estimated that seventy thousand inhabitants live in islands and make use of water transport.

There are many models of vessels used in Belem, mostly of wooden hulls, driven by gas or diesel, without proper comfort and accommodations for cargo and passengers. Past studies have estimated that 56% of users would like to accommodate their luggage in reserved spaces on the vessel, provided of security, knowing that the types of luggage are low value and easy accommodation. On site, it was observed that there is no regular inspection and many vessels operate without respecting of gratuity rights and essential safety criteria. However, the importance of service to the population is emphasized, since it is usually the only transportation alternative, with the public power absent or acting unsatisfactorily in service operation and in a proper inspection. They are private carriers that, precariously, assure the right to travel of travel-dependent users of water transportation, especially those living in the insular area of Belem.

There is only operation done by the government in the extreme west of Belem. Water transportation offered from Icoaraci (inland) to Cotijuba Island is made by a medium-sized vessel, with a capacity for 200 passengers and only 2 trips a day. Departures take place at 06:00 in the morning and at 17:00 in the afternoon from Cotijuba, and departures from Icoaraci are at 07:00 in the morning and at 18:30 in the afternoon. Outside these times, the demand is served by small private boats, with capacity for 15 to 50 passengers, with departures every hour or until full capacity.

In general, they have life jackets in the ceiling, bathrooms in reasonable condition, however, uncomfortable seats and little space for circulation. This type of vessel is also used in the southern sector, where it does not have the service operated by the government. The government vessel of Icoaraci-Cotijuba route has certain attributes that differentiate it: greater capacity, therefore more space for internal circulation of people, becoming more comfortable. The roof is covered by lifejackets, have regularly cleaned bathrooms, an on-board snack bar, mineral water and toilet and the seats are padded. There is, in the tariff, respects to gratuity rights and halfway ticket for students.

## 2.2 Ports

Water transportation is presented under different kinds of operation, either local or regional, carried out between downtown Belem and the riverside cities of Amazonian rivers. Local water transportation is characterized by occurring transversely to the course on the river, within the region itself. There are several kinds of informal mooring locations, having been selected ports of public use, city suppliers or place of passengers boarding and landing from city insular area. In addition, it was considered the origin and destination of the flows in the ports, with selection of ports having origin or destiny of trips in urban area under study. That is, ports with only regional services and ports of use private, which trips with origins and destination are outside the urban area were withdrawn from the sample, as part of defining the sample universe. This is because the object of analysis is to investigate the relation between port and city being restricted to the urban environment and its interfaces of activities and flows with the existing ports in its edge. Thus, two ports were withdrawn, restricting the sample to eight ports, with relevant operations identified in loco. Fig. 3 shows Belem waterfront and selected ports for study.

