sociedade & natureza

DOI: http://dx.doi.org/10.14393/SN-v31n1-2019-43381

Sustainable Scenarios to the São Paulo Macrometropolis

Cenários Sustentáveis para a Macrometrópole Paulista

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Resumo
A Macrometrópole Paulista (MMP) compreende três Regiões Metropolitanas do Estado de São Paulo: a Região Metropolitana de São Paulo (RMSP), a Região Metropolitana de Campinas (RMC) e a Região Metropolitana da Baixada Santista (RMBS), além de suas áreas de influência. Abriga cerca de 30 milhões de habitantes e é uma das áreas mais críticas em termos de demanda e disponibilidade de recursos hídricos. O Objetivo é propor cenários alternativos, que visem o planejamento ambiental integrado das bacias que compõem a MMP, a saber: Alto Tietê; Piracicaba, Capivari e Jundiaí; Sorocaba e Paraíba do Sul. A metodologia utilizada baseou-se no modelo Pressão-Estado-Resposta proposto pela OECD (1993; 2003), com base na seleção de indicadores, considerando a relevância política, utilidade aos usuários, confiabilidade e mensurabilidade de cada indicador. Para a execução do diagnóstico ambiental foram selecionados os indicadores demanda, disponibilidade, área florestada, qualidade da água e índice de perdas na distribuição, permitindo a representação das bacias e subsidiando a elaboração dos cenários. Os cenários elaborados (Tendencial, Desenvolvimento Sustentável e Conservação) simularam a evolução dos indicadores em diferentes situações, propondo medidas de priorização de investimentos e de gestão dos recursos hídricos. Dessa forma, foi possível propor ações que busquem garantir a sustentabilidade das bacias que compõem a MMP.
Palavras-chave: Macrometrópole Paulista. Sustentabilidade. Gestão Ambiental.

Abstract
The São Paulo Macrometropolis (MMP, *Macrometrópole Paulista*) comprises three Metropolitan Regions of the State of São Paulo: the Metropolitan

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Article received in: 08/06/2018. Accepted for publication in: 18/02/2019.

Region of São Paulo (RMSP), the Metropolitan Region of Campinas (RMC) and the Metropolitan Region of Baixada Santista (RMBS). It is home to more than 30 million people and is one of the most critical areas in terms of demand and availability of water resources. The objective of this paper is to propose alternative scenarios aiming at an integrated environmental planning of the basins that make up the MMP, namely: Alto Tietê; Piracicaba, Capivari and Jundiaí; Sorocaba, and Paraíba do Sul. The methodology used applied the Pressure-State-Response model proposed by the OECD (1993; 2003), based on the selection of indicators, considering their political relevance, utility to users, reliability, and measurability. In order to carry out the environmental diagnosis, the indicators concerning demand, availability, forested area, water quality and loss index during distribution were selected, allowing for the representation of the basins and subsidizing the elaboration of the scenarios. The scenarios elaborated (Trend, Sustainable Development and Conservation) simulated the evolution of the indicators in different situations, proposing prioritization measures for investments and management of water resources. Thus, it was possible to propose actions that seek to guarantee the sustainability of the basins that make up the MMP.
Keywords: São Paulo macrometropolis, sustainability, environmental management.

Introduction

The São Paulo Macrometropolis (MMP, *Macrometrópole Paulista*) is the region in the State of Sao Paulo that houses the largest urban spot in the country and the third largest in the planet.

The MMP has an area of 53,400 km^2 that refers to 21.5% of the São Paulo state area. It lodges a population of 33.6 million inhabitants in 2018, which represents 74.7% of the state's population, being accountable for around 81.9% of the state's GDP in 2016. It comprises 174 municipalities, which add up to 50% of the urban area in the state. From an environmental standpoint, it is responsible for 20% of the protected natural heritage of the state (EMPLASA, 2017).

The MMP encompasses the metropolitan regions of São Paulo, Campinas, Baixada Santista (greater Santos area), Vale do Paraíba (Paraíba Valley), Litoral Norte (Northern Coast), and Sorocaba, as well as the Urban

Agglomerations of Jundiaí and Piracicaba municipalities, with the unit of Bragança municipality to join soon (EMPLASA, 2014).

Its high economic level also brings social and environmental challenges, especially to the sectors of infrastructure, mobility and logistics, housing, and environmental sanitation. Thus, it is important to analyze its current condition and implement holistic public policies, which must be as diverse as its territory (EMPLASA, 2014).

