São José dos Campos' Alluvial Plain Protected Area: a case of urban forests conservation

The Alluvial Plains of the Rivers Paraíba do Sul and Jaguari Protected Area

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São José dos Campos in Context

São José dos Campos (SJC) is located in the east of São Paulo State and is the main municipality in the metropolitan region of Vale do Paraíba. Despite being the fifth most populous city in the state of São Paulo, SJC's population density is low compared to other large urban centers in Brazil. The Vale do Paraíba is situated between the cities of São Paulo and Rio de Janeiro and is noted for contributing a considerable part of regional GDP. It is also known for being an important aeronautical and aerospace hub in Latin America and for hosting important federal scientific research institutes, technology companies, universities, colleges and training centers for development of labor skills. These factors contribute to it being a center of innovation in the region.

Food-Water-Energy Nexus in SJC

Although the city does not have programs or policies that are directly aimed at the Food, Water and Energy Nexus (FWEN), SJC was chosen for this study due to its initiatives that indirectly impact the nexus. The initiatives with the most potential to generate a positive impact in this area include the recently built innovation center, municipal law to encourage innovation, and the protected areas of the municipality and programs for environmental compensation.

Facts & Figures

Population
629,921 (2010) [3]

Annual population growth rate
1.57% [3]

GDP per Capita
USD 12,919.337 (2010) [3]

Population Density
572,96 persons/km^2 (2010) [3]

Since the 1940s, SJC has grown due to people migrating for its industrial and technological development [4]. To accommodate this, residential areas and services have expanded to support the population. However, despite this expansion, SJC has a history of environmental preservation dating back from the 1980s. In 1985 the municipality created the first Brazilian municipal Environmental Protection Area (EPA), the Banhado EPA. In 1997, the city's master plan and municipal Zoning Law cited environmental preservation as a key aspect of the city's development plan and for this reason, were regarded as milestones of innovation [5]. Simultaneously, the urban development in the region was challenged by the municipality, who developed conservation policies which limited activities such as mining, deforestation and urbanization. This has positively impacted the FWEN as it has reduced the prevalence of unsustainable activities in the region.

The development of Green and Blue Infrastructures (GBI) becoming protected areas in SJC increases water security and, in addition, offers the opportunity to strengthen environmental protection and ecosystem services. Energy production is directly affected by GBI since hydroelectric power represents 39% of the total energy produced in Sao Paulo's State and water scarcity is a key issue for hydroelectric systems [6]. Therefore, SJC initiatives demonstrate that protecting vulnerable areas can stimulate and improve the FWEN.

Regarding water sources, SJC makes use of superficial waters (the Paraíba do Sul River) and underground waters (through deep tubular wells) for public supply. Water treatment is supplied by the Basic Sanitation Company of the State of São Paulo (SABESP), which is also responsible for sewage treatment in São Paulo and is one of the largest water companies in the world in terms of the number of people they serve [7]. The intensive use of the Paraíba do Sul River has led to concern about its use and a need for integrated management strategies. This need has been intensified by the water crisis of 2015 which led to the diversion of part of the river flow and impacted SJC, mostly by water catchment in affluent basins of Paraíba do Sul [8].

The city is not currently facing issues of water scarcity and in 2018, SJC was among the cities with the best basic sanitation indicators [9]. However, 3% of the population live without access to water. This is especially concerning given the fact that those without access live in at-risk areas or in EPAs [10]. Underground sources are also being threatened by fuel and industrial waste contamination. In addition, a central concern of the municipality has been the lack of sanitation treatments for the Paraíba do Sul River floodplains [10].

The main risks pertaining to water sources occur during the rainy season in Spring and Summer [11] and consist of flooding and landslides in 53 high risk areas, as identified by the municipality [12]. These risks are amplified by the fact SJC is surrounded by floodplains. However, it is important to note the crucial role floodplains play in balancing the hydrological cycle, filtering pollution and purifying river waters [13]. They also present favorable conditions for agriculture which when combined with Brazil's tropical climate, increase potential agriculture opportunities.

