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WATER AS FREEDOM IN THE BRAZILIAN AMAZON*

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Abstract. Universal access to the commons, such as to clean water, might be seen as a strong challenge to development as freedom. Beyond water scarcity, several regions are already suffering from lack of access, even where water is abundant. Meanwhile, climate change, overpopulation and agricultural demand are severely affecting the quality and availability of water resources. At the global level, concerns about water are tied to the Amazon Region, which contains the greatest potential water stock in the world, and which simultaneously faces the worst troubles in access and supply. This paper is therefore aimed at pointing out the role inclusive social innovations can play in mitigating the impact of growing water shortages and securing effective water use. After a first introduction to Brazil, Amazonas and Pará state statistics on water-related aspects, the research focuses on results emerging from the AguaSociAL project.

Keywords: Brazilian Amazon; water management; natural resources; social innovation; freedom

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JEL Classifications: Q25, Q53, Q55, Q56, Q57

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1. Introduction

According to Schopenhauer (1818), the Veil of Maya disguises reality, preventing the observer from focusing clearly on the object. Often, economists make the same mistake when they pay attention only to tools, rather than targeting ideas. Behind the policies and instruments adopted there is the *Weltanschauung*—visions of the world that could differ from one another. Even John Maynard Keynes, in his masterpiece, underlines the importance of the effects ideas produce in all aspects of daily life (Keynes, 1936, pp. 383-384). Indicators and policies are not “technicalities,” since they are the direct expression of a chosen framework. Gross domestic product (GDP), for instance, derives from a target framework that identifies production as the driving force behind well-being and development. Changing ideas might not be sufficient since, before becoming policies, ideas are filtered by institutions (De Muro et al., 2013). If institutions are old or unfit for the context in which they operate, then ideas, even the most successful ones, will not become good policies. Therefore, attention should be paid to ideas and institutions, rather than to debating, often without concrete results, individual tools and instruments (Monni, 2013).

Economics cannot provide a single answer to complex and interrelated issues, since their implications go beyond mere “economic growth” or “gross domestic product” arguments. A new development paradigm should take place with a strong interdisciplinary approach and the capacity to answer correctly to similar emergencies. Specifically, introducing innovative and discontinuous elements from former solutions adopted can represent not only a simple process of technological innovation but also, and foremost, an actual “social innovation”.

Therefore, when talking about water issues, technologies and management models should necessarily take into account social arguments as well as rethinking a more traditional planning methodology, aiming at granting populations better access to water resources and at improving the quality of this essential element of people’s well-being. Such an approach opens new possibilities and perspectives on management, research and evaluation of innovation processes.

The present paper aims to point out the results achieved by AguaSociAL, a project focused on “Social Innovation in the Water Treatment Sector in the Amazon”[†]. In order to do so, in the second and third chapter economic growth and development indicators will be provided, both for Brazil and the states of Pará and Amazonas. The research will then analyze the key role of water in development processes. In the fifth chapter, this paper will be engaged with the study of social innovations in water treatment. Finally, results and conclusion will be discussed.

2. Brazil between economic growth and development

Brazil began the new millennium with a sense of uncertainty. However, since 2003 president Lula has focused policy on fostering public and private investments in energy and transportation by raising taxes. In addition, he fostered the significant expansion of credit by state-owned financial institutions and set a wide net of social programs in order to push so-called *demand-led growth* by means of redistribution. This model of expansion of the market, substantially based on consumerism, was based on internal mass consumption and exportation of primary goods (Morais and Saad-Filho, 2012).

[†] For more information see: https://cordis.europa.eu/project/rcn/111055_en.html

However, after the financial crisis of 2008, in which the BRICS countries suffered less than other hegemonic poles like the United States and European Union, Brazil quickly recovered thanks to the accumulated reserves and the prospect of continuing favorable prices for internal commodities.