In that sense, the aim of this article is to propose scenarios for the integrated environmental planning of the basins that comprise the MMP, by conducting the following:

a) Physical and environmental diagnosis of such basins,

b) Selection of relevant environmental indicators in the current scenario (Trends), and

c) Development of alternative scenarios for the situation of the natural resources, called Sustainable Development Scenario and Conservation Scenario, analyzing aspects of water demand and availability, water quality, water losses control, and forested areas.

Environmental Planning, Indicators, and Development of Environmental Scenarios

The environmental planning is the time scale that guides the analysis of the studied area, as well as the creation of future situational models to indicate the changes that occurred during the examined period. It allows one to note the types of modifications, identify their sources, and observe both the natural environment and the environment modified by the action of man, which may facilitate the decision-making process (SANTOS, 2004).

According to Santos (2004), the timeline representation is achieved by building scenarios to contextualize the landscape in certain moments of the time scale; and it gives planners a better understanding of the actions performed on the area and their resulting environmental impacts. Based on them, decision makers can shape a more efficient relation of space, time and environment and have a more realistic outlook on the points of attention in the area.

For Sánchez (2008), contrasting ideas is the first step for building scenarios and understanding the variation – or the absence – of planning activities, restrictions, limitations, and conditions for preserving the environment and improving the quality of life of the population.

São Paulo Macrometropolis (MMP, Macrometrópole Paulista)

The MMP encompasses the main productive pole and urban density in the country.

Three Metropolitan Regions are located in the State of São Paulo: the Metropolitan Region of São Paulo (RMSP), the Metropolitan Region of Campinas (RMC), the Metropolitan Region of *Baixada Santista* (RMBS), as well as their influence areas (EMPLASA, 2017).

The metropolitan regions also include the municipalities located in UGRHI 05 (Piracicaba, Capivari, and Jundiaí), with some cities that belong to the State of Minas Gerais; the cities in UGRHI 10 (Sorocaba and *Médio Tietê* [Tietê River Basin municipalities]); and cities in UGRHI 02 (Paraíba do Sul region). The cities in the Northern Coast of São Paulo are also part of the MMP, due to their high level of touristic activities and potential economic growth, result of the improvements that are being carried out and future projects, especially the ones related to the infrastructure of São Sebastião port (COBRAPE, 2013).

Figure 1 indicates the region comprised by the MMP. (SÃO PAULO, 2013).

Figure 1 – Perimeter of the *Macrometrópole Paulista* (MMP).

Source: DAEE, 2013.

As the main urban concentration in Brazil, the MMP has a complex, well-diversified production structure, characterized by its heterogeneous nature. Its urban network is different in terms of population dimension, configuration, and functional profile, for being a region that has an intense flow and consumption of goods and services and for having a housing-work commuting relation (RQA, 2015).

This is a prominent region, with the current population of 30 million inhabitants, which represents 75% of the population in the State of São Paulo and 80% of the state's GDP (RQA, 2015).