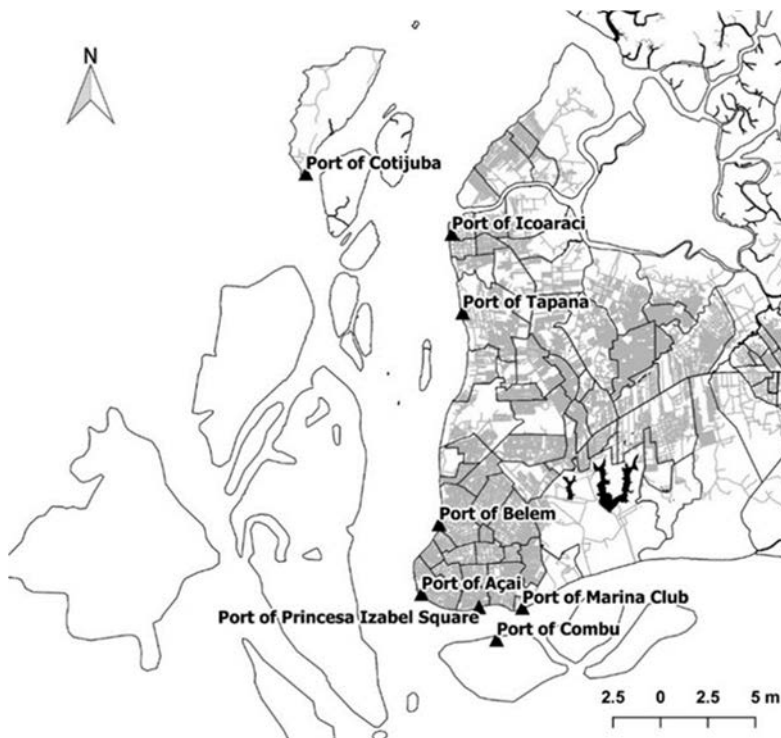


Figure 3: Belem ports selected for study.

Ports studied are in insular and continental areas, with precarious infrastructure attending to boarding and landing passengers and cargoes (Fig. 4). Passenger and cargo flows at berths varies, sometimes together, depending on the time, day of week and season of the year. Survey undertaken revealed, in Table 1, main average travel flows estimated at crossings for area, time of year and week, classified in extreme west ports and south sector ports.



Figure 4: Port infrastructures.

Table 1: Average flows of passengers at crossings in studied ports.

Area/period		Landing		Boarding	
		Weekend	In the week	Weekend	In the week
West Extreme	On vacation/weekend	4,990	1,800	5,800	2,800
	Out vacation/weekend	1,480	550	2,800	1,400
South Sector	On vacation/weekend	1,100	850	960	950
	Out vacation/weekend	1,120	900	920	900

West extreme ports: Cotijuba, Icoaraci, Tapaná and Belem; South sector ports: Açai, Marina Club, Combu and Princesa Isabel Square.

### 2.3 Users' survey

Survey was undertaken in order to obtain users' profile, the origin-destination matrix, port infrastructures conditions and accessibility. Table 2 shows results of users' survey at ports and surroundings, highlighting the profiles, travel patterns, perception about ports' infrastructures and accessibility, as also suggestions for improvements. In general, users have education profile at high school, with income centered in 335 US\$, occupation as freelance, in economically active age and male (55%). Interviewees use, predominantly, bus transportation on the mainland part, with most of them travelling 1 to 2 times a week for work reasons. Among the problems most cited, the main one is a lack of safety during trip boats, followed by travel time that is for users too long. Among suggestions, users want higher quality in the service and, consequently, more public safety.

On-site observations, one could see that port infrastructure is one of main problems, with passengers having to cross over the boats until reaching the access ramp that, in low tide, is submerged. There is excess of garbage accumulated in margins and in the own port, damaging the operation. In Table 2 it can be observed that the user perceives the precariousness of situation, just as suffers with a lack of security.

Table 2: Users' survey results: profile, travel patterns and perception.

Variables	Profile	West extreme (%)	South sector (%)
Education	Graduated	9.0	5.0
	High school	45.0	20.0
	Elementary school	28.0	19.0
	less than elementary school	18.0	56.0
Income	Up to 1,400 US\$	13.0	2.0
	From 680 US\$ to 1,399 US\$	8.0	7.0
	From 336 US\$ to 679 US\$	22.0	25.0
	Until 335 US\$	57.0	66.0
Occupation	Employers	45.0	22.0
	Freelance	41.0	66.0
	Students	7.0	7.0
	Others	7.0	5.0
Age	15 to 25 years	22.0	30.0
	26 to 37 years	25.0	38.0
	38 to 48 years	33.0	17.0
	Up to 48 years	20.0	15.0
Travel patterns			
Travel time	Until 1h	50.0	67.0
	Up 1 h to 1,5 h	25.0	15.0
	Up 1,5 h to 2 h	10.0	8.0
	Up 2 h	15.0	10.0
Frequency	Everyday	17.0	15.0
	working days only	10.0	14.0
	From 1 to 2 days in the week	28.0	28.0
	From 1 to 2 times in a month	17.0	18.0
	Other frequencies	28.0	25.0
Purpose	Labor	40.0	33.0
	Health	3.0	11.0
	Leisure	27.0	22.0
	Other purposes	30.0	34.0
Transport modes	Boat + on foot	24.0	12.0
	Boat + bicycle	10.0	8.0
	Boat + Bus	28.0	63.0
	Boat + auto	10.0	0.0
	Boat + motorcycle	10.0	7.0
	Others	18.0	10.0



Table 2: Continued.

