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Natural factors or environmental neglect? Understanding the dilemma of a water crisis in a scenario of water plenty

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ABSTRACT

The objective of this study was to discuss how natural factors associated with poor land use policy and ineffective water resources management triggered a severe water crisis in a region with water plenty. The idea developed throughout the text is the result of a water shortage experience in a Brazilian medium-size city, related to recurrent climatological events, indicating the need for national and international water management agencies to elaborate policies, guidelines and mechanisms that take environmental seasonality into account. The study area (Itabuna city) is located within a rainforest biogeographic context, with high rainfall rates and perennial fluvial regimes. Nevertheless, in a period of climatic oscillation (2015-2016), the region experienced a water shortage because it relied on what it neglects. Through GIS and geoprocessing, we estimate the levels of degradation of two neighboring watersheds to illustrate the problem discussed here. The discourse adopted by the urban managers pointed out that the natural factors caused the water crisis. However, one of the watersheds that supply water to urban areas did not meet demand during the dry season, the other is degraded and with reduced ability to deliver ecosystem services. Due to the water crisis, an old proposal of implementing a dam in the watershed with highest level of degradation was resumed and implanted. The method chosen to solve the issue of water shortage, although valid, isn't enough, in addition to demanding large engineering interventions in the natural environment, it does not guarantee water security without an effective land use policy for watersheds. Therefore, as a complement to the dam, we suggest watershed restoration and preservation policies that can effectively regulate water production and promote resilient and sustainable water security should be implemented.

1. Introduction

The policies and guidelines that regulate water use in Brazil consider this resource based on demand and availability in superficial and underground water bodies, providing environmental and socio-economic components (Tundisi, 2008). However, climatological scenarios that directly influence the amount of water in watersheds, at all geographic scales, are not incorporated in management strategies (Gudmundsson et al., 2017; Vásquez-Rowe et al., 2017; Clifton et al., 2018).

The northeastern region of Brazil has a history of water deficits and is an example of how climatological normals can change the whole water infrastructure framework (Rebouças, 1997). The El Niño phenomenon (which presents a 15-year cycle, originated by an increase in Pacific Ocean temperature, changing the condensation nuclei in South America) promotes a long dry period in this area, which intensifies droughts in arid areas and reaches humid zones, thus affecting water production in watersheds, altering water availability and the demand

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patterns of municipalities (Melo, 1999; Gutierrez et al., 2014). This phenomenon is cyclical and, when it occurs, characterizes a period of intense pressure over freshwater availability and quality in Brazil, compromising water supply (Gutierrez et al., 2014). In humid zones, such as the Atlantic Rainforest region, municipalities still commonly present water supply structures only based on lotic systems, not taking advantage of reservoirs or other alternatives.

However, regarding water resources, the public administration and/or eventual concession companies could be considered irresponsible in trusting the hydrological cycle alone for contributing towards public water supply to human communities. As previously mentioned, the Earth's atmosphere is highly dynamic and meteorological patterns present constant variations in occurrence means and, consequently, water input values in the biosphere system (Rasmusson and Wallace, 1983; Bradley et al., 1987; Jahfer et al., 2017). On the other hand, reservoirs require meticulous hydrological and socioeconomic studies, since these elements of water infrastructure are not definitive solutions for urban water security (Aini et al., 2001; AghaKouchak et al., 2015; Lin and Qi, 2017).

Reservoirs are also exposed to water stress, even in humid tropical climates, as observed in some regions of Brazil which occasionally reach critical water levels (Cortez et al., 2015; Kelman, 2015). The main reservoirs of Malaysia, which presents similar climate compared with Brazil, suffered in 1998 from El Niño effects, triggering a severe water crisis (Aini et al., 2001). According to these authors, ineffective water management magnified the effects of the crisis, affecting approximately 2 million people. Urban planning problems also contribute significantly to water crises, as shown by Morckel (2017) when discussing the case of Flint (Michigan) in USA and Kirk et al. (2017) in reporting the case of the Canterbury region (New Zealand).

Thus, the central objective this study was to show how natural factors associated with ineffective water management (environmental negligence) triggered a severe water (and consequently socioeconomic) crisis in a medium-size city in northeastern Brazil. The idea developed throughout the text is the result of a water shortage experience related to recurrent climatological events, indicating the need for national and international water management agencies to design guidelines, mechanisms, and considerations that take environmental seasonality into account. Finally, a panorama of future perspectives and integrated water resources management is discussed for solving socioeconomic and environmental problems that may occur in the territory.

2. Material and methods

2.1. Study area

The municipality of Itabuna is located in the southern portion of the state of Bahia (Ilhéus-Itabuna economic microregion) between coordinates 14°41′, 15°2′ S and 39°13′, 39°30′ W (Fig. 1). There are two watersheds (Almada – ARW and Cachoeira - CRW) located within the territorial limits of this municipality that belong to the East Atlantic water management region, according to the Brazilian National Agency of Waters - ANA. These watersheds supply the Itabuna city, which is classified as a medium-size municipality. According to IBGE Instituto Brasileiro de Geografia e Estatística, (2016), Itabuna presents an estimated population of 220,386 inhabitants, placing it among the thirty most populous municipalities of the northeastern region of Brazil.