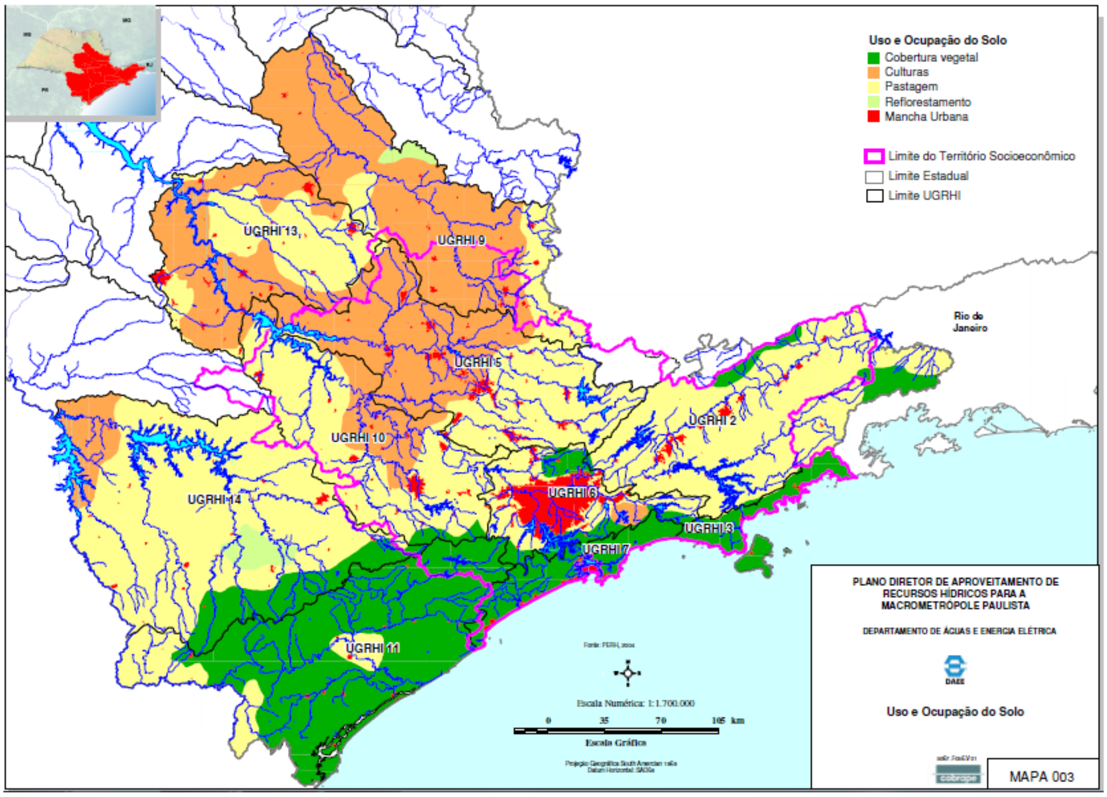
Economy

The RMSP stands out for having a high industrial production, a strong presence of the tertiary sector and the largest concentration of financial activities in the country, being connected directly to the world economy (COBRAPE, 2013).

Land Use and Vegetation Cover

Figure 2 shows the land use and occupancy in the MMP.

Figure 2 – Land use and occupancy in the MMP.



Source: Cobrape, 2013.

The State legislation demands 20% of vegetation cover as Legal Reserve, and that percentage is even higher in some UGRHIs. However, that number does not apply in most Units of the MMP, as shown in Table 1. Most of the vegetation cover is located in the coast, which represents 60% of the remaining original vegetation (SigRH, 2015).

Table 1 – Total Area and Vegetation Cover of each UGRHI in the MMP.

UGRHI	Area (km²)	Vegetation Cover (km²)	Minimum Vegetation Cover (km²)	Deficit (km²)	Surplus (km²)
02 - Paraíba do Sul	14,444	1,271	2,888.8	-1,617.8	-
03 – Northern Coast	1,948	1,899	389.6	-	1,509.4
05 – PCJ	14,178	1,911	2,835.6	-924.6	-
06 - Alto Tietê	5,868	1,397	1,173.6	-	223.4
07 - Baixada Santista	2,818	2,669	563.6	-	2,105.4
09 - Mogi Guaçu	15,004	1,598	3,000,8	-1,402.8	-
10 - Tietê/Sorocaba	11,829	2,104	2,365.8	-261.8	-
11 - Ribeira do Iguape/Southern Coast	17,068	14,388	3,413.6	-	10,974.4
13 - Tietê/Jacaré	11,779	1,106	2,355.8	-1,249.8	-
14 - Alto Paranapanema	22,689	2,995	4,537.8	-1,542.8	-
TOTAL	117,625	31,338	23,525	-6,999.6	14,812.6

Source: SigRH (2015), adapted by the authors.

The table shows a small amount of native vegetation in heterogeneous locations. The situation in the countryside is the opposite of the one observed in the coast, as the large vegetation deficits in the UGRHIs show.

The absence of vegetation cover is one of the causes of watershed degradation in the State of São Paulo, because it directly influences the quality and quantity of water available.

In order to revert that, large areas need to be reforested. Although a long-term measure that requires high investments, this is essential for the restoration of the watersheds.

Water Supply and Sanitation

Data from the National System of Information on Sanitation (SNIS, 2007), SABESP (2008), and the Watershed Plans were used for the indexes of water supply and sewage collection and treatment in the MMP; however, they had to be adapted because they considered only the urban population (COBRAPE, 2013).

Table 2 shows the Average Indexes for Water Supply and Sanitation in each UGRHI based on the data available. Note that in all the MMP, the water supply and sewage collection are not 100% available, highlighting the precariousness of this service.

Table 2 – Average Indexes for Water Supply and Sanitation by UGRHI.

UGRHI	Total Water Supply Index (%)	Sewage Collection Index (%)	Sewage Treatment Index (%) (Collected Sewage)	Sewage Treatment Index (%) (Total Generated Sewage)
02	79.0	73.6	42.7	34.9
03	94.0	39.3	100.0	39.3
05	84.0	71.0	36.6	29.5
06	88.3	55.3	32.1	19.0
07	91.9	41.8	95.4	40.4
09	89.6	81.9	30.2	25.7
10	76.7	72.4	57.0	41.8
11	38.2	17.0	100.0	17.0
AVERAGE	80.2	56.5	61.8	31.0

Source: Cobrape (2013), adapted by the authors.