Despite this agricultural potential, the main challenge regarding food "is to develop an economic system that allows food production in the city to be robust in the rural area. SJC has a rural area that corresponds to 68% of [the area] of the municipality and it does not have an identity of rural production" (Livia Corrêa – Supervisor from Urbanism and Sustainability Department). In addition, the most productive areas in the region of SJC are threatened by urbanization, the intensive use of pesticides and social challenges such as a lack of basic sanitation and violence [14]. The demand for agricultural produce is predominantly met by cities in the states of São Paulo and Minas Gerais [15]. The early stage of public policies that encourage agricultural practices, land speculation and the construction of hydroelectric dams defer the potential for food production to be explored in the region. Electricity production in the region is commercialized by a private company, *Empresa De Portugal* (EDP). Currently, SJC is listed as the 12th highest municipality consumer of electricity (kWh) in the São Paulo state, with the industrial sector greatly contributing to consumption [18]. The municipality is the 5th largest consumer of oil derivatives and ethanol in the state which means the city is a high contributor to the state's total CO2 emissions [16]. SJC is trying to find new ways to improve the energy efficiency of public spaces, such as the project Iluminar. This project started in 2018 and has been completed with 100% of the 75,000 streets

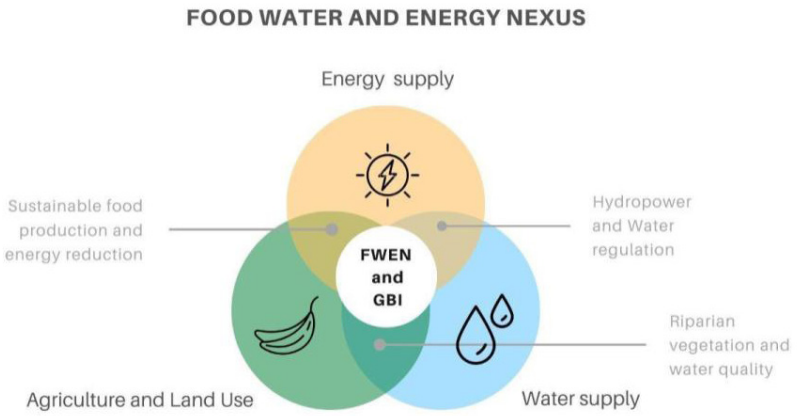

Figure 1 – IFWEN and GBI in SJC

and avenues being fitted with LED lights [17].

It is clear that SJC has access to abundant water sources to supply the population, hydroelectric production, and floodplains' potential for food production. However, as seen above, the development and urbanization history of the city has resulted in the interconnectedness of systems on the nearby centers of São Paulo and Minas Gerais which has resulted in a profound dependence of SJC on the importation of food, water and energy. Using more efficient technologies and policies to benefit the FWEN is a central challenge. The following section will provide insights on how the city has worked towards changing this scenario.

Major initiatives in context of Food-Water-Energy in SJC

Municipal Program for Payment of Environmental Services - Programa Mais Água

Established by a municipal law [20] in 2012, the *Payment for Environmental Services Program* encourages the preservation of native vegetation and the adoption of sustainable practices in rural areas to protect the water supply in the region. For rural landowners to obtain monetary returns, they must follow the regulations regarding conservation of native vegetation and restoration of Permanently Protected Areas, *(Áreas de Preservação Permanentes - APP[1])* as well as adopting sustainable models of production [21].

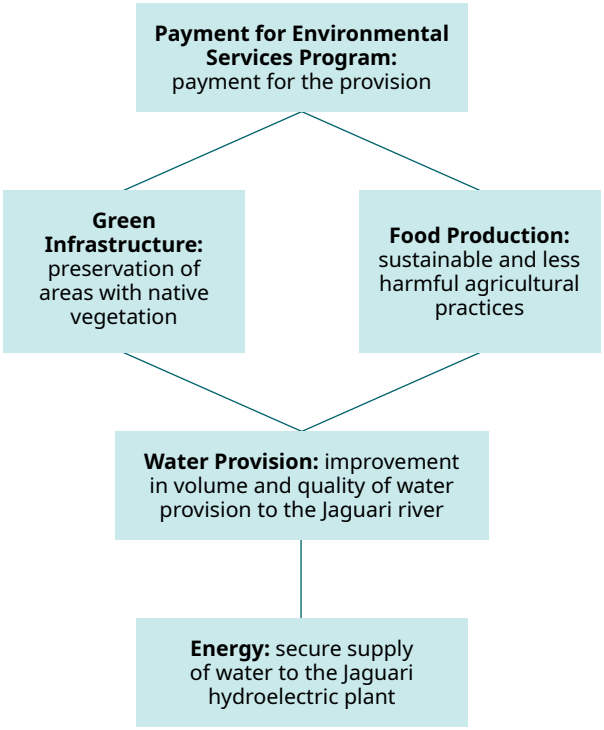

Figure 2 – The impact of the More Water Program on water and energy security

1 As defined by Law no. 12,651 / 2012, Permanent Preservation Area is a protected area, covered or not by native vegetation, with the environmental function of preserving water resources, the landscape, geological stability and biodiversity, facilitating the gene flow of fauna and flora, protecting the soil and ensuring the well-being of human populations.

