

Water scarcity, the Castanhão dam and development in the Brazilian semiarid region: the thematic obstacles of an unsuccessful practical experience

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Summary

The objective of this article was to analyze the social impacts of a large dam in the Brazilian semiarid region, according to the population displaced from urban as rural areas. Semi-structured, open interviews were conducted with 371 families, representing almost 10,400 families living in the new municipality of Jaguaribara. The results showed that the resettled families were not satisfied with their new living conditions, despite their contentment with their new homes, water supply and food supply. Despite the improved infrastructure, the resettled people poorly evaluated the Sanitation, Health and Education Systems, as well as the labor and income policy. The government has invested considerably in infrastructure, but not in its operation and maintenance, nor in qualified personnel, this indicated that the focus of the investments was mainly on transferring capital to the construction industry and not on providing good services to resettled people. The construction of the Castanhão Dam did not provide a better standard of living for resettled people, which suggested that water scarcity may be one of the reasons, but certainly was not the main cause of obstacles to development in the Brazilian semi-arid region.

Keywords: Deslocamento obrigatório. Políticas públicas. Reassentamento. Saneamento. Semiárido. Trabalho e renda.

Escassez de água, a barragem do Castanhão e o desenvolvimento na região semi-árida brasileira: obstáculos temáticos a uma experiência prática mal sucedida

Resumo

O objectivo deste artigo era analisar os impactos sociais de um grande reservatório na região semi-árida brasileira, de acordo com a população deslocada das zonas urbanas como rurais. Foram realizadas entrevistas abertas e semi-estruturadas com 371 famílias, representando quase 10.400 famílias que

viviam no novo município de Jaguaribara. Os resultados mostraram que as pessoas reassentadas não estavam satisfeitas com as suas novas condições de vida, apesar do seu contentamento com as suas novas casas, abastecimento de água e alimentação; apesar da melhoria das infra-estruturas, os reassentados subestimaram os sistemas de saneamento, saúde e educação, bem como a política de trabalho e rendimentos; o governo investiu consideravelmente nas infra-estruturas, mas não no seu funcionamento e manutenção, nem em pessoal qualificado; isto indicou que o foco dos investimentos foi principalmente na transferência de capital para a indústria da construção, em vez de fornecer bons serviços aos reassentados. A construção da barragem de Castanho não proporcionou um melhor nível de vida aos reassentados, o que sugere que a escassez de água pode ser uma das causas, mas certamente não foi a principal causa dos obstáculos ao desenvolvimento na região semiárida brasileira.

Palavras-chave: Viagem obrigatória. Políticas públicas. Repovoamento. Saneamento. Semi-árido. Trabalho e rendimentos.

1 Introdução

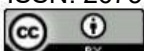
For Bachelard (1984), some generalizations, connections and/or discourses may constitute obstacles that slow down scientific progress and knowledge. In this sense, supplying reliable water is a key challenge for the progress of semi-arid regions and areas that aim for sustainable development. Some of the most common generalizations found in the specialized literature were that one of the goals of building large dams (funded by international organizations) was to supply reliable water (Howell, 2015) and that large dams play an important role in improving human well-being (BISWAS; TOTAJADA, 2001). Contradictorily, experts have warned about the obstacles to development that have been causing the construction of large dams such as biophysical and geopolitical impacts, Kirchherr et al. (2016) and especially the compulsory displacement of populations, Randell, 2016 and Fearnside (2016), Canada, Keilty et al. (2016), Mozambique, Isaacman, Isaacman, (2013) and Howell (2015), Lesotho, Tilt et al. (2009), Vietnam, Singer et al. (2014), Cambodia, Siciliano et al. (2015) and China (TILT et al., ; TILT; GERKEY, 2016; WILMSEN, 2016; XI, 2016).