Studies About Future Availabilities in the MMP

Over the years, many studies have discussed the water planning for the MMP with the objective of increasing water availability. According to the DAEE [Water and Power State Department] (2015), there are several studies about how to expand availability in the MMP, such as the following:

a) Availability studies that considered increasing the MMP flow by using the dams of Itapanhaú and Itatinga; a total of 5.65 m^3/s to be made available in the municipalities of Biritiba and Jundiaí.

b) A study that states that the dam of Jurumirim would contribute with 6 to 8 m^3/s, and the Guarani Aquifer with 5 m^3/s for the RMC.

c) A study that states that reverting the water flow of the Médio Tietê Basin would make 30 m^3/s available for Guarapiranga and Cantareira dams.

These studies show that the availability could increase from 46.65 to 48.65 m^3/s, but there are high costs involved that must be considered (DAEE, 2015).

Water Balance

The water balance – the difference between availability and demand in the MMP – is presented below based on data and information available in the reports by CEIVAP (2013) and COBRAPE (2013). These figures are important because the actions considered by DAEE to increase availability in the MMP, presented in the previous item, have not been put in place yet.

Table 3 presents the current availability, demand and water balance in the MMP.

Table 3 – Water balance for the main UGRHIs of the MMP.

Water balance for the main UGRHIs of the MMP			
UGRHI	Demand (m^3/s)	Availability (m^3/s)	Balance (m^3/s)
2 - Paraíba do Sul	305.4	311.9	6.5
5 – PCJ	37.0	38.0	1.0
6 - Alto Tietê	111.1	77.0	-34.1
10 - Sorocaba	31.5	39.0	7.5
TOTAL	485.0	465.9	-19.1

Source: CEIVAP (2013); Cobrape (2013), adapted by the authors.

All the UGRHIs present critical availability conditions and the following items comment on the water balance presented in Table 3:

a) UGRHI 05 has 1 m^3/s to 'spare', but only if considering the addition of the flows of Duas Pontes and Pedreira dams, whose construction has started in 2018 (DAEE, 2019).

b) UGRHI Alto Tietê presents the worst situation, with a deficit of 34.1 m^3/s; as a result, there will be an increasing need for bringing water from distant places in order to meet the RMSP demand for future availability, as shown in this article.

c) In the Paraíba do Sul Basin, there is a great reversal of water to the Guandu System (up to 160 m^3/s), used to provide water to the Greater Rio de Janeiro region. A huge part of that volume is used for sewage dilution, due to the lack of treatment. However, in critical times, the flow of the Paraíba do Sul River decreases sharply, and that may increase the problem.

d) In the Médio Tietê/Sorocaba Basin, the water consumption is high due to farming activities, accounting for more than half (56%) of the consumption of the basin, which jeopardizes the water supply to other sectors, as cited by COBRAPE (2013).

Loss Control

A distribution network with no losses is not technically and economically feasible, but there must be a reduction of lost volumes (ABES, 2013).

In the case of the RMSP, there are some data variations on the subject, depending on the source. In the report by the Board of Directors of SABESP (2015), the loss index in 2013 was 31.2%; on other occasions, it has been said that the index was only 25%. However, for the city of São Paulo, in the year 2013, the index was 35.8%. If we add up the losses in the supply of the most populated municipalities of the RMSP, the average loss index reaches 41%, according to the data provided by the National Information System on Sanitation (SNIS), as Table 4 shows.

Table 4 – Most populated cities in the RMSP and water supply loss index.

Municipalities	Population (inhab.)	Supply loss index (%)
Carapicuíba	387,788	32.86
Diadema	406,718	44.04
Guarulhos	1,299,249	35.00
Itaquaquecetuba	344,558	51.44
Mauá	444,136	48.22
Mogi das Cruzes	414,907	56.42
Osasco	691,652	51.51
Santo André	704,942	23.74
São Bernardo do Campo	805,895	41.92
São Paulo	11,823,871	35.79
Suzano	279,520	36.13
Taboão da Serra	264,352	34.93
TOTAL	17,867,588	-
AVERAGE	-	41.00

Source: SNIS, 2013, adapted by the authors, 2016.

Methodology

Data and information used in the previous sections of this article were collected in an extensive literature research performed by the authors. Reading and interpreting the data and information contained in the reports by the DAEE was an arduous task, since many figures are presented in contrast with each other.