These two watersheds are under a climate regime that favors rainfall throughout the entire year. According to the international classification proposed by Köppen (1948), this region presents an *Af* type of climate, which represents the classification of tropical rainforest climate without a well-defined dry season. According to Alvares et al. (2013), this climate is also characterized by mean temperature values of 24 °C, and annual rainfall above 2,000 mm. Still according to these authors, rainfall values indicate that this region is a zone with similar levels to those observed in the Amazon climate.

Regarding the water resources of the region, Santos et al. (2008) and Franco et al. (2011) stated that the mean drainage density of both watersheds is 2.35 rivers/km^2, characterizing an abundant hydrological surface system. On the other hand, the groundwater in the region of Itabuna, according to Maia et al. (2009), occurs in domains of crystalline basement rock, which leads to fissure aquifers with low to medium hydrogeological potential. The vegetation domain of the area is Tropical Rainforest (Atlantic Forest), with ombrophilous phytophysiognomy.

2.2. Methodology

Levels of environmental degradation in ARW and CRW were estimated using a spatial approach based on field observations to better understand the causes of the water crisis in the municipality of Itabuna. These two watersheds were separated in three quadrants with equal areas within a geographic information system (GIS). In each one of these quadrants there were 20 observation and sampling points (Fig. 2). The influence of the landscape on the rivers was investigated based on the identification of land use classes that could interfere with the hydrological regime. These classes were weighted according to a mathematical formula that interprets environmental phenomena (levels of degradation within a watershed).

Franco et al. (2011) and Lúcio et al. (2012) quantified forest patches and the predominant land use patterns of these two watersheds through remote sensing techniques. These studies were the base upon which our estimates were refined and were used to guide field observations. The classes observed for our study were forest, agroforestry system, pasture, exposed soil and urban area. Weights were distributed among these classes in a scale of 0–10. Forest and agroforestry systems were combined into a single class (low or no degradation to the hydrological regime), which received a weight of 1. Pastures received a weight of 4 (considerable degradation). Exposed soil and urban area were also combined into a single class (high level of degradation) and received a weight of 5. The procedural structure is described below:

$$LD = \frac{(N.5) + (N.4) + (N.1)}{100} \quad (1)$$

where N is the amount of points in each class of each quadrant, which is multiplied by its respective weight. Thus, an estimate is calculated in which the closer to 1, the higher the level of degradation of the water resources in that quadrant.

3. Why did a water crisis happen?

3.1. Water shortage

As previously exposed, the watersheds that supply the Itabuna city with water are located within isolines of approximately 2,000 mm of annual rainfall, second only to the Amazon. However, the mean values of 180 mm per month experienced an accentuated reduction during the period of occurrence of the El Niño phenomenon, which promotes a decrease in rain clouds over the central region of South America (Yeh et al., 2009; Mcphaden, 2015). According to the records of the Brazilian National Institute of Meteorology, for the southern region of the state of Bahia (Fig. 3), the months between August 2015 and June 2016 presented mean rainfall of 67 mm, with September 2015 presenting the lowest rainfall value (4.2 mm). These records are compatible with observations made by Jiménez-Muñoz et al. (2016), in the Amazon rainforest, which, in this period, showed a record warming and extreme dryness caused by ENSO.

River flow levels reached extremely low values (Fig. 4). Previous studies indicated that, due to the environmental and land use characteristics of the region, surface waters would undergo an accentuated reduction in quality. Thus, water bodies presented high concentrations of nutrients (eutrophication) and salt saturation, becoming high in