In Northeast Brazil, the poorest region of the country, there is a large semi-arid area (970,000 km²), (Figure 1), where almost 30 million inhabitants live, consisting of nine



federal states and where the Caatinga biome prevails. The average annual precipitation of the Caatinga varies from 500 to 900 mm, while potential evaporation varies from 2,000 to 2,600 mm per year. Groundwater is limited and often saline, and the temporal regime of precipitation is concentrated both intra-(over 70% of precipitation occurs between January and April) and inter-annually (ARAÚJO; BRONSTERT, 2016). This combination of factors confines natural water availability to a few intense rainfall months. In addition, the region is prone to severe and frequent droughts and is composed almost exclusively of intermittent rivers. Despite its water scarcity, demands have increased over time, mainly for irrigation and human supply. As a consequence, many conflicts caused by water restriction have arisen (VAN OEL et al., 2008). To help mitigate this problem, numerous dams have been built over the past century, aiming to reduce temporal and spatial water restrictions. In fact, the Caatinga hosted one dam for every 6 km², which generated a complex network with considerable impacts not only on nutrient, sediment, and water flows (Peter et al., 2014), but also on social relations (TADDEI, 2011).

In this context, the Castanhão weir was built to supply water to the semi-arid state of Ceará as a key structure of the São Francisco River water transfer project (LEE et al., 2014). The weir dam dammed the Middle Jaguaribe River, generating the largest surface water reservoir in the state. Castanhão has a catchment area of 45,300 km² capable of storing 6,700hm³ and floods an area of 325 km². After eight years of construction, in 2003, the reservoir began to fill and in 2004 its effective operation took place. The reservoir was built under the multiple-use paradigm, including water supply for humans and animals, industry, fishing and irrigation. It partially flooded four municipalities, including the urban area of Jaguaribara. The planned new town (Nova) Jaguaribara was built near Lake Castanhão to receive part of the displaced population. Rural resettlements were also built for those affected residents who chose not to move to the urban area. In the year 2010 there were 10,339 inhabitants in Nova Jaguaribara (CEARÁ, 2011). The displacement process was mandatory and caused several conflicts, some of which still remain (TADDEI, 2011).

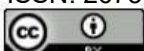




The present research aimed to understand the main social effects caused by the construction of the Castanhão dam, according to the opinion of the displaced population, both in urban and rural resettlements. Furthermore, it intended to verify the hypothesis - frequently stated by businessmen and decision-makers - that the main obstacle to the development of the Brazilian semi-arid region is water scarcity. The spatial outline was the municipality of Nova Jaguaribara, and the temporal delimitation was the period 2013-2016, i.e., the field research took place approximately a decade after the construction of the weir. The relevance of ex-post research lies in the possibility of assessing the effective impacts of anthropogenic interventions on the lives of those resettled living closest to the affected area, in comparison to ex-ante studies, which assume an excessive number of parameters and hypotheses.

2 Methodology

The area investigated in the context of this research was the municipality of Nova Jaguaribara, a region directly affected by the construction of the Castanhão dam (Figure 1). The climate is semi-arid (Bs, according to the Köppen classification), with average annual precipitation of 650 mm and potential evaporation of 2,200 mm.yr⁻¹ (ARAÚJO; BRONSTERT, 2016). The Jaguaribe River is intermittent, despite its large catchment area (75,000 km²) and reasonable runoff (30 to 60 mm.yr⁻¹), which justifies the existence of a dense network of dams in its basin (PETER et al., 2014). The geology is characterized by the crystalline complex, with some sedimentary areas. The paleoproterozoic lithology (Jaguaretama complex) prevails in the geological and geomorphological context of Castanhão, generating moderate to flat relief, typical of the Sertaneja Depression. In addition, Neoproterozoic formations (low mountains and residual inselbergs). And Quaternary-Cenozoic formations, such as flat plains, can also be found. The Paleoproterozoic rocks have generated associations of Luvisols and Litholic Neosols, as well as associations of Neosols and Litholic Argissols. The Cenozoic rocks formed reddish basal conglomerates, with pebbles of various crystalline origins, red

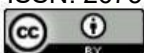




sandstones and siltstones. From this Era, there are also Argissols associated with Quartzarenic Neosols, as well as Fluvic Neosols associated with Planosols and Vertisols.