The described scenarios were built by the authors based on the available information related to the Trend scenario, as well as on projections and assessments made by the authors for the preparation of Sustainable Development and Conservation Scenarios, where the year of 2035 was used as a planning horizon.

We based methodology on the model State-Pressure-Response, proposed by the OECD (2003). For the OECD (2003), human activities lead to direct and indirect pressures on the environment, causing quantitative and qualitative impacts (state).

The response occurs through the society, which is aware of the impacts and looks for interventions by the use of environmental, economical, and industrial policies in order to try to mitigate such impacts.

Tayra and Ribeiro (2006) state that:

> "In general, the model seeks to describe the dynamics of an environmental problem; for example, the environmental pressure resulting from the deposition of sewage into a river or the decrease of available area for wildlife. Such pressures change the state of the environmental system, reducing the quality of the water or the diversity of species. In some cases, such changes regulate the responses of the governments, or the institutions (including the market itself)."

Environmental indicators are essential for the decision-making processes because they provide the diagnostic data and the tools for building

scenarios, so decision-makers can analyze the environmental conditions and observe the consequences of their decisions. In addition, they make it possible to analyze changes in the environment, so that officers are able to plan preventive measures based on future scenarios and define what the essential actions are, as established in the planning objectives (LAURENTIS, 2008).
In this sense, according to the OECD (2003):

> "The OECD environmental indicators are regularly used to test environmental performance; they constitute a valuable tool in monitoring the integration of environmental and economic decisions on environmental policy analysis and evaluation of the results. But its usefulness goes beyond the simple field of OECD's environmental performance surveys: they also contribute to the broader objective of reporting facts about sustainable development".

The amount of indicators used in a study has to do with the work scale used and the characteristics of the location. Another factor is the amount of information available about the location, subject to interpretation, and those directly connected to the degree of generalization of the planning (SANTOS, 2004). Having that in mind, the following indicators were selected for drawing up each scenario: demand, availability, forested area, water quality, and index of losses.

Drawing up scenarios

The scenarios described below have been prepared by the authors for the MMP, with emphasis on the UGRHIs 02 (Paraíba do Sul), 05 (PCJ), 06 (Alto Tietê), and 10 (Sorocaba), due to the higher criticality of such water basins.

Trending Scenario

In the year 2035 (horizon used for planning) the water demand is expected to increase 1.00888% per year, according to current rates. This means that the total water demand will be 517.05 m³/s for the UGRHIs above, as shown in Table 5.

Table 5 - Water demand and availability for the year 2035.

UGRHI	Urban	Irrigation	Industrial	Total Demand	Total Availability
02 - Paraíba do Sul	228.40	53.16	13.66	295.22	311.9
05 – PCJ	22.36	19.23	17.13	58.72	38.0
06 - Alto Tietê	82.84	4.54	39.56	126.94	77.0
10 - Tietê/Sorocaba	8.10	20.48	7.59	36.17	39.0
TOTAL	341.70	97.41	77.94	517.05	465.9

Source: Authors, 2016.

It is possible to notice that the demand will exceed the water supply in most UGRHIs of the MMP. The Alto Tietê basin has an estimated demand of 126.94 m³/s and an availability of only 77.0 m³/s. Even if 48.65 m³/s are added – which is the only feasible increase in future supplies – the total would still be 125.65 m³/s; this means that the situation of the Alto Tietê would still be critical.

The PCJ basins have a similar situation, as the demand of 58.72 m³/s is higher than the future availability of 47.1 m³/s.

The Tietê/Sorocaba basin's water balance is close to the required level, with demand for 36.17 m³/s and availability of 39.0 m³/s, which can be considered critical.

The situation of the Paraíba do Sul River basin is quite complex, since it is necessary to evaluate it in the context of the entire river basin, which covers the states of São Paulo, Minas Gerais, and Rio de Janeiro. In this context, the total demand is expected to be 295.22 m³/s, for a total availability of 311.9 m³/s on its base level. However, such availability corresponds to the regularized flow (Q95) by the existing reservoirs along the Paraíba do Sul river, which is more restrictive than the steady flow ($Q_{7,10}$). Thus, along the Paraíba do Sul River, between São Paulo and its base level in the State of Rio de Janeiro, there are places where the demand exceeds the availability. There is also the matter of the high reversion flow rate to the Guandu System (205 m^3/s), where part of the flow is used for sewage dilution.