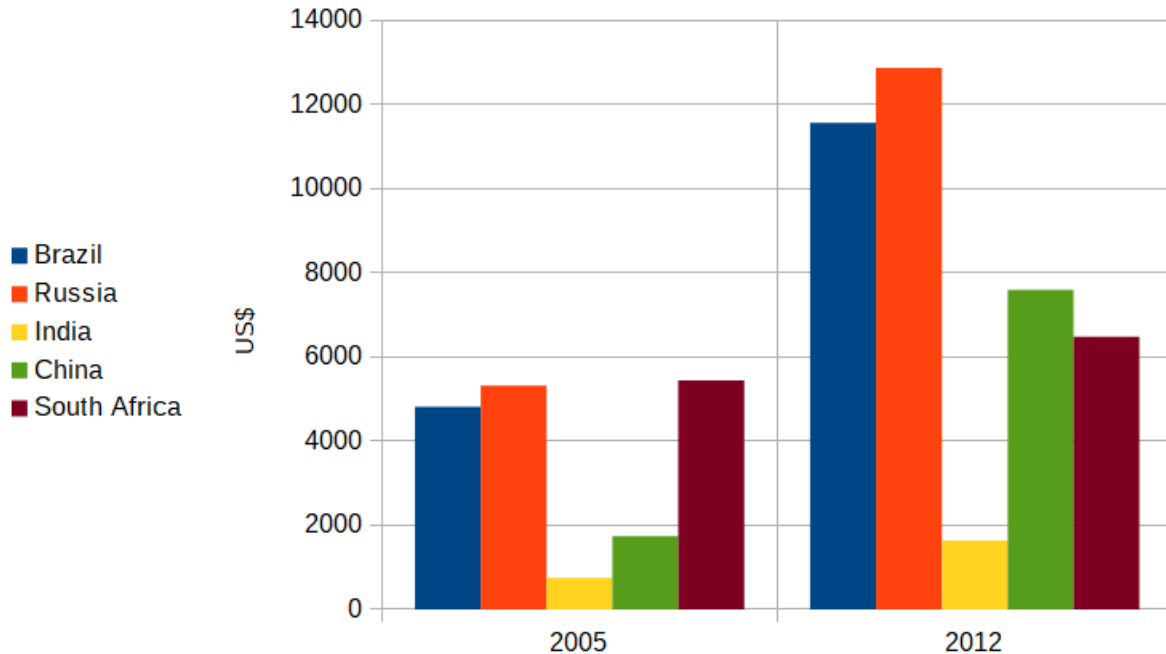


Fig.1. Gross Domestic Product per Capita (Current Prices) in BRICS countries
Source: Personal elaboration from BRICS Joint Statistical Publication, 2015

However, at the end of the commodities boom the country found itself with a stagnant economy and a population clamoring against the high cost of living, revealing insufficient public services (Contipelli, 2016). In the second decade of the third millennium, economic performance was not as positive as in previous years. In 2011, the year the Rousseff mandate (2011-2014) began, GDP growth fell from 7.5% (in 2010) to 2.7%. It contracted by 3.8% in 2015, and was expected to fall at least 3% more in 2016 (World Bank, 2016).

In fact, although Brazil succeeded in lifting more than 28 million people out of poverty and inequality (MDS, 2011), the rate of reduction of those two indicators appears to have stagnated since 2015 (World Bank, 2016). According to the OECD (2015), Brazil's Gini index has kept falling since 2000, but its value remains around 0.6 points, a score in line with BRICS performances but higher than the OECD average (Gomes e Da Cruz, 2016). After more than ten years under leftist governments, Brazil has to face two main paradoxes: the first is related to public expenditure, since the Brazilian government is not yet able to offer high quality services; the second is the fact that Brazil didn't take proper advantage at the opportune moment to implement structural reforms, and instead concentrated its efforts on commodities trading (Contipelli, 2016). However, historical and current evidence suggest that income inequality concomitant with a rise in economic growth can be limited and reduced by political reforms (Cavalcanti, 2014; Tvaronavičienė, Gatautis, 2017). In this process, social participation and democracy are very important; political freedom is highly valued as pivotal in the achievement of human development (Sen, 1999).