To understand the social impacts of the construction of the Castanhão Dam, semi-structured and open-ended interviews were conducted in situ for displaced residents, as in Tilt et al. (2009). The interviews addressed 13 social variables, grouped into three groups: sanitation services; labor and income; and public policies. These variables were elected based on previous research (TILT et al., 2009; ISAACMAN; ISAACMAN, 2013); and on a set of pilot visits to the resettlement. The relevance of the variables can be confirmed by the works of Singer et al. (2014) and Kirchherr et al. (2016). The sample size (371) was estimated for margin of error of 5%, confidence level of 95%, standard deviation of 41% (based on pilot sample) and population of 10,339 inhabitants of Nova Jaguaribara in 2010 (CEARÁ, 2011). For each household, only one person was interviewed. The long period of application of the questionnaires (from 2013 to 2016) was mainly due to the logistics required to cover a large area under difficult transportation conditions. To ensure that the results of the most recent questionnaires (2016) would not differ statistically from the first (2013), the two-sample t-test was applied. The results showed no difference between the samples at 5% significance. Of the total sample size (371), 63% of respondents lived in urban resettlements, while 37% lived in rural areas. This is in line with the average proportion of urban and rural populations in the settlements for the period 2003-2016 (GOMES; KHAN, 2004; CEARÁ, 2011). Respondents were to rate whether life after compulsory displacement was "better," similar ("same"), or "worse" than before the dam was built. They were also given the option of not answering the questions. After each question, they were asked to justify their answer, and the most relevant notes were recorded. In order to summarize the satisfaction (or dissatisfaction) of the displaced population, a Satisfaction Index (SI) was used. The index, whose value ranges from - 1 to +1 (Table 1), is simply a weighted average of the responses (Equation 1).

$$= \sum (\cdot \mu) 4 = 1 / \sum ()$$





In Equation 1, ' N_i ' means the number of ' i ' responses; AND ' μ_i ' means the respective degree of satisfaction. If the response indicated that the displacement made the quality of life worse for a specific variable, then the degree would be -1.0 ('worse', $i = 1$, $\mu_1 = -1.0$). If the response indicated that quality of life did not worsen or improve, Regardless of the subjective impacts of displacement (community fragmentation: Singer et al., 2014, emotional disconnection: Xi, 2016, loss of cultural and scenic links: Keilty et al., 2016, among others), the grade would be -0.5 (' If the response indicated an improvement in quality of life, the grade would be +1.0 ('better', $i = 3$, $\mu_3 = +1.0$); And if the respondent did not answer the question, the grade would be zero ('no response', $i = 4$, $\mu_4 = 0$).

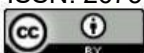
3 Results

The results showed responses referring to 13 variables, which were grouped into three categories: sanitation services; work and income; public policies. The resettled respondents answered for better, equal or worse access or service, also having the option not to answer; to finally calculate the overall satisfaction index, urban and rural.

In the overall opinion of the resettled, the sanitation system has improved insufficiently after displacement: the satisfaction index was close to zero; the water supply system was rated positive; and the sewage and solid waste systems were rated negative.

More than half of the resettled people are satisfied with the water supply after the weir construction and considered it better than that of the pre-dam period. Almost 1/3 (29%) felt that the state of supply is similar and 7% consider the situation worse than before displacement.

The overall index on water supply ($IS = +0.30$); contentment was higher among urban resettlers ($IS = +0.39$) than among rural resettlers ($IS = +0.15$).





Resettlers were not satisfied with the sewage system: for urban resettlers, satisfaction was close to neutral (IS = +0.07) while for rural resettlers they were definitely dissatisfied (IS = -0.73).

The new solid waste system was evaluated as similar to that of the old municipality (IS = -0.06). Neutrality was observed in the urban (IS = -0.14) and rural (IS = +0.08) settlements.

Resettlers in Nova Jaguaribara considered their current work and income situation to be worse than before resettlement (overall IS Index = -0.28). Access to land after resettlement was worse than in the previous situation (IS = -0.24), especially for rural resettlers (IS = -0.38).

The only variable assessed as positive was soil fertility among rural resettlers (IS = +0.36). But in the overall index it was also evaluated negatively (IS = -0.04).

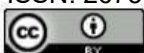
Although the situation about job possibilities seems less dramatic (IS = -0.25), unemployment and wage reduction explain the notable dissatisfaction in Nova Jaguaribara (IS = -0.44).

Public policies have not improved the quality of life of resettled people. On the one hand, resettled people were satisfied with the housing policy (IS = +0.36), both in urban (IS = +0.28) and rural resettlements (IS = +0.50); and they were satisfied with the food supply policy (IS = +0.27); the health system was considered to be of the worst (IS = -0.53), as well as, the educational system (IS = -0.11) and the energy system (IS = -0.10).

4 Discussion

Rao (1989) argued that large and small dams caused social problems and that under Indian conditions, the social impact of small dams could even outweigh the impact of large dams; whereas in Brazil, conflicts are often generated by the construction of large dams. Tilt and Gerkey (2016), when investigating four large dams in China, concluded that resettlement could be directly associated with low levels of social capital, which was also the case with Brazilian dams.