In the case of the Paraíba do Sul Basin, a 20% growth of the industrial sector would not cause the major pressure for resources; in fact, the reversal of water back to the Guandu System would.

In the Sorocaba Basin, the total water demand (36.17 m^3/s) corresponds to approximately 93% of the $Q_{95.}$ However, in drought periods, the available flow does not exceed 22 m^3/s, which indicates the suppression of the resource. The supply loss index will not vary much, with an average of 38% in the MMP, as indicated on Table 6.

Table 6 – Supply loss index for the main UGRHIs in the MMP.

UGRHI	SLI (%)
02 - Paraíba do Sul	39.00
05 - PCJ	32.80
06 - Alto Tietê	35.80
10 - Tietê/Sorocaba	45.00
AVERAGE	**38.15**

Source: SNIS, 2013, written by the authors, 2016.

This means that, if such index is maintained, from the total demanded (517.05 m^3/s), approximately 197.3 m^3/s will be lost between the collection in the springs and the arrival to the end user. Decreasing the lost volume of supplied water would reduce the pressure for existing resources and the need for building new reservoirs and water transpositions, which in addition to environmental impacts, involve greater investments.

Appropriate management procedures and measures in all sectors must be enforced in all the basins of the MMP in order to ensure the supply, because resources are scarce in comparison with the demand.

For the urban area, not only is it vital to control losses, but also it is necessary to have a rational use of the resources, with the reuse of water and the use of rainwater. Social and environmental education is also important to raise awareness of the water stress scenario in the macro-metropolis.

As for the agricultural sector, less volume can be used if more efficient and smarter technologies are applied to the use of water, such as drip irrigation and the use of rainwater.

For the industrial sector, leveraging production technologies to lower water consumption and creating the culture of water reuse are essential.

Water Quality

In this scenario, the quality of the water maintains the current trend and the universalization of water supply is not achieved (average of 80% in the MMP). The sewage system still does not have adequate collection levels (average of 57%) and there is no expectation of major investments in basic sanitation, which leads to further deterioration of the water quality in the MMP.

Forested Areas

Based on the figures presented in the bibliographical revision, although the MMP has more than 20% of the forested area, such areas are heterogeneously spread. That is why it would be necessary for each river basin to have its calculation of Legal Reserve done individually.

A total of 6,994 km^2 need to be reforested, but this is not expected to occur in this trend scenario.

Sustainable Development Scenario

We suggest that water demands would reduce in the UGRHIs in this scenario.

In the case of the Paraíba do Sul Basin, it is necessary to decrease the demand for irrigation water, mainly by the use of drip irrigation. An updated record of water usage would allow a better surveillance of water withdrawals by the agricultural sector and reduce abusive use of water.

The reduction of losses in the water distribution system is also critical. If losses decrease to 25%, the resulting savings would be 3.28 m^3/s. Another important action is the expansion of the sewage collection and treatment system, which would decrease the flow of the Guandu System, as it is excessively high today due to the sewage dilution. If the water quality improves, the reversal of the Guandu System would reduce from 205 m^3/s to 160 m^3/s.

In the case of residences and places with an intense flow of people, the adoption of water-saving devices can bring great savings, with a reduction of approximately 40% in used water.

In the Industrial sector, the scenario will have little change. Measures seeking a lower consumption of water are already in place, and that indicates that the demand for water will remain the same for years to come (13.66 m^3/s).

Similar actions must be taken in the JCP and the Paraíba do Sul River basin, because future water demand is high, especially in the urban and industrial segments. Decreasing the supply of quality water demands higher investments in the basic sanitation sector. In this sense, the reduction of water losses to 25% and the use of water-saving devices are essential to reduce water consumption in both urban and industrial areas.

For the Alto Tietê basin – as the area is responsible for more than half of the consumed water – the reduction of water usage in the Urban Sector is of utmost importance. The goal of 25% of distribution losses would result in nine m³/s of water savings. Industrial sector should take similar measures, with investment in technologies that use less water and that can reuse it. There is not much to do about the agricultural demand, but one important measure would be fortify inspections to prevent the pollution of water sources.

In the Sorocaba/Médio Tietê Basin measures must be aimed primarily at the agricultural sector, as it is responsible for most of the consumption. Alternative irrigation methods, as well as better control of water withdrawal, are indispensable to reduce water demand. A decrease to 7.9 m³/s would ensure water security in the region. In addition, because the urban area has distribution losses of 45%, a reduction of 20% in these losses would cause a considerable decrease in the urban water demand.