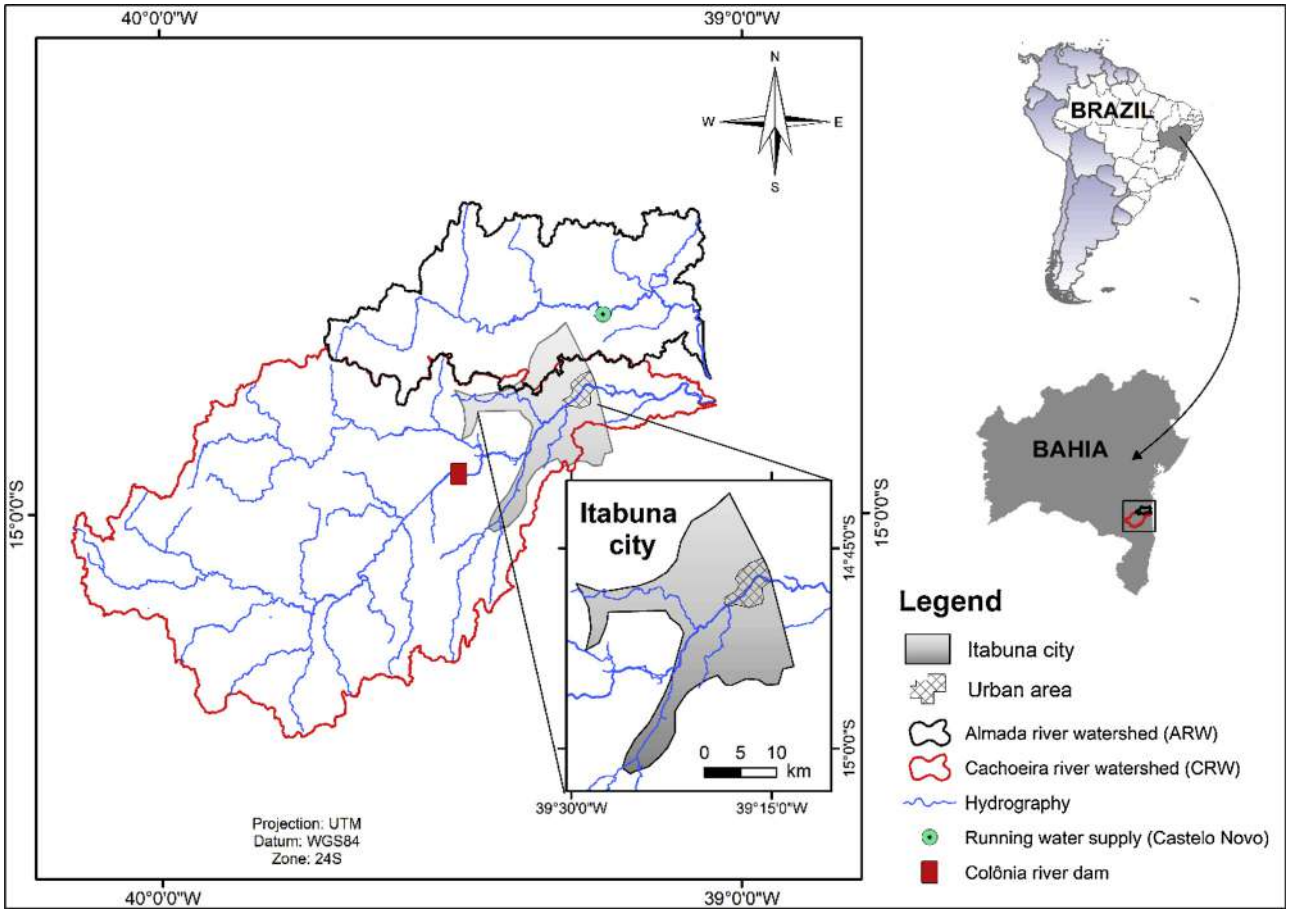


Fig. 1. Location map with city and watersheds.

salinity levels, turbidity and biochemical oxygen demand (BOD) (Klumpp et al., 2002; Lúcio et al., 2012; Chaussê et al., 2016; Santos et al., 2018).

3.2. Levels of degradation in watersheds

The economic shift that occurred in the region has promoted changes to the local landscape over the past decades. The watersheds have lost a significant portion of their original characteristic forests. The predominant change in ARW was towards agroforestry systems (cacao), while in CRW the main change was towards pastures. Deforestation, increase in environmental vulnerability, and deficits in river flow rates have been observed by Santos et al. (2008) and Franco et al. (2011).Fig. 5 shows the pattern of degradation of these two watersheds and the implications over the main water catchment point in Itabuna (ARW - Castelo Novo) and over the dam reservoir (CRW). The LD observed for the upstream quadrants from Castelo Novo were lower than for ARW, suggesting that the environmental degradation of these rivers had low influence in the water crisis of 2015–2016. Thus, the main cause observed was the unbalance between water supply and demand, which demonstrates the flaws in water resource management. A municipality without a reservoir combined with the absence of other strategic investments and effective environmental policies broadened the effects of the crisis and prolonged this situation for months.

After the crisis, investments were made to the dam, but the watershed chosen for this endeavor was the CRW. The map of Fig. 5 shows that the quadrants upstream from the new dam present higher LD estimates than CRW. The LD values are also higher in comparison with ARW. These results demonstrate that the dam was implemented in a degraded watershed with reduced capacity to control the hydrological regime (river flow). Although these estimates presented are not conclusive, they are coherent with other studies regarding the classification of land use patterns in these watersheds (Franco et al., 2011; Lúcio et al., 2012). The current scenario projects challenges to future water management and to the management of CRW regarding the restoration of ecosystem services, increasing water supply to reservoirs and guaranteeing permanent water security.

3.3. Failures in water resources management

The climatological normals that indicate a more intense ENSO in an average cycle of 15 years (Jiménez-Muñoz et al., 2016), already predicted, since the 1990s, a water deficit in the environment of the previously mentioned watersheds. In 1997–1998, when the last more intense ENSO occurred, there was a similar water crisis to that of 2015–2016 that lasted 3 months, with extremely low flow rates of the water supply river. In addition, at its lower course, the intrusion of a saline wedge into the water collection system deteriorated water quality.

The municipal public water company did not finance appropriate water treatment and did not provide effective alternatives for water supply in the municipality. For four months, brackish water was distributed to consumers in the Itabuna city. In the 2015–2016 crisis, the same management failures were exposed, and the problem regarding supply of salinized water lasted 8 months, until mean rainfall values were reestablished in the area (Silva and Silva, 2016). The measures taken to solve the problems faced were once again palliative. Over the last few decades, water company has not promoted targeted governance in investments and strategies for water production in the regional watersheds. With the supply of water compromised, some other problems

