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Papers

Socio-environmental indicators in the integrated river basin management at the Sorocaba metropolitan region, São Paulo state, southeastern Brazil

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Abstract
We aimed to diagnose the current status of water resources at the seven river basins that form the Sorocaba Metropolitan Region (SMR) in São Paulo state, southeastern Brazil, by using indicators that would enable us to identify socio-environmental issues. Indicators of demography and social responsibility, water quality, water supply and demand, as well as state and response indicators of sanitation services, were obtained for the SMR basins. Three basins are strongly compromised in terms of environmental indicators, and two of them also underperformed on social indicators, despite the high local wealth. The three basins that have low wealth, low urbanization rate and low demographic density yielded good or intermediary values for social indicators, yet two of those basins should be given special attention, as they were revealed to be having issues related not only to water supply and demand but also to water pollution. Lastly, the basin that harbors the largest water supply in the region yielded good values for environmental indicators, yet it also yielded poor results for social ones. As the SMR basins have diverse features, their integrated management may pose a huge challenge, insofar as it should meet different social, economic and environmental needs that are necessary for development. In that sense, the present study should contribute to identifying actions that should be taken at the municipal and regional scales in order to foment sustainable development in the region.
Keywords: Regional Development. Environmental Management. Water Resources.

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Introduction

The Sorocaba Metropolitan Region (SMR) at São Paulo state, southeastern Brazil, was established aiming to foment integration of the planning and execution of public functions of common interest to the public entities in the region. The institutionalization of SMR is justified by its economic importance, demographic density, significant conurbation, socioeconomic aggregation, and by the diverse specialized urban functions of its municipalities.

According to Masullo and Lopes (2017), the treatment and analysis of actions taken by the agents involved in the planning and management of metropolitan regions has been the focus of the most recent studies on the matter, as such agents usually tend to think those regions in a segregated and isolated manner, which does not allow for the achievement of wider and more flexible interests among the constituent municipalities. Tischer and Pollete (2016) stated that the absence of socio-environmental, economic and governance-related indicators in Brazil has been one of the major challenges for the effective implementation of instruments of environmental and urban public policies in the country.

To evaluate the proposal to establish the SMR, the Planning Center of Southwestern São Paulo State has conducted a study that considered demographic, economic and social indicators. The study did not consider, however, indicators on water resources management, which are of pivotal importance to identify the main environmental issues of the basins that integrate the region. In terms of sustainability, water resources management is of major importance, since water bodies have been under ever-increasing anthropic pressure (CARVALHO et al., 2011).

Indicators are commonly used in monitoring actions, being projected to simplify information while also enabling temporal follow-up of transformations in a given region, e.g. a water basin (CBH-ALPA, 2013).

Gomes and Malheiros (2012) and Malheiros et al. (2008) have emphasized the importance of using indicators as tools to establish a big picture as well as to identify barriers related to public policies involving social, economic and environmental aspects (CARVALHO; CURI, 2016). Effective indicators may reveal the existence of cause and effect relationships, thereby allowing for immediate decision-making related to interventions (NAEEM; WRIGHT, 2003).

> In the context of water resources management, there is a complex decision-making process which is full of variables and data that need to be structured in order to allow for contributing to a better planning and management of water bodies, aiming to contribute to improving and defining public management strategies (CARVALHO; CURI, 2016).

The São Paulo State Integrated System for Water Resources Management has adopted an Indicator Database to elaborate the Report of Water Resources Status. Such report aims to monitor the balance between the amount and quality of water resources as well as to evaluate the efficiency of investments and of the Water Resources State Plan in recovering water quality and increasing water supply (SIGRH, 2013).

The use of socio-environmental indicators, which aim to evaluate the status of water resources, allows for diagnosing demographic information, social responsibility aspects, water quality, water supply and demand, and sanitation services. These indicators are basic parameters used in the analyses made at all Water Resource Management Units (WRMUs), and their results allow for directing efforts to strategic lines of municipal and regional sustainable development. In that context, we aimed to diagnose the status of water resources from the seven basins that compose the SMR at São Paulo state, using indicators that would enable us to identify socio-environmental issues.