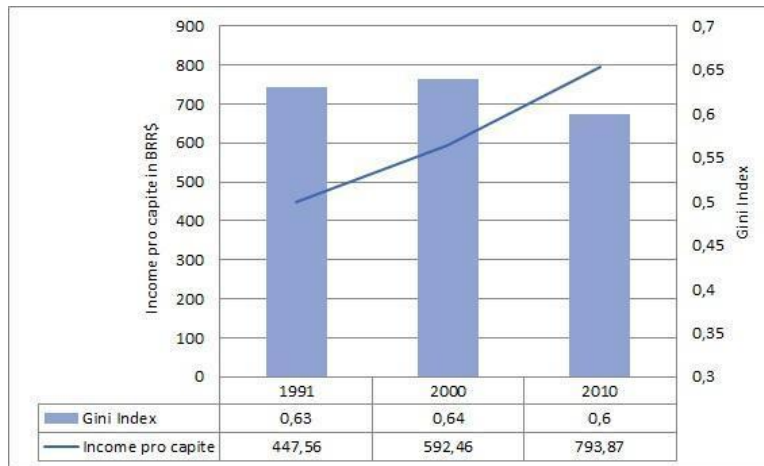
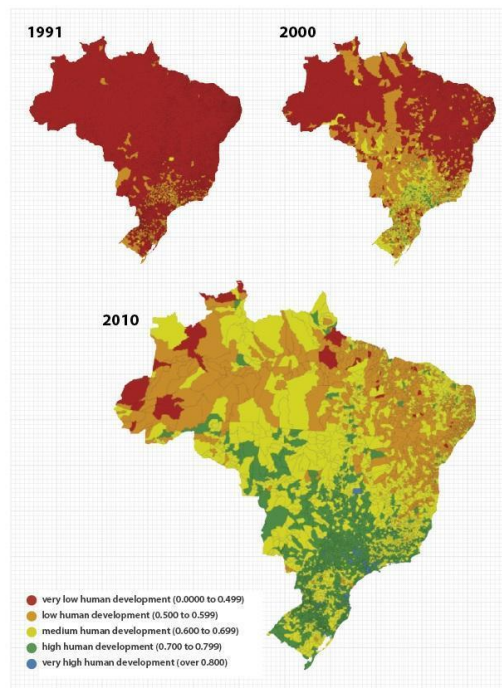


Fig.2. Income inequality in Brazil

Source: Personal elaboration from IBGE data on Brazilian census, 2013

In this view, both high public services and low inequality (that is, fair income distribution) are influent on the development of a country.



Map 1. Human Development Index in Brazil

Source: Instituto Lula from UNDP; FJP; IPEA

Nevertheless, Brazil remains one of the largest exporters of raw materials in the world and its case is emblematic of how investments may produce income concentration (centers of extraction) without really positive affecting the country's development as a whole. According to the Human Development Report (UNDP, 2016), Brazil has a high human development value (0.754), positioned at 79 out of 188 countries and territories considered. It scored

above average for the Latin America-Caribbean area. However, it must be taken into consideration that there are still huge gaps in the distribution of human development across the national population, as shown by Map 1.

The imbalance between extractive costs and revenues from the use of natural resources not only concerns Brazil's relationship with foreign commercial partners, but rather represents an internal North-South dynamic (Costantini and Monni, 2008 a. and b.; Cori, A. and Monni, S., 2015). From this point of view, the case of the Brazilian Amazon clearly reveals a reckless use of natural resources (e.g. the use of water for national hydroelectric production) (Pinto, 2017). Development of the Amazon is then driven by a national project constantly threatened by external pressure (i.e. big international capital). This draws a framework of perpetrating both social and political exclusion, preventing a project of real inclusive national development (Domingues, 2002).