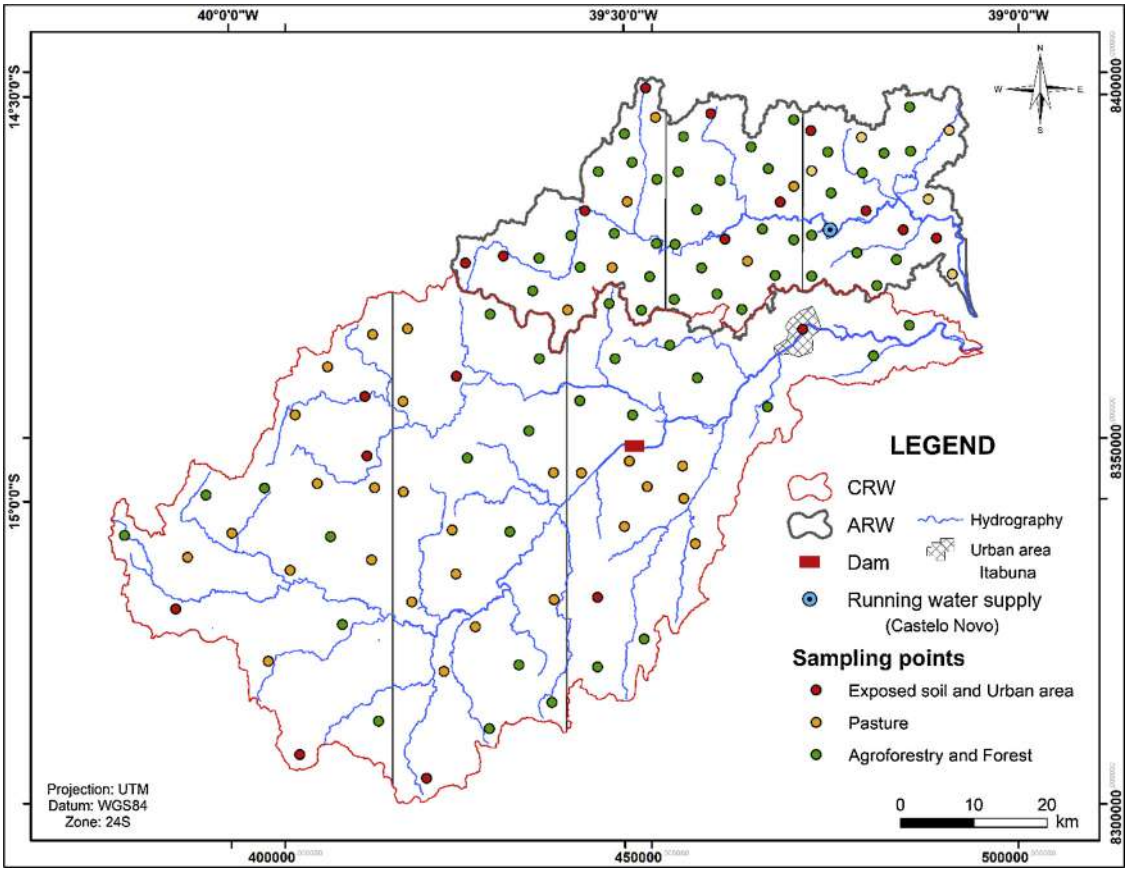
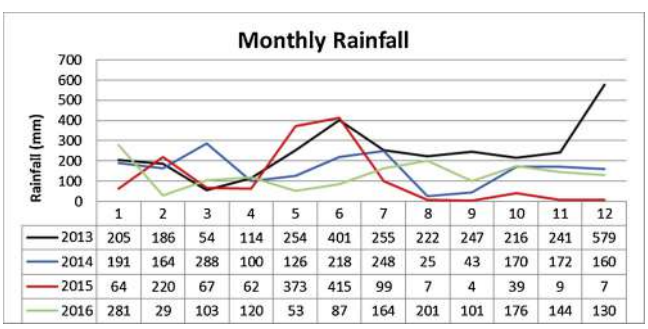


Fig. 2. Map with field observations for three quadrants in each watershed.



	1	2	3	4	5	6	7	8	9	10	11	12
2013	205	186	54	114	254	401	255	222	247	216	241	579
2014	191	164	288	100	126	218	248	25	43	170	172	160
2015	64	220	67	62	373	415	99	7	4	39	9	7
2016	281	29	103	120	53	87	164	201	101	176	144	130

Fig. 3. Rainfall values for the region of Itabuna between 2013 and 2016.

such as absence of transparency and effective policies, associated with poor systemic vision and disregard for legal issues, contributed to the emergence of the water crisis. In the regional scenario, the state water company that serves the neighboring municipalities also does not have an effective governance model to promote water production in the watersheds, inserting the region in a stage of water vulnerability.

Although the occurrence of ENSO is predictable and the region is rich in water resources, a crisis still occurred, which demonstrates the fragile strategies and poor policies used to promote water security. Biggs et al. (2013) reports a scenario for both water and management observed in cities and watersheds in Nepal that presents some similarities with Itabuna, which suggests that integrated management of water resources and interinstitutional articulations should be promoted and improved. The municipality of Itabuna missed the opportunity to learn with the failures in water management of other regions in the world, such as Iran (Madani, 2014), the USA (Morckel, 2017) and even other parts of Brazil (Dobrovolski and Rattis, 2015). This would have minimized the damages and effects of the crisis by renewing the way in which water resources are managed so that prevention is promoted, and palliative actions are disregarded.

Silva et al. (2015) identified several problematic aspects in the use of spring waters in the vicinities of the Itabuna city. According to these authors, the most appropriate plans to make up for water shortage in a short-term period would be water transposition from other watersheds and even using water from an environmental conservation area (Encantada Lake). However, the main course of action in the region was the construction of the dam in CRW. The justification for this endeavor was “to solve eventual problems in water supply”. However, Silva et al. (2015) suggested that the dam was possibly a support structure for a harbor complex that would be implemented in the area. With approximate cost of R$ 115 million (US$ 31 million, according 1.0 US$ = R$ 3.70 rate), in June 2018 the dam started operations.