This pilot stage of this program was financed by the Paraíba do Sul River Basin Integration Committee *(Comitê de Integração da Bacia Hidrográfica do Rio Paraíba do Sul)* and by the City of SJC, managed by the Agency of the Rio Paraíba do Sul *(Agência da Bacia do Rio Paraíba do Sul)*, and executed by the Municipal Secretary of Urbanism and Sustainability (Secretaria Municipal de Urbanismo e Sustentabilidade). The project was technically supported by more than ten other projects and institutions, such as UNESP (São Paulo State University), SABESP, WWF Brazil, ITA (Technological Institute of Aeronautics) and The Nature Conservancy [22].

The project recognizes that the conservation of these green areas is essential for ensuring water provision safety and quality to the City of SJC [22]. Despite focusing on the potential of forests as Green Infrastructure for water regulation, the project also impacts food production in the region as most of the areas covered by the program are used for livestock production (60%) [22]. Properties with more sustainable practices (no pesticide use and organic production) are better evaluated by the standardized tests and therefore receive a higher reward [21]. Green Infrastructure and Food Production are targeted by the project as ways to ensure water provision and preservation. The enhancement of water security at the Jaguari river will, in turn, ensure supply for hydroelectric energy production by the Jaguari Hydroelectric plant.

São José dos Campos Technological Park (SJC TechPark)

SJC TechPark was implemented in 2007, through a partnership between the municipality of SJC and the State of São Paulo - Technological Parks System [23]. It operates by "permanently promoting research and technological innovation as well as cooperation between research institutes, universities and companies" [24]. The Park has been designed to facilitate communication between startup hubs, research centers, private companies and laboratories to encourage efficient demand-driven solutions [25]. Currently, over 300 institutions make up SJC TechPark, researching and developing technology in a broad field of expertise.

Centers for Technical Development (CTDs) create networks of interaction between big companies (responsible for managing and financing studies), universities, research centers and small and medium companies. Amongst the six CTDs at the Park, three develop technology directly related to FWE and GBI:

Table 1 – Centers of Technological Development from SJC TechPark - adapted from [26]

CTD	Goal	Financing company
Water and Environmental Sanitation CTD (WESCDT)	• Foster development of new technologies for environmental sanitation and better water resource management • Capacity building towards solving urban growth-related environmental issues faced by the municipality	AGEVAP
Construction CTD	• Incentivize sustainable construction through innovative technologies • Research solar light use, reuse of rainwater and wood recycling	Association of Construction Companies from the Paraíba Valley (ACCPV)[2]

[1] SABESP is responsible for water distribution and sewage treatment in the State of São Paulo and is one of the largest water companies in the world (regarding the number of people served) [6]
[2] ACCPV is a non-profit organization created to articulate interests between companies responsible for construction in São Paulo [27]
[3] VER is an extension of Vale (the main energy entrepreneurship in Brazil) destined to develop science and innovation

The Water and Environmental Sanitation CDT (WESCTD) was cited by the municipality as a key initiative as it has the most direct impact on the FWEN. It develops technologies and resources to promote a better management and quality of water provision at the Paraíba do Sul water basin [6]. Codirected by the Pro-Management of Waters in the Paraíba do Sul River Basin and by the Paraíba do Sul River Basin Integration Committee, the center aims to "unite the expertise of the private sector to reverse the current logic of water management in the country, where more is spent to mitigate losses in the distribution system than to treat sewage" (André Marques, CEO of the Committee) [40]. WESCTD has also promoted an open call for innovative projects regarding environmental sanitation and selected the best proposals that are now in the trial phase and will potentially be upscaled [28].