3. Amazon State and Pará between economic growth and development

The uneven trend between growth and development occurs at the level of Federation as much as of macro regions. For instance, the Brazilian Amazon, which area includes the North Region plus Mato Grosso and Maranhão, is rich in natural resources, whose exploitation has strongly influenced the economic growth of the area for decades, especially in terms of energy production (Table 1). Amazonia Legal corresponds to 64% of the Brazilian territory and stands out in the economic scope by virtue of its vegetal and mineral extractivism, agriculture and fishery. It presents high income inequality, despite being below the national average (SUDAM, 2016).

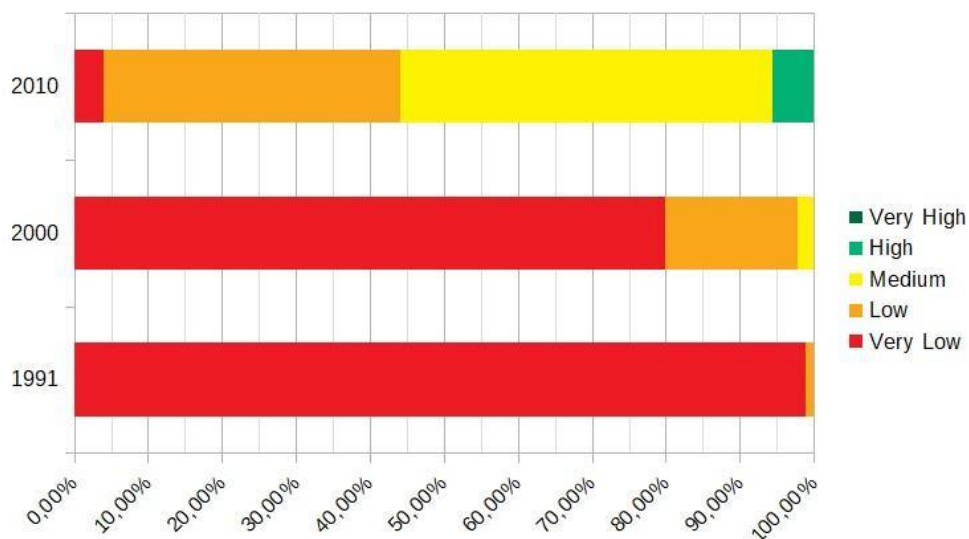


Fig.3. Distribution of Municipalities by level of human development (North Region)
Source: PNUD; FJP; IPEA, 2013

However, the average score of the human development index within the area is still one of the lowest in the country. With five to seven states belonging to the medium human development zone, the North Region scored just 0.667 on the human development index in 2010; it also houses Melgaço (Pará), the municipality with the worst human development index in the country (0.418) (Figure 3). As far as human development is concerned, it is noteworthy that the Amazon has been the subject of national development projects since the seventies, owing to its enormous availability of resources. The Grande Carajás program, launched in the 1980s in the state of Pará, is a classic example of a “sectoral” program, including the implementation of various regional investments. Among others, the iron and aluminum extraction and refining industry of Barcarena has been active since 1985, while the hydroelectric power plant of Tucuruí has been active since 1984, and was built with the objective of supplying energy to the abovementioned foundry. Nowadays they have both a massive role in the national production of

refined aluminum and hydroelectric energy, respectively, while the state of Pará has shown increasing participation in the national GDP. In fact, in 2014 it provided for 40.44% of the North Region GDP, covering 2.16% of the National GDP (Fapespa, 2016).

The second state of the North Region in terms of GDP is Amazonas. After decades of successfully exploiting rubber and other natural resources, since the seventies the federal government has encouraged growth by creating the Industrial Pole of Manaus. The main goal of the project was to accelerate the industrial revolution in the region and nowadays the industrial park has a diversified production, with prominence for electrical materials, even though both in Amazonas and in Pará extractivism still represents a strong part of the local economy, while agricultural production is mainly focused on traditional but strategic cultivations such as rice, cassava and tropical fruits.