As the water crisis worsened by the end of 2015, the construction of the dam reassumed a political position. The justification for the construction was emphasized as public supply, even in a scenario that indicated, according to Silva et al. (2015), that the best cost-benefit decision would be the formulation and execution of an extensive recovery plan for the ARW and CRW. This action would certainly would improve environmental conditions of the areas in which the main springs of the region are located. Socioeconomic gain would be a positive mid- to long-term externality. Considering the implementation of a dam as a complement to the context of environmental recovery is probably the wisest decision, provided that costs and benefits are better evaluated to ensure long-lasting water security (Chen et al., 2016).

3.4. Consequences of the water crisis

With prolonged water shortage, the municipal government and local population sought alternatives to meet the demand for water that affected the municipality. However, some mistakes in governance

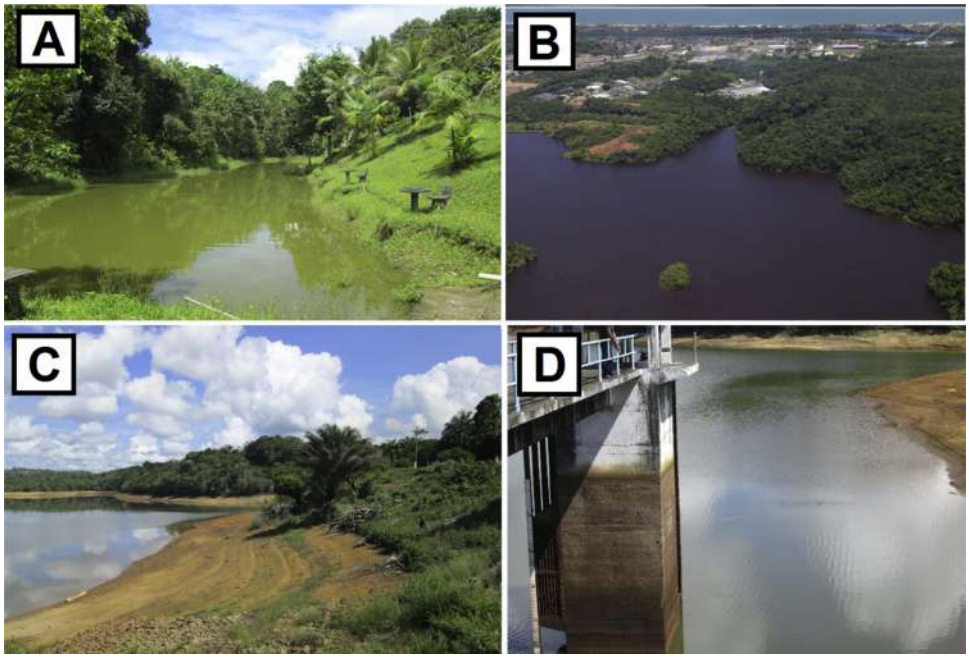


Fig. 4. Water sceneries in region of study: (A) Natural configuration in tributary streams of region; (B) Landscape of main stream in Almada watershed; (C) Low level in main stream in Almada watershed in crisis period; (D) Low water level in water supply point of the Almada river (Castelo Novo).

decisions during this crisis period yielded administrative and economic disorganization within the local government, which hindered actions towards the scarcity of this resource. The lack of a robust and efficient policy for priorities extended the effects of the crisis and promoted unequal experiences of water shortage among the population. Less privileged classes suffered disproportionate impacts in a similar scenario to that of the 2015 water crisis in São Paulo, as shown by Millington (2018), which may suggest a typical pattern for cities in emerging countries.