The same idea was said by Randell (2016), referring to those resettled not only by dams, but also by other "development projects," such as mines and urban



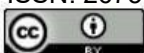


infrastructure. Furthermore, the social impacts of large dams were predominantly negative for those resettled by their construction and positive for families living away from it. In fact, Howell (2015) argues that the biggest beneficiaries of large dams may even be a specific company or another country and mentions the cases of Mozambique and Congo. Similarly, Tawfik (2016) presented the example of the large Ethiopian Renaissance Dam, which generated cross-border disputes between Ethiopia and Egypt. While Leylekian (2016) reports the conflict between the Azerbaijan and Upper Karabakh Republics caused by the Sarsang reservoir. In the Brazilian Amazon, Fearnside (2016) reports the case of large dams, whose main beneficiaries were aluminum industries. In addition, national and local divergences can also occur, as was the case of the Kamchay weir in Cambodia (SICILIANO et al., 2015). And the case of Castanhão, where the main beneficiary was the Metropolitan Region of Fortaleza (RMF), located about 300 km from the weir, which is home to 3.5 million residents and the most industrialized area of the state. With the construction of the new water supply system for the RMF, the old infrastructure became available especially for export agribusiness irrigation.

Mészáros (1995) states that the dynamics of the real requires the researcher to look at the complexity and totality that compose it, as a synthesis of many determinations. In this way, the analysis of the particularities of those resettled by Castanhão requires a careful look at the Brazilian reality. From the research in Nova Jaguaribara, it was clear that the prevailing environmental and economic models prevailed, as also observed by Tilt et al. (2009) in China.

In Brazil, there was no paradigm shift, regarding land concentration, an important issue in the country (WILKINSON et al., 2012). Land near the lake was granted mainly to local groups, not to the displaced population (MONTE, 2005). The resettlement project does not regulate any ongoing support program, as recommended by Singer et al. (2014).

This research did not identify any pertinent actions to improve job skills for displaced people, as suggested by Tilt et al. (2009), nor did it include payment for environmental services, as advocated by Singer et al. (2014).



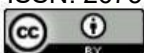


The planned irrigation system (43,000 ha), which could eventually generate employment and income, was not realized. Instead, only a small fraction (less than 5%) of the irrigation system was installed.

In summary, the employment and income policy for resettled people consisted almost exclusively of the installation of aquaculture in the lake, for the intensive production of fish (*Oreochromis niloticus*). In the initial phase of the fishing program, the number of jobs in Nova Jaguaribara increased considerably and the salaries of the resettled people were relatively high: up to three times the Brazilian minimum wage. At that time, indicators already showed that the fishing program had only a moderate level of sustainability (SOUZA, 2010). The author op. cit. also identified flaws in management practice, which led to a decline in workers' income and water quality.

This process has become more pronounced since 2012, when there was the beginning of a multi-year drought - 2012/2016, Araújo; Bronstert (2016), in the basin, leading Castanhão reserves to decline from 5,500 hm³ (82% of its storage capacity) in 2011 to 340 hm³ (5%) in 2016. With the falling water levels, fishing activity should have been adequately restricted, but this did not happen. The drought reduced the productivity of rainfed agriculture, livestock and irrigation systems, which had been rationalized since 2013. Thus, pressure on aquaculture as the main source of income in the basin and weakly sustainable fisheries prevailed. The System became explicitly unsustainable, leading to mass fish mortality within Lake Castanhão: 100 tons in a single day in 2013, Diário do Nordeste (2013); 2,600 tons in 2015, O Povo (2015); and 100 tons in 2016, Tribuna do Ceará (2016). The combination of low water levels and unsustainable fishing practices led to the bankruptcy of aquaculture in the lake and thus the policy of work and income for the displaced population.

However, well-planned and well-executed economic policies can soften the socioeconomic consequences of compulsory displacement. Wilmsen (2016) analyzed the case of the Three Gorges Dam in China on two occasions: in 2003 during the resettlement processes and eleven years later, the author found that during the period, "income inequality decreased" among the displaced people, which meant that specific

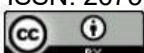




policies can favor resettled people by increasing income and justice; despite the deleterious social effects caused by the construction of the dam.