States (Federation Units)	Electricity Production Gwh*		
	2011	2012	2013
Acre	203	377	234
Amapá	1.566	1.704	1.816
Amazonas	9.036	9.561	9.970
Maranhão	1.943	3.621	11.181
Mato Grosso	7.200	10.802	12.361
Pará	43.092	41.217	41.191
Rondônia	3.214	4.173	6.407
Roraima	133	128	169
Tocantis	10.650	12.747	11.881
Amazônia	77.037	84.330	95.210
Brazil	531.758	552.498	570.025
*including self-production			

Table 1. Energy Production in the Brazilian Amazon—electricity
Source: Personal Elaboration from SUDAM 2016, MME 2011

However, the strong participation of foreign investments in the case of Manaus, together with the creation of the energy pole of Pará as a means for national development, lays the ground for a further discussion about the real impact of growth on local development.

In fact, sectoral projects of national interest are usually considered capable of boosting both growth and development of so-called peripheral areas. However, the results in terms of development in the North Region, although in line with the country's performance, do not exactly meet expectations. The non-synchronous trend of development of the North Region with respect to the country as a whole provokes reflection. Although sectoral programs usually absorb greater funding than regional projects, satisfactory results for the national economy keep pace with the escape of benefits out of the local context. The flux has a double direction, local to national as much as local to abroad (in the case of revenues from the industrial pole of Manaus).

The economic growth of the country is not always able to drag local development with it, as in the case of the Amazon Region. Similarly, national development strategies in Brazil seem not to be able always to drive the

regional development process without increasing internal core-peripheral dynamics (Magalhaes, 1987; Furtado, 2000).

4. Water as Freedom: a key issue for better understanding Brazil

In 1999, Amartya Sen wrote about the concept of development as the process of expanding the freedoms that people enjoy. Policies should be aimed at removing major sources of “unfreedom”: poverty, tyranny, poor economic opportunities, social deprivation, and neglect of public facilities, as well as intolerance (Sen, 1999). Access to clean water, for instance, should be one of those forms of “unfreedom” tackled and eradicated, due to its key role in human activities. Indeed, it has been argued in the 2018 United Nations World Water Development Report that clean water has a crucial role in achieving SDGs, and more generally in implementing development processes. More specifically, clean water, not just an end in itself (SDG 6—ensure access to water and sanitation), has an impact on sustainable agriculture (SDG 2), healthy lives (SDG 3), building resilient infrastructure (SDG 9), sustainable settlements (SDG 11) and disaster risk reduction (SDG 11). Moreover, this report highlighted the relevance of water scarcity mitigation policies (UN, 2018).

The relevant literature agrees that water scarcity has three main dimensions: physical, infrastructural and institutional. As far as physical water scarcity is concerned, estimates show that a withdrawal rate, on average, above 20% of renewable water resources would put “substantial pressure” on water resources, while reaching 40% or more would be “critical”. Moreover, as in the case of Brazil, where water may appear abundant, much of it is not accessible due to natural (e.g. deep within the Amazon Forest) or engineered (e.g. use for energy purpose) causes (UNDP, 2006).

4.1 Land use of water

Present projections indicate that the world population will increase from 6.9 billion people to 9.1 billion by 2050 (United Nations, 2009). At the same time, food production will also grow by about 70% globally and by 100% in developing countries (FAO, 2011). When looking at data on the world’s cultivated areas, numbers follow the same trend: lands dedicated to agriculture have grown by 12% over the last 50 years, while irrigated areas have more than doubled in the same period (FAO, 2011). Even if some major improvements have been introduced in the sector, agriculture still uses 70% of all water withdrawn from aquifers, streams and lakes, posing the key question of sustainability. Total water withdrawals still represent only a small share of all internal renewable water resources, but these figures have major regional discrepancies (FAO, 2010).

In fact, Spera et al. (2016) have underlined the considerable implications for water cycles that Brazil is facing. In particular, the study showed that in some areas in Brazil, such as the Amazonian and Cerrado areas, cropland agriculture doubled, changing from 1.2 to 2.5 million ha, with 74% of new croplands sourced from Cerrado.