The crisis period was characterized also by an intense water-related

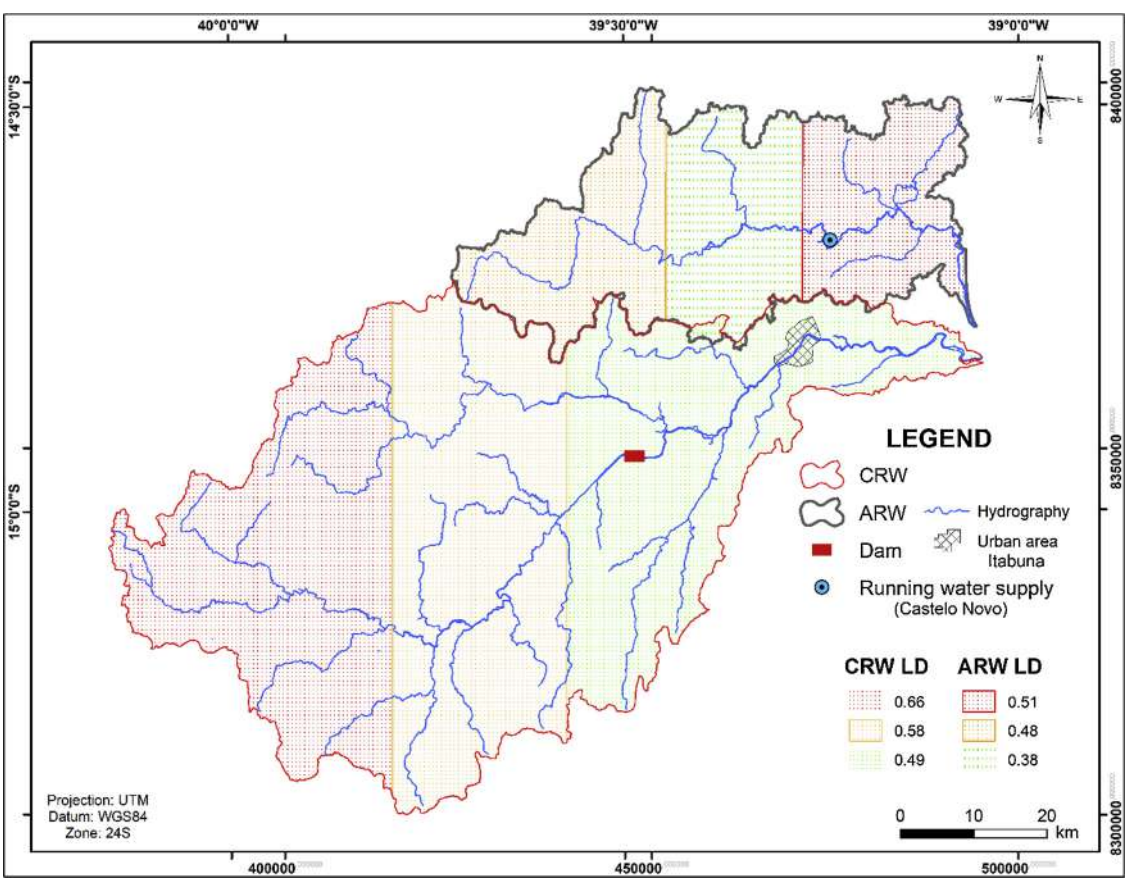


Fig. 5. Map with levels of degradation for each quadrant.

commercial speculation that reflected in a significant increase in the prices of related goods. The sales of bottled mineral water multiplied, as well as the use of tank trucks that transported and sold water from other areas of the state. In some cases, the origin of the waters delivered by tank trucks was unknown, raising suspicion regarding their quality and implications to public health and food security. A significant increase in (private) deep well drilling was also observed, with approximately three hundred new wells in an urban fractured aquifer of low hydraulic potential. This panorama revealed other problematic issues related to the exacerbated use of groundwater, which may harm the water production of aquifers.

Thus, municipal sanitation also becomes a concern, once it may imply contamination risks and affect groundwater quality. Some zones of the Itabuna city present deficiencies such as inadequate wastewater disposal, with open-air sewers and total absence of water infrastructure. According to Van der Bruggen et al. (2010), these are chronic problems detected in urbanized regions of developing countries. The municipality itself, through its own municipal water and sanitation agency, does not treat wastewater, but rather channels it *in natura* into the Cachoeira River. Naturally, urban areas are hotspots of medium and high risk of groundwater contamination, also depending on geological typology, as shown in studies by Foster and Chilton, (2004) and Kihumba et al. (2016). Thus, the scenario projected for Itabuna suggests that a significant amount of the groundwater from aquifers that underlie the urban area may be contaminated and inappropriate for consumption.

4. Future perspectives and integrated water resources management

4.1. Dam and reservoir management

The dam for this medium size city was implanted with a lag of decades, but despite the delay, it is welcome and arrives in good time. Certainly, this dam will lessen the water problems of Itabuna city, with potential to promote economic and population expansion. The reservoir presents a surface area of 1,621 ha, and estimated water volume of 62,670,695 m^3. Its dimensions, according to the Environmental Impact Report conducted for its construction should provide effective water supply over the next century (Fig. 6).

However, CRW presents high rates of deforestation, as well as the reduction of water productivity per hectare. Without a recovery plan for the CRW, the reservoir will be more vulnerable to climatic weather and high demand, and may experience water deficit in future, especially in a time of climate uncertainties. The example of the water collapse in the reservoirs of the Cantareira system, which supplies water to millions of people in São Paulo state, is an alert that environmental negligence can trigger significant losses in times of climatic adversity (Dobrovolski and Rattis, 2015). In other words, the reservoir for Itabuna and region will be extremely important, however, can fail if the rivers that feed the water production system are not recovered.

O'Connell, (2017) reiterates that constant economic pressure and population growth are a major threat to global water security. The author suggests that efforts should be greatly focused on actions related to water use efficiency by the economic sector and, thus, avoid reservoir water stress and generalized water shortage. Ehsani et al. (2017) suggests that holistic management that considers the operation of dams, water use, and environmental policies should also be designed to meet the future needs of cities and metropolitan populations that need stability in water supply. Itabuna is an important regional pole of services and trade, with an increasingly larger demand for water to maintain socioeconomic activities. Itabuna also presents industries and, according to IBGE Instituto Brasileiro de Geografia e Estatística, (2016), over the past six years, the mean population growth rate was larger than that of the past thirty years.

The increase in demand associated with periods of severe water shortage, climate change, and a degraded watershed, should influence the reservoir. Thus, a water collapse could occur, triggering a new crisis and causing severe socioeconomic and environmental damage. A degraded basin tends to lose a higher rate of sediment due to surface runoff, which can cause over the year's siltation of the reservoir and thus compromise the ability to regulate flow, spill and storage. In addition, water quality can also be compromised, significantly increasing the cost of water treatment (Fiquepron et al., 2013; Lopes et al., 2018). Finding better ways to operate a reservoir is a challenge that can mitigate negative environmental and socioeconomic impacts, as explained by Chen et al. (2016) by showing that the absence of a balanced political and participatory approach can have implications for the development of dam infrastructure, thus limiting its positive externalities.