Perception		
Critical factors	West extreme (%)	South sector (%)
Low quality service	18.0	12.0
High travel times	22.0	23.0
Insecurity	23.0	23.0
Suggestions		
Improve service quality	16.0	13.0
Improve ports' infrastructure	15.0	11.0
Police	15.0	20.0
Waterway transportation expansion	16.0	20.0

Flow of travel in the ports is intense in the morning, where many of the passengers arrive on the boats carrying their cargoes to sell in mainland. Table 1 shows that the islands of the extreme west have a greater amount of trips of water transportation in the high season, being low one in the vacation period. The integration of transport was observed with the predominance of the use of boat-bus and boat-to-foot.

In terms of economic activity in ports, one can observe activities linked to agriculture, such as horticulture; production of utensils from natural resources, and fishing of fish and shrimp are the main economic activities linked to the river. Islands supply the municipalities of the BMR, and business initiatives are individual or cooperatives, still showing traces of a very fragile economy. On-site observation and users' survey appointed ports with mixed use: passenger and charges. Their functionalities are on both to passenger accessibility in urban services on mainland but, also, to bring goods to supply the mainland and to carry goods from mainland to supply the islands. The fact in evidence is that ports play a role in the local economy, giving sustainability to the islands also in the social aspect, as the islands also serve as suppliers of primary products to the mainland and tourism and leisure space. From origin-destination survey undertaken at ports, there were geo-referencing routes, boarding and landing. Fig. 5 shows concentration of desire lines of trips between islands and mainland from the studied ports, and Fig. 6 shows main routes between mainland and islands.

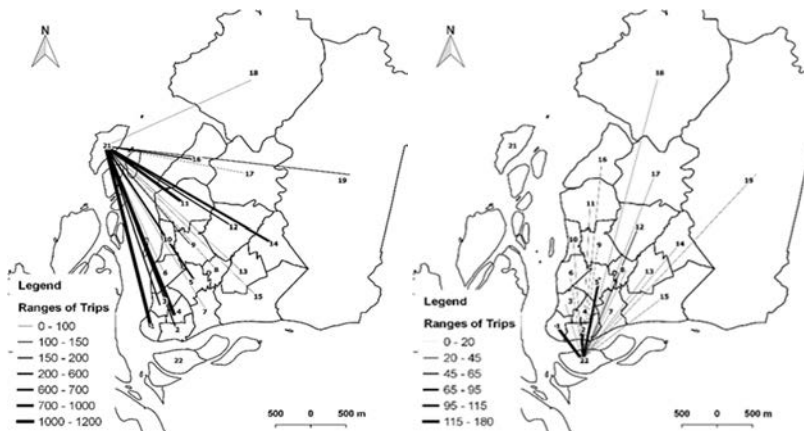


Figure 5: Desire lines of trips between islands and mainland from the studied ports.

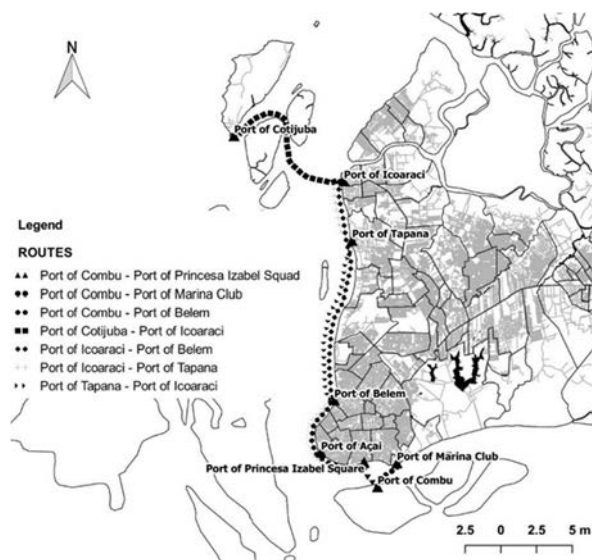


Figure 6: Travel routes.