4.2 Urbanization

The latest trends clearly show that 40% of the global rural population now lives in river basins that are physically water scarce (FAO, 2011). At the same time, urban areas are forecast to grow, by about 1.4 billion to 5 billion between 2011 and 2030. By 2050, 70% of all people on earth are expected to live in an urban environment (World Water Council, 2015). Notably, an increase in urbanization will affect mainly developing countries such as Brazil, and will feature the rapid growth of small and mid-sized cities, alongside the development of new urban areas. In Brazil, the percentage of the population living in urban areas has constantly increased from 1950, reaching more than 85% of the total population in 2018 (UNDESA, 2018). In particular, looking at disaggregated data on urbanization trends in Brazil, all typologies of urban settlements are experiencing an increase in numbers:

currently, there are two cities with 10 million (or more) people, and 19 cities with 1 to 5 million people (seven more than in 1990) (UNDESA, 2018).

From a water perspective, urbanization could negatively hit water resource-intensive development paths over the next decades, excluding more people from access to drinkable water sources. Challenges to water infrastructure and water resources management could develop steadily, and cities need to adapt to these ever-changing social and economic circumstances, promoting inclusive and innovative ways to secure access to safe and drinkable water. As far as the Amazon goes, the increasing trend of urbanization is leading to a rising consumption of natural resources, especially water, for various purposes (Rocha and Neves, 2018). However, the greater the consumption, the greater the pollution of water, due to the urban context, which results in a worsening of surface water quality. The real challenge to the Amazon Region is therefore the creation of treatment systems, together with the boosting of the still unfeasible sewage systems.

4.3 Climate change

As briefly mentioned, climate change not only affects weather conditions and human lives, but could also affect demand for and availability of water resources. There is an overall agreement on the scale of global warming and the effects on the hydrological cycle (IPCC, 2008). Precipitation, receding glaciers and melting permafrost could hit seasonal flows, causing longer dry periods that, in turn, are likely to reduce groundwater recharge and water supply for agriculture, energy production or navigation (United Nations—Water, 2010). Furthermore, rising sea levels will have problematic effects on coasts, putting many cities under stress, as well as straining food production in major delta regions that, in some cases, are the main source of food supply.

According to the Brazilian UNESCO office (2014), Brazil still faces problems related to climate change and without proper mitigation policies the situation will get worse. It has been emphasized that in Brazil, water will be the first resource affected by climate change (UN Global Compact, 2017). Scholars and researchers underline that human perturbations, which are altering the correct functioning of the Amazon ecosystem, are especially affecting the Amazon hydrological cycle (Andreae et al., 2015). Since the Amazon is pivotal within the global ecosystem, due to its abundance of biodiversity and amount of water, deflection in rainfall patterns and in amount of rainwater, the main effects from human activity, are going to damage agriculture and fluvial transportation, among other activities, not only in Brazil, but also in other countries as well. In the same way, the increasing presence of algae and the shift of vegetation in the Amazon may induce a change in the human use of water, even if in this case scientific evidence is still not unanimous (Cardoso et al., 2018).

4.4 The fight for water

Most of the water in the Amazon region is polluted and only 20% of consumed water is treated, but just 73% of the urban population have real access to treated water, while the percentage for the rural population is dramatically smaller, at just 24% (MMA, 2006). Increased competition for water resources could lead to social and political turbulence, resulting in conflict. Water scarcity and unfair supply could be a destabilizing factor in emerging countries like Brazil. Competition for water could represent a potential source of instability due to population increase and, most of all, to large-scale acquisitions of cropland (FAO, 2011). It has been argued that in the next years Brazil will face inadequate budgetary and financial resources to respond to the water crisis. This will create increasing conflicts between economic development and conservation and sustainable use of environmental resources, creating more deprivation in the already deprived areas of Brazil (UNESCO, 2014). The Amazon Region is featured due to the interaction between natural resources, water resources and human use. However, the abundance of water coexists with scarcity, since plenty of water does not imply an easy and fair supply to communities (Muniz et al., 2018, De Melo et al., 2018; Schiffer et al., 2018).