4.2. Land use management in watersheds

In face of the approach presented in this study, for the dam and their reservoir as an effective and long-lasting solution to the water needs of the Itabuna city, we suggest that bold recovery and conservation plans for the watershed would have to be designed and executed. The payment for ecosystem services (PES) program can be a mid- to long-term solution that could guarantee forest restoration, river flow rate regulation, and improve water quality (Pagiola et al., 2007; Osuna et al., 2014; Zolin et al., 2014).

PES programs for watersheds (PWS) consist of an internationally broadcasted management element (Martin-Ortega et al., 2013; Nguyen et al., 2013; Caro-Borrero et al., 2015) where each country has a specific form of managing their water and environmental resources, defined by the characteristics and needs of their society, and their political and economic ability (De Groot and Hermans, 2009; Richards et al., 2015). PES programs in Brazil have already presented positive results in some locations, such as the municipalities of Extrema, state of Minas Gerais (Jardim and Bursztyn, 2015) and Apucarana, state of Paraná (Young and Bakker, 2014).

As with Extrema and Apucarana, Itabuna would need strong political articulation among city halls, watershed committees, governmental agencies and non-governmental organizations, in order to define a solid structure that would provide a PWS policy with technical and economic guarantees. An integrated and participative water resource management could stimulate dialogues and promote best practices to implement and monitoring PWS policy in the CRW and ARW.

The Itabuna city, the main interested party in water products of PWS, can use your leadership to formulate and propose effective economic mechanisms in order to make the program more appealing to rural producers, minimizing market gaps between ecosystem services and food production (agriculture and livestock). Monitoring is fundamental to the whole process (Young and Bakker, 2014), since, besides monitoring the evolution of the PWS, it can also be incorporated into the environmental market from some alternative mechanisms, such as forest or ecological certification (Jaung et al., 2018).

Promoting technical and political efforts to make water governance feasible with the intention of recovering watersheds could definitively be a good cost-benefit alternative for Itabuna, which would also strengthen the decentralized management of watersheds. The economic autonomy guaranteed by the "Water Law" (Brazil, 1997) allows the incorporation, within the context of watersheds and watershed committee, of economic engineering mechanisms proposed to optimize water availability for water users. The products generated by implementing such mechanisms would have the potential to generate benefits in multiple economic sectors within watersheds, as shown by Hejnowicz et al. (2014), thus comprising a consistent policy, with permanent practical results.

4.3. Economic policies and natural capital

Depending on the type of economic and environmental proposals elaborated, in approximately ten years, forest restoration in a degraded

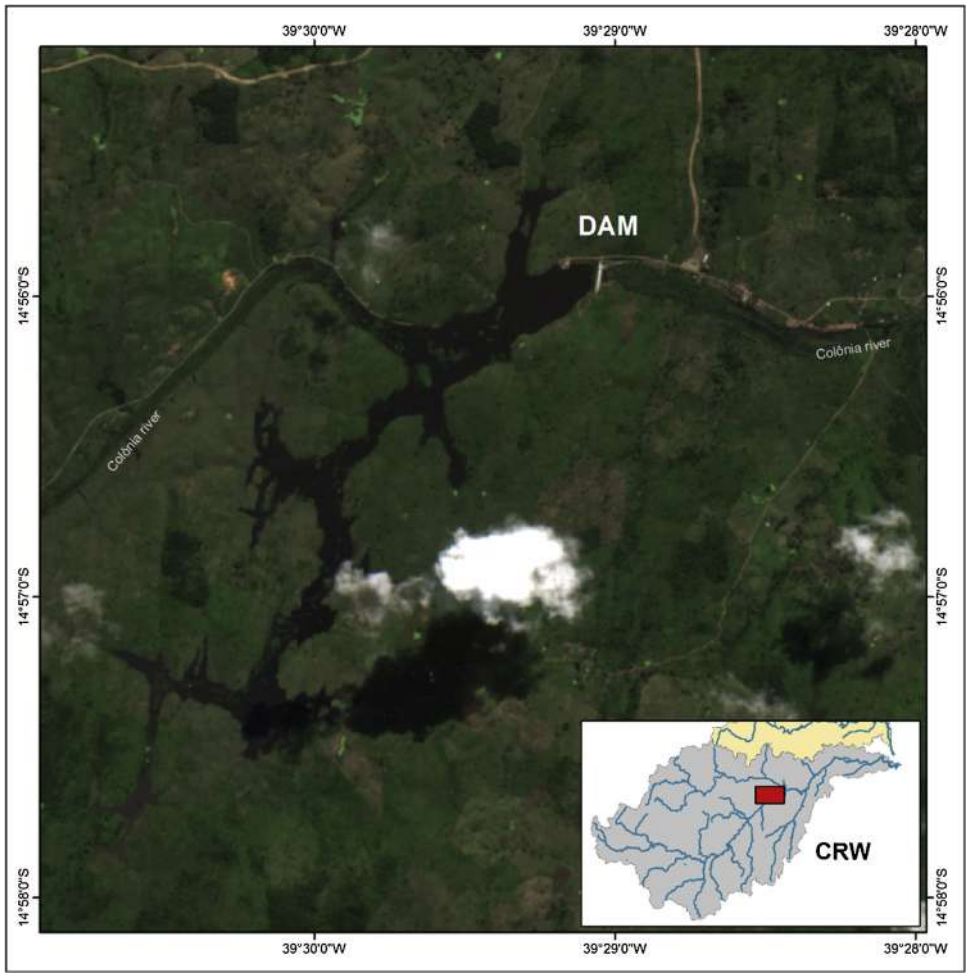


Fig. 6. Aerial image of the Colônia River dam (CRW).