Businesses offer services based on the innovations and technologies developed at the TechPark. More than 100 startups and resident businesses make up this category and the following explicitly provide services regarding FWE or GBI innovation:

Table 2 – Businesses within SJC TechPark that explicitly provide services regarding FWE or GBI innovation

Business	Impact over FWEN
Squitter	Provides systems to monitor meteorological and hydrological data, climate prediction and alert systems in order to provide security for food producers and data to support decision making regarding irrigation, potentially lowering water usage
TecSUS	Develops remote monitoring of gas and water production, sending alerts when leakages are detected, avoiding wastage at energy and water distribution chains
Plantem	Research plant responses to different environments and conditions providing scientific data and supporting the optimized use of resources for irrigation and pesticides
Climatempo	Provides climate data and analysis for food producers in order to optimize production and predict extreme weather as well as orienting the most efficient use of irrigation. Also, carries out research and study applicability of renewable energy (wind and solar), commercialization and power generation as well as smart cities

A Story of Innovation: participatory management of IFWEN solutions

The Alluvial Plains of the Rivers Paraíba do Sul and Jaguari Protected Area

The Alluvial Plains of the Rivers Paraíba do Sul and Jaguari Protected Area have been identified as the most impactful initiative for the FWEN. This extended area is located in an urban zone protected by Municipal and State Law. Banhado EPA is a part of the Alluvial Plains of the Rivers Paraíba do Sul and Jaguari EPA on which, in 2002, the state established a sustainable use conversion unit. Figure 3 demonstrates the direct and indirect effects that the EPA legislation has had on the FWEN and GBI in SJC.

Satellite land use data collected every five years from 1995 to 2015 was analyzed in order to evaluate the impacts of the implementation of the Banhado EPA to environmental indicators. In 1995, there were 62,7596 hectares of water bodies within the Banhado EPA. This area has more than doubled, with the total land being 140,90 hectares in 2015 [30]. This demonstrates the potential of the area as a water provision site. Forests areas also increased from 236,3585 hectares in 1995 to 395,52 hectares in 2015 [30]. The increased forest area can act as a soil quality enhancer, as it reduces erosion, protects soil biodiversity and re-establishes ecosystemic function [31].

All these areas were categorized as a "Zone One EPA" by the SJC Land Use Law in 2019. This categorization exists to protect areas that occupy the margins of rivers with hydromorphic formation and that are highly susceptible to floods. This legislation also reinforces that the land use in this area is restricted to livestock and agricultural research and production [18].

Regarding the overlap of a protection

mechanism, local and state governments have experienced intergrated governance. Led by a State body, the Forestal Foundation, in February 2019, an Advisory Board was formed with civil society representatives and the public sector, including the municipal government, in order to accompany the preparation, implementation and review of the Management Plan [19]. Participatory management processes were used to create effective policy for regulating the area.

In addition, in 2012, a municipal law was applied to the Natural Park of Banhado. The EPA means the Natural Park is fully protected by a c onservation unit and this has been fully funded by environmental compensation funds from private companies such as Henrique Lage Refinery (Revap), which has been crucial for financing the expropriation of private properties within the territoy of the protected area [19].

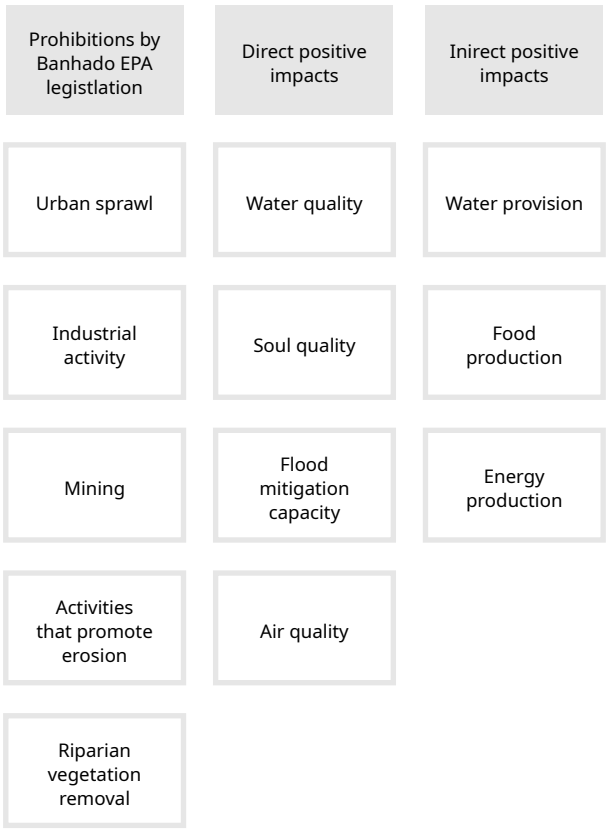

Figure 3 – Correlations and impacts of the preservation of the Floodplains in SJC