A major contradiction found in the construction of Castanhão was that the state of water supply has worsened for 13% of the displaced rural population, who have no access to the reservoir water, nor to another reliable source. On-site visits to these communities showed that most of them now rely on small dams (storage capacity typically ranges from 10m³ -106 m³) for their supply, regardless of their relative proximity to the large reservoir that flooded their original locality. For example, the community of Barra II, located 30 km southwest of the Castanhão weir (Figure 1), has to rely on its own small reservoir. Its construction, as well as its operation and maintenance, derived from communal initiative and effort. This strategy was an attempt to reappropriate the water resources they previously had, but lost because of compulsory displacement; similarly to what happened to the population displaced by the Lesotho Highlands Project (TILT et al., 2009).

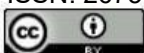
Due to financial and technological limitations, the solution reached by the resettlers was far from ideal, as their new water source dried up, a few months after the end of the rainy season each year. Indeed, small weirs are known to be vulnerable to pollution and unable to provide water with acceptable reliability in dry years or even during the dry season of regular years (ARAÚJO; BRONSTERT, 2016). The occurrence of water scarcity in a poor community so close to the largest water source in the state revealed that water, despite its socioeconomic centrality in the Brazilian semiarid region, is not a sufficient condition for development. Lynch (2014) stated that anthropogenic actions (the export agribusiness boom, in the case of Peru) are more relevant to water scarcity than natural phenomena. The same has been observed by Haddadin (2001), while investigating water conflicts in the Middle East and North Africa. Similarly, Schmied et al. (2016) concluded that during the last century, changes in river discharge have been caused more strongly by human interventions (such as dam construction) than by climate change.





To resolve water conflicts, three alternatives were presented by financial institutions: the construction of water infrastructure; the generation of water markets; and/or the installation of an institutional framework for water management. In studying the Ica River Basin, Lynch (2014) claimed that Peruvian support for agribusiness caused unequal access to surface and groundwater and the privatization of public lands. In fact, Wilkinson (2012) identified similar behavior in Brazil, where land concentration and foreign ownership improved rapidly. Another similarity between Peru and Brazil was that both countries' exports were based on agricultural commodities, fulfilling a subordinate role in the global market (PEREIRA, 2010). In the Ica River Basin, Oré and Geng (2014) stated that the construction of the weir met strong resistance from local settlers; and considered that water and political power are intertwined; and that conflicts occur mainly between export agribusiness companies and local producers. The water resources committees and councils that have been installed in the Ica Basin have been the main institutional support for local people to dispute access to water resources. Taddei (2011) describes conflicts and contradictions of Brazilian water policy in the Jaguaribe River Basin (dammed by Castanhão), from which one can conclude about the similarity between the Jaguaribe and Peruvian basins.

From the results of this research, one can see that the displaced population recognizes the investments in infrastructure, however, the resettled were dissatisfied with the services in the health, sanitation, and energy systems, which seems to be a contradiction. Harvey (2010) analyzed the social dynamics under capitalism and highlighted the contradiction between social demands and economic interest of corporations. The author op. cit. identified that the main function of infrastructure megaprojects was more the expanded reproduction of capital than the improvement of the well-being of populations. Despite the social function that some large water resources infrastructure projects may have, it is clear that the interest of capital amplification prevails. This logic was visible in the case of Castanhão, where funds were made available for infrastructure, while the same did not occur for operation, maintenance, or personnel, resulting in poor performance of expensive construction.





5 Final considerations

The result of the present research indicated that the population displaced by the construction of the Castanhão Dam is not satisfied with their new living conditions.

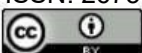
The overall average satisfaction index was marginally negative for the urban resettlers. According to the interviewees, the benefits of their new standard of living did not compensate for the subjective losses caused by compulsory displacement. Among the main causes of dissatisfaction was the population's disappointment with the work and income policy, which was monotonically focused on intensive fishing. The collapse of the fishing initiative occurred soon (a decade) after the construction of the weir due to a combination of unsustainable practices and the occurrence of a drought.

In contrast, most resettled people were satisfied with their new homes, the greater reliability of water supply (given by the proximity of the large reservoir), and the food supply.