area could be more profitable than using the land for extensive livestock production (Brancalion et al., 2012). In addition, preserving and restoring watersheds has been proven to be an excellent business, as indicated by Chichilnisky and Heal (1998) and Pires (2004), who described which the city of New York has invested millions of dollars in the conservation and restoration of the watersheds that attend the city's water demand, saving approximately US$ 6.5 billion in engineering interventions. In the case of Itabuna city, local climate, in the context of water production, is historically favorable. However, after a period of water crisis, the decision made was to allocate resources towards engineering measures (dam) to the detriment of investments for the recovery and conservation of watersheds, thus constituting a palliative strategy.

The implementation of recovery policies and programs based on payment for ecosystem services will be able to, according to Tundisi and Tundisi (2016) and Mattos et al. (2018), introduce new opportunities for the economic development of watersheds. Among these opportunities, are the creation of employments, movement of financial capital, attraction of external investments, stimulation of the environmental service market, interinstitutional articulations, stimulation of water equity, environmental education, and research. These programs, if effectively conducted, will significantly contribute to the socioeconomic and environmental development of the municipality of Itabuna, generating natural attractions and dividends at a regional scale.

Promoting water security requires a broad interdisciplinary approach (James and Shafiee-Jood, 2017) that enhances watershed productivity and reservoir operation from water resources management that enhances the performance of ecosystem services and minimizes environmental and economic risks. There is a variety of possibilities and economic mechanisms available to improve water resources management, including the participation of water users (Roesch-McNally and Rabotyagov, 2016; Del Saz-Salazar et al., 2016). These authors reiterate that projects of this kind demand significant political will, transparency in the process, provision of guarantees, and consistent dialogues with water users. Therefore, Itabuna city needs to channel the strength of its 220,000-person community, its regional economic influence and market experience to its favor, aiming to mobilize the private initiative, minimize associated risks, and guarantee incentives and subsidies necessary for the stakeholders involved in the programs.

The difficulty in securing funding for promising policies such as PWS is still a barrier that limits conservation practices in watersheds worldwide. The absence of universal guidelines directed to this type of policy, combined with technically unprepared promoters, weakens the business and investment capacity for PWS, as shown by Benett et al., (2014), who analyzed some experiences in the USA. Many researchers have relentlessly investigated alternatives that work around this reality, such as Young and Bakker (2014) and Mattos et al. (2018). These authors suggest that water companies, which hold a large cash flow and profit margin, could be the protagonists in the economic engineering process of a market for watershed environmental services.

The process of opening a market for environmental services faces the cultural reality of a market based on food production, in a scenario where current institutions and market structures still favor traditional engineering approaches (Vogl et al., 2017). The search for water security through PES programs is a challenging strategy that requires effort, dedication, boldness, and awareness, but is capable of producing

durable benefits. Water managers and users need to react and adapt to climate oscillations and changes in order to reduce human impacts on water availability (Mehran et al., 2017). The authors of the present study discuss that feasible opportunities through an integrated water resources management framework demand institutional, economic, and political advances that must include prudent and objective natural solutions with alternative and effective engineering approaches.

5. Conclusions

The governance and management of water resources of a given geographic site should contemplate, in a technical and responsible way, the environmental variables that eventually may affect water production, catchment and distribution mechanisms. The land use in the watersheds that supply the Itabuna city is based from inverted priorities that accentuate the problems during water shortage periods, triggering severe water crises that directly influence the economy, as well as affecting environmental safety and social welfare. In addition, dialogues between mid- and long-term actions are needed regarding scenarios where watersheds present degraded environmental states. The 2015–2016 crisis was certainly amplified by land use policy negligence, which revealed a series of other problems in sectors such as the economy, infrastructure, and health.

The current land use panorama suggests that the implementation of watershed forest and water recovery plans is necessary. The Itabuna city, the most interested party in the products that could be generated by this policies, and an important regional pole in the state of Bahia and northeastern region of Brazil, could promote PES-PWS policy from innovative economic mechanisms and strong political articulation. The implementation and subsequent amplification of the environmental policies in the region would deliver results over a mid- to long-term period, with the potential of generating countless socioeconomic and environmental opportunities.

Finally, but not least, it must be noted that while the focus of this study was on a Brazilian medium-size city, the problems and solutions discussed are not unique her. We argue that governance without a balanced and smart policy of priorities can promote water insecurity, even in a scenario of water plenty. The discussion conducted in this study shows to other countries of the global community that also deal with water crises, that the methods adopted by Itabuna city to solve the problem of water shortage, although valid, isn't enough, since they require large engineering interventions, that alone it does not guarantee water security. The impression that remains is that choices are merely based on politics advertising, since investing in large infrastructure projects in Brazilian cities has a much more relevant media and electoral appeal than investments in environmental policies for recovery and conservation. We suggest the engagement of universities and education and research institutes to conduct new studies aiming to reinforce the points addressed in the present study, and to quantitatively elucidate several environmental and socioeconomic issues involving watersheds and water security in the region.

Conflict of interest

None.

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