### 3 DISCUSSION

Survey with interviews and observation of port environment, in addition to secondary data, from previous studies, allowed to identify important characteristics of water transportation in Belem waterfront, which highlight the role of ports as elements of social inclusion and economic development, responsible for sustainability of its activities:

- Port as a tool for social inclusion: in Table 1, it can be seen that half of population has a household income of a minimum wage, being an adult, low level of education, with activities related to commerce. It is noted, also, that most performs travels often to mainland of Belem, motivated by social demand for labor and health and, on the other hand, most arriving is for leisure, that is, the islands are mainly consumers of mainland urban services and rely heavily of tourism from mainland. These movements are essential for survival of local population and are manifested through a strong demand for water transportation, with an expressive daily amount of travel. There are people who do not travel and, judging by the absence of basic social services in the islands, plus the lack of job opportunity, they live in degrading conditions from the point of view of human dignity. This makes the issue of transport more serious, since it completely isolates people who could be living in better conditions of life.
- Port as a link between the urban and the island, whose performance affects the activities performance of the population: the problems performance ports generate impedance to displacement, promote a sense of detachment from the island population, expressed in the lack participation of them in claims. The feeling of not belonging to city and always refer to it as if it were another place, a distant space in the imagination of everyone. Thus, ports interventions should be promoting territorial accessibility and approximate people, in their citizen rights exercise. Port as an opportunity for social and economic development: river itself served as territorial occupation barrier. The existence of land distance favored the unequal

development, having an island reality completely differentiated from the land portion. This aspect makes it difficult to physical accessibility and basic social infrastructure deployment: water, energy, schools, health clinics and raises the cost of living. On the other hand, plenty of rivers, intersecting the territory, enhances the use of water transportation as the most suitable way for this kind of urban space, generating jobs and income, enabling the development of economic activities.

- Port as a territorial management tool: the lack of basic services to the population, such as drinking water and energy and the lack of health services are indicators of the need for greater attention by the government. With regard to transportation, the same is done without disciplinary rules, vessels are inadequate, and the port structure is deficient. Investments in the waterway sector promote economic activities, increase the possibility of setting the population in the insular portion, control overflows and sustainable socio-environmental planning and generate jobs and income. In addition, port serves as territorial integration equipment of transport, in many cases, is the only way to connect with the mainland.
- In the framework of conditions established for transportation situation in the islands of Belem, the activity of water transportation planning should considers aspects such as formulation of a main water transportation network that can articulate with urban transport system in mainland and promote activities on the islands that generate income and social welfare.

#### 4 CONCLUSIONS

The research allowed from the scientific point of view to expand the database and information on water transportation and ports with their respective demands. From the technological point of view, it opened space for proposals that trigger actions and projects to improve the quality of the service and infrastructure conditions of ports and vessels, based on opinions of users and operators of water transportation in the case studied.

Ports need to be seen as instruments of urban interventions in port cities in a more comprehensive way, in order to take into account existing socio-economic and spatial dynamics and promote the sustainable development of cities. The problem is not the port, but the distance of governance between port management and city management, which need to be taken together, so that the port provides the necessary functionality within the dynamics of the city itself that has developed around it. That it can be (re)qualified to continue playing the historical role of growth and development vector.

Finally, the initial hypothesis was tested in the study and highlighted the importance of ports for the city, its shortcomings, which hinder the development of their economic activities. Reflection on analytical tools of intervention and relevant policy allowed summarize the main roles of the ports as elements of social inclusion and to the port city of economic development.

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