4.5 Brazilian water abundance

In terms of dimensions, Brazil is the fifth country in the world for diversity and size of population, as well as natural resources. An estimated 20% of global biodiversity is found in Brazil, which is the home to more than 100,000 animal species and about 46,000 plant species (Secretariat for Social Communication Presidency of the Federative Republic of Brazil, 2012).

Due to its extremely vast territories, Brazilian authorities have divided the country into six biomes, with the Amazon being one of the most important areas. The Amazon is the largest tropical forest in the world—touching nine different countries—with 4 million square-kilometers coverage and high rates of biodiversity. Most of the Amazon region is situated in Brazil, and its rainforest is well-known in terms of biodiversity and fresh water production (Caravaggio and Iorio, 2016).



Map 2. Map of South America (Water Basins) including the Amazon Basin (in light blue).

Source: CNN <https://edition.cnn.com/travel/article/river-maps-art/index.html?gallery=1>

Brazil is a water abundant country, with about 12% of the world's freshwater resources, and some of its largest water basins, as, for instance, the Amazon, Paraná and São Francisco river basins (Map 2). The average annual water flow amounts to 260,000 m³/s (ANA, 2016).

Even though total water extraction amounted to only 0.9% of total available fresh water (based on 2010 data), the figures are constantly increasing—by almost 30% over the past five years—reflecting Brazilian trends in demographics and economic development (Formiga Johnsson, 2014).

Nevertheless, populations do not have the same access to water. A large share of the nearly 13 million households that remain without access is concentrated in the North and Northeast regions of Brazil, where only half of the households were connected to piped water (OECD, 2015). Several factors are causing or exacerbating this particular issue: the lack of attention in protecting and conserving water, under-investment in necessary upgrades to water infrastructures, geographical disparities, and so on.

In addition, water pollution remains critical in most of the country, especially in the Amazon region, where, despite the abundance of water supply, there is a lack of drinkable water for human consumption. Domestic wastewater discharge is the main problem affecting the quality of surface waters, as only half of domestic sewage is collected and less than 40% is treated (IBGE, 2011). As a result, issues concerning water quality and access strongly affect social life and public health in the region.

Possible solutions need investments to improve technologies and to implement them, strengthening skills and capabilities and realizing participatory processes to convey knowledge transfer and generate awareness.

5. Social innovation in the Amazon water treatment sector

In 2013 the AguaSociAL project arose, trying to face and discuss the abovementioned matter of water. It fits perfectly in this context and the European Union, under the Seventh Framework Programme (FP7), financed it within the International Research Staff Exchange Scheme (IRSES) Marie Curie Actions that aims to consolidate knowledge cooperation and knowledge sharing, in relation to water issues, between Brazil and the European Union. The principle of social innovation lays the foundations of a project that aims to enhance practical use of research and to support the creation of new paradigms related to water resources treatment in Pará and Amazonas states (within the Brazilian Amazon region). AguaSociAL has brought together early-stage and experienced researchers, as well as technical and managerial staff, in interaction on the field with local communities, in order to implement the participatory approach which is the basis of social innovation. Researchers involved had the benefit of onsite training during their whole period of secondment. By emphasizing cross-disciplinary training, the project enhanced the scientific excellence of the cooperating partners.

5.1 AguaSociAL: results from the field

In the first phase of the project, many exchanges occurred between the actors involved in AguaSociAL. On the one hand researchers and professors from Brazilian universities participated with working teams, giving and attending seminars and workshops at the universities of Rome, Leeds and Barcelona. On the other hand, European partners had the opportunity to do field work in the Amazon.

Interestingly enough, several side activities emerged from AguaSociAL, such as the creation of working groups involving bachelor, masters and Ph.D. students from the partner universities (Monni, 2015).