One relevant aspect was that the substantial government investment in infrastructure (urban facilities such as houses, streets, health centers, schools, sewage, solid waste and energy systems) was not accompanied by similar investments in service operation and maintenance. The population complained severely about the lack of qualified personnel in health and education; about the lack of rural sanitation; about the operation of the landfills and their proximity to the settlements.

Therefore, despite admitting the modernization of the infrastructure, the resettled people poorly evaluated the sewage, health and education systems, which were generally presented as satisfactory by the authorities.

From this contradiction, it can be inferred that the focus of government action was more the transfer of capital to the construction industry than the provision of good services to the population that had to leave their homes for the sake of the industries and beneficiaries living far from the area flooded by the dam.





Finally, the construction of the large dam did not provide a better standard of living for the directly affected population, which indicates that water scarcity may be one, but certainly is not the main cause of the impediment to development for the population of the Brazilian semi-arid region.

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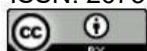
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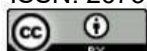
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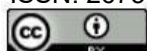
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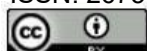
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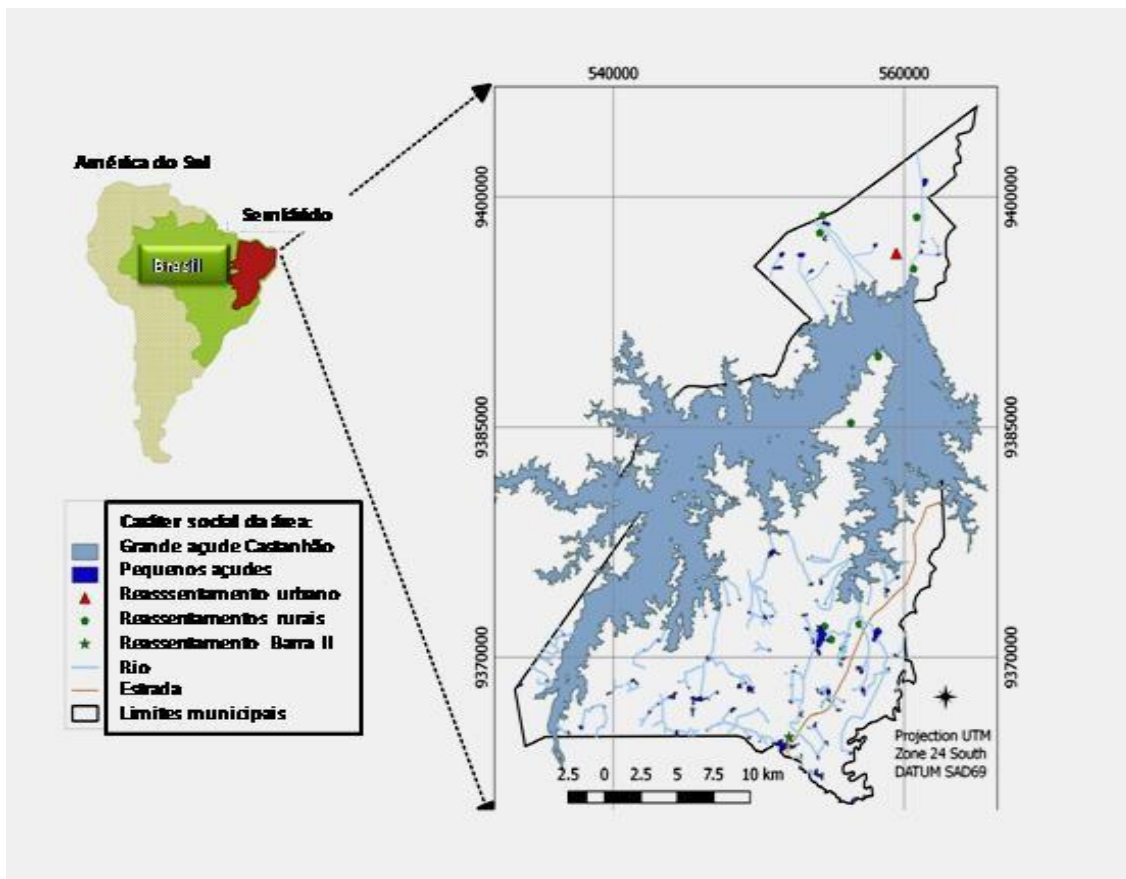
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Anexo 1

Figura 01: Localização de estudo: município de Nova Jaguaribara



Fonte: Elaborado pelos autores.

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