On the other hand, the industrial sector has the lowest consumption, and its demand will probably remain constant. This means that, with such reductions in the urban area, the UGRHI 10 would have a total demand near the flow $Q_{7,10}$ of 22.0 m³/s.

Table 7 indicates the water demand in 2035 if such reduction measures become effective.

Table 7 - Water demand for the year 2035 - Sustainable Dev. Scenario.

UGRHI	Urban	Irrigation	Industrial	Sum
02 - Paraíba do Sul	180.12	31.90	13.66	225.68
05 – PCJ	20.62	11.54	17.13	49.29
06 - Alto Tietê	73.89	2.72	39.56	116.17
10 - Tietê/Sorocaba	6.48	12.29	7.59	26.36
Total	281.11	58.45	77.94	417.50

Source: Authors, 2016.

Water Quality

The area of basic sanitation could benefit from more investments. This will lead to better water quality indexes, because in all UGRHIs the sewage is the main contributor for the deterioration of the quality of water resources.

Nonetheless, sanitation companies estimate that an annual investment of BRL 691 million for the next 19 years is required for the sanitary sewage service to be universalized in the MMP.

Forested Areas

Vegetation cover in the MMP may reach the required 20% of Legal Reserve in all its Water Resources Management Units. D ue to their high vegetation cover deficit (925 and 1,618 km², respectively) the natural vegetation in the JCP and Paraíba do Sul basins will probably recover at a faster pace. In addition, maintaining the vegetation cover of the reservoirs that supply all the MMP is a must, as well as investments to create green corridors to connect all the remaining portions.

The financial matter is that high investments are needed in order to recover larger areas with vegetation deficit (estimated BRL 10,835.00 per hectare), totaling BRL 7.6 billion, which makes it hard to achieve such goal (SANT'ANNA, 2015).

There is another variable in this equation. Some changes in the Forest Code affect the preservation of CUs. The law has changed and now it foresees protection only for areas with more than 25º of declination and 100 m of height. The previous decree provided protection for areas of 17º of declination and 50 m of height. The consequence is that a greater monitoring and maintenance of protected areas is of paramount importance as well as ensuring the protection of forest remnants.

Conservation Scenario

In the Conservation Scenario, a greater reduction of water demand in the UGRHIs and the intensification of activities in the basins of the MMP are expected.

In the Paraíba do Sul River basin, crops that require less water must replace the rice fields, which would diminish considerably the consumption of water in the basin. Besides, all water withdrawals by the agricultural sector are expected to be registered and inspected properly, with a full control of how much water is used in order to avoid abuses.

For the Urban Sector, losses in supply will strongly decrease, reaching the levels of developed countries, that is, 15%. That would lead to a reduction of 5.62 m^3/s in water demand. For the Guandu System, improvement in water quality via sewage treatment to decrease the reversion in the system added to the rational use of the resource would add up to 110 m^3/s. Water saving devices must be used on a large scale to meet these objectives.

As in the Sustainable Development Scenario, the industrial demand should maintain the 13.66 m^3/s until 2035.

In the case of PCJ Basins, a better control of distribution losses would result in savings of approximately 19% in the demand of water in the urban sector and measures to foster rational consumption can contribute to this goal.

It is also necessary to decrease water consumption for irrigation, which is also high in this UGRHI, since there is a high level of water stress in this basin. In addition, the region has a large industrial park with high water consumption today – one third of the water consumption demand – with little reduction expected for the coming years.

In a far more critical situation, in the Alto Tietê Basin, the demand for urban supply would fall more than 17 m^3/s if there were a strict control of losses. This region has the smallest agricultural demand in the MMP, but that does not imply any significant economies. For its industry, an effort to maintain the current demands for the next 20 years will be essential.

The UGRHI Tietê/Sorocaba basin should prioritize the reduction of demand for irrigation, the sector with the highest water demand (55%). By decreasing consumption through better technologies, as well as an adequate program to control losses and promote social and educational awareness, its total demand would have a reduction of 35%.

Table 8 illustrates a predicted water demand for 2035 after implementation of the actions suggested above.

Table 8 – Water demand – Conservation Scenario.

UGRHI	Urban	Irrigation	Industrial	Sum
02 - Paraíba do Sul	127.78	26.58	13.66	168.02
05 – PCJ	18.38	9.62	17.13	45.13
06 - Alto Tietê	65.61	2.27	39.56	107.44
10 - Tietê/Sorocaba	5.67	10.24	7.59	23.50
TOTAL	217.44	48.71	77.94	344.09

Source: Authors, 2016.