The field of natural resources, together with the focus on water resources represents an interesting and broad field to be explored through different approaches applied by researchers from different countries.

The use of water as an energy resource led to copious research on the hydroelectric sector. Economists applied cost-benefit analysis to hydroelectric investments at the national level, analyzed the correlation between energy production and economic growth, and also studied the variables of economic growth, a few of which were correlated with the development process. Geographers and sociologists tried to follow at the local level urban and rural dynamics resulting from the construction of big-impact infrastructures such as dams. Territorial governance, a participation approach and the creation of human capital providing help to the local and regional administration of both territory and energy production are other socio-economic questions arising in the broader legislative field. Hydroelectricity, one of the cleanest technologies in the world, calls attention to the need to guarantee a better and higher regulation of water resources, especially in a remote area such as the Amazon. Water use for the production of energy is allowing Brazil to increase its energy independence from the rest of the world, with a significant further reduction of climate-change emissions, despite growing national consumption of energy. Nevertheless, indiscriminate use of water resources, even for noble purposes, is generating notable impacts

socially and environmentally. First, the appropriation of water by public and private enterprises in order to produce energy is complicating, more than simplifying, the spread of access to this precious natural resource, and is damaging mainly local populations (Caravaggio and Iorio, 2015). Secondly, excessive and still growing exploitation of water is causing conflict situations, interrupting water flow that could be otherwise used for transportation and commerce. Lastly, the intervention of both the private sector and the large public companies is mainly focused on energy, rather than on providing basic welfare services. Therefore, local communities are those suffering the most from negative impacts, without receiving particular benefits in terms of well-being diffusion (Caravaggio and Iorio, 2015).

Other water-related matters were debated by taking advantage of the previously developed collaborations and the field work. A consolidated international working team then developed studies concerning water as a common good. Many were promoted by the use of surveys and interviews among local communities, experts and local media (such as regional television channels). From this point of view, European and Brazilian scientists focused on the treatment of polluted water for daily use; rainwater storage and purification systems, not only in urban, but especially in rural contexts, emerged as areas of inquiry to be deepened (Schiffer and Swan, 2018). Forest engineers observed changes in vegetation due to the changes in the original natural path of water, especially around fluvial areas and artificial lakes (reservoirs) in the Amazon Basin (Melo et al., 2018).

Some of the last contributions were developed in 2017, with the main field work carried out in Belém, resulting in deep studies on the development processes of the municipalities' nearby large-scale projects. They highlight how downstream municipalities are usually less developed than upstream ones, raising interesting questions to be answered in further research (Iorio et al., 2018).

6. Conclusions

Water is a pivotal resource for humans and societies, integral to several quite various functions of human life (e.g. nutrition, agriculture, trade, mobility). One of the more important issues affecting the natural and fair use of water by human societies is energy production through hydroelectric plants.

A comprehensive approach, going beyond pure economic and financial figures, should take into account the specificities and the socio-cultural background of the area. Small plants, rather than major projects, could be a possible alternative to the present situation, in which local communities are facing exclusion and even more "unfreedom", to use Sen's word (Caravaggio et al., 2018)

The results of the abovementioned research are nothing but the output of the AguaSociAL program, which underlines the importance of an interdisciplinary approach to development issues. Technical knowledge in scientific fields such as biology, chemistry, engineering and economics, combined with local expertise and awareness, create articulate and deep reflections. For these reasons, cooperation had an important role in the definition of some key challenging goals, and is still proceeding positively. The main goals to be defined in the process have emerged as: "what" are the real problems of the treated region; "where" we can find feasible solutions to these problems; and "how" we can do our best to influence and orient policy making. International collaboration among interdisciplinary teams revealed itself as a precious tool for development: interviews, working groups and multidisciplinary meetings, through a bottom-up approach, contributed to the creation of a consolidated network still working for a sustainable economy that respects local communities and enhances fair and integrated development.

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