Table 3 – Enabling factors and capabilities for the establishment of the Banhado EPA according to the framework structure Compiled from the sources and synthesized by the authors

Capabilities (initial) & Enabling Factors (facilitating)					
Aspect	**Knowledge** (Types and sources of knowledge)	**Institutional** who was involved (governments / stakeholders)	**Social** (relationships required between partners)	**Ecological** (landscape/ ecological/ geographic unit, and scale)	**Technological**
Capabilities	Legal basis, such as environmental municipal legislation, to reinforce land use restrictions within the EPA	Local civil society organizational capacity for claiming for the protection of the Banhado EPA Municipality of SJC / Municipal secretary of environment responsible for categorizing the area as an EPA	Support and financing between the SJC's municipality, researchers and civil society	Characteristics of the Banhado EPA as a floodplain and potential food production area, as well as riparian buffer zone	SJC historic background as an innovation hub
Enabling Factors	Technical and scientific knowledge were required in order to evaluate and identify the benefits of implementing the protected area	Technology and research institutes supporting data collection and evaluation of the environmental characteristics of the EPA's area	Land use restrictions from the municipality to public use Participatory management and funding	Ecological functions of the floodplains Vegetation protection to water springs	Capacity to assess reforestation and conservation impacts as GBI for protecting water springs

Enabling Environments & Capabilities

The Banhado EPA initiative was analyzed through the SETS framework approach [29] in order to identify and describe the enabling environments ("trigger events") and capabilities required for them to take place. By describing the social, ecological, technological and financial factors, it aims to assess the common characteristics and patterns that feature within the initiatives.

The creation of the Banhado EPA was a result of social mobilization of the environmentalist movement that aligned with representatives of the city in order to protect the area. The awareness that these actors had of the ecological importance of floodplains was essential for arguing for the protection of the area and to challenge the ongoing real estate pressures. The city had a central role in this initiative by reinforcing it as a municipal law and for providing resources from Environmental Compensation of private companies to fund the implementation of this EPA.

The city also posed as a central actor for enabling the Environmental Services Payment Program, which was reinforced by municipal law and financed and executed by the city. Yet, in this case a wider array of actors was involved: complementary financial input was provided by the Water Basin Committee and more than ten other institutions provided technical support. This project also required interest from the landowners in the region to provide access to their properties. In addition, ecological knowledge regarding the importance of forests for the conservation of water supply and water springs was fundamental to justify the project.

As for the SJC TechPark, a major aim that inspired the capabilities scenario was aiming to investigate the socio-economic crisis that was taking place. This added to the cities' background as a technology development center and was crucial for attracting investors and companies to this initiative.

Synthesis

The initiatives described in this case study present SJC as a front runner city in creating local protected areas and stimulating innovation in different sectors. Although the initiatives discussed do not directly tackle issues pertaining to the nexus, the creation of the Banhado EPA, the More Water Program and the SJC TechPark positively impact the FWEN.

In this context, a major incentive for protecting areas of GBI is the opportunity it creates to improve the FWEN by regulating the water regimens. A key component of the aims of the city is to become independent regarding water provision. This was accentuated by scarcity of water during the water crisis of 2015 as it compromised the water distribution and impacted the generation of hydroelectric energy in the municipality. The previous precarity of the water supply highlights the importance of creating innovative FWEN (IFWEN) solutions.

Stimulated by the recognition of SJC as an innovation hub and by the municipal law to encourage innovation, the initiatives developed at the SJC TechPark also demonstrate great potential to generate positive impacts for the FWEN and GBI. By providing an enabling environment for innovation, the CDTs, businesses and universities established at the TechPark have proposed innovative solutions for water use, treatment and distribution. This has created a long lasting stream of innovation and technology which contributes to the city becoming self-sufficient in production and optimizing the FWEN.

SJC has demonstrated how aligning ecological and technological knowledge with municipal action can result in fruitful projects and positive impacts for the city. With political interest and the goal of innovation, the city has moved towards increased independence regarding food, water and energy. Furthermore, understanding and expanding the nexus between these factors will enable the city to realize its technological, ecological and innovation potential.

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