Water Quality

As in the Sustainable Development Scenario, more investments in basic sanitation would universalize the drinking water distribution services and the collection and treatment of sewage in all UGRHIs of the MMP.

Forested Areas

Vegetation cover in the MMP may recover by 50% in the deficient basins, much more than the Legal Reserve demands. This represents a green area more than two times larger than the minimum demanded by the Legal Reserve, with greater recovery in the Paraíba do Sul and PCJ basins. As it would be necessary to reforest 16,477 km², the cost would be approximately BRL 18 billions, an average of BRL 10,835.00 per hectare.

Table 9 shows the recoverable area if the reforestation rate is 50%, comparing the existing vegetation cover values and the minimum values required by the Legal Reserve.

Table 9 - Amount of the recovered area with a reforestation rate of 50% of the main UGRHIs in the MMP.

UGRHI	Area (km²)	Vegetation Cover (km²)	Minimum Vegetation Cover (km²)	Recovered Vegetation Cover (km²)	Surplus (km²)
02 - Paraíba do Sul	14,444	1,271	2,889	7,222	5,951
05 – PCJ	14,178	1,911	2,836	7,089	5,178
06 - Alto Tietê	5,868	1,397	1,174	2,934	1,537
10 - Tietê/Sorocaba	11,829	2,104	2,366	5,915	3,811
TOTAL	46,319	6,683	9,264	23,160	16,477

Source: Authors, 2016.

Table 10 indicates the investments needed for the preservation of water resources (by universalizing the collection and treatment of sewage), as well as the values to be applied for the recovery of green areas, according to each scenario.

Table 10 - Costs for the improvement of environmental quality in the MMP in billions of BRL.

Scenario	Basic Sanitation	Forested Areas	Total
Sustainable Development	13	7.6	20.6
Conservation	13	18	31.0

Source: Authors, 2016.

Both scenarios show the same costs for the improvement of basic sanitation, because its universalization is essential and imperative for improving the quality of water resources. For forested areas, investments are proportional to the recovered area. Despite the high investments, the benefits of such recovering would be countless, not only environmentally, but also socially.

Final Remarks

This study proposes actions to achieve water sustainability in the MMP.

The indicators presented herein make it possible to assess environmental issues in their entirety, instead of only focusing on increasing water availability, which has been the emphasis of the studies contracted by the DAEE.

We designed scenarios based on the Pressure-State-Response methodology, and they show that it is possible, desirable, and highly necessary to decrease water losses in the MMP, as well as to implement large-scale reforestation aiming at of water production. They also show that it is essential to invest in sewage treatment to improve the quality of water before building dams that will most likely receive sewage disposal.

The demand management measures pointed out in this study are also important. The Trend Scenario observes an alarming total demand of 517.05 m^3/s, far above the maximum water availability possible of 465.9 m^3/s, which clearly shows that other actions – considering more than just increase availability – are necessary.

Therefore, we conclude that the MMP presents several environmental issues and it will be a great challenge to address them in the coming years. Such problems directly affect the demand and availability of existing waters and expose the conflicts between the sectors that demand such resource and between the states that manage them.

It is essential to recover the native vegetation to guarantee the 20% demanded Legal Reserve. The PCJ and Paraíba do Sul basins will face the biggest challenge for such recovery because of their large vegetation deficit. For them, the presence of vegetation is essential for improving water quality and quantity.

Better monitoring of the conservation units is also necessary in order to eradicate devastations. The New Forest code, however, ends up being another obstacle to achieve these objectives.

As for water quality, investments in basic sanitation must reach the entire MMP, since sewage is a chronic problem in all the basins of the MMP. Two basins are noteworthy: the Paraíba do Sul Basin, for using a large volume of water for sewage dilution; and the Alto Tietê Basin, for the highest concentration of population and lower rates of collection and treatment of urban effluents.

Regarding the demanded quantities, it is necessary to reduce water consumption through social and environmental projects so that population can achieve a more rational use of water. The use of water-saving technologies in large scale has an important role to save water. Sanitation companies should act more intensely and focus on reducing losses in supply, because the values observed in the MMP are alarming and end up making even greater pressure on water resources.

Data reliability hinders an accurate analysis of the reality of the MMP basins. Most data are outdated and differ from one source to the other. Therefore, the Basin Committees need to employ efforts to quantify the water demand and availability accurately; and the Sanitation companies need to update the volume of water lost throughout the supply.

Finally, State and Federal agencies, such as ANA (National Water Agency), need to be more active in the river basins that form the MMP, seeking to ensure an efficient management of natural resources and taking into consideration the economic aspects involved with water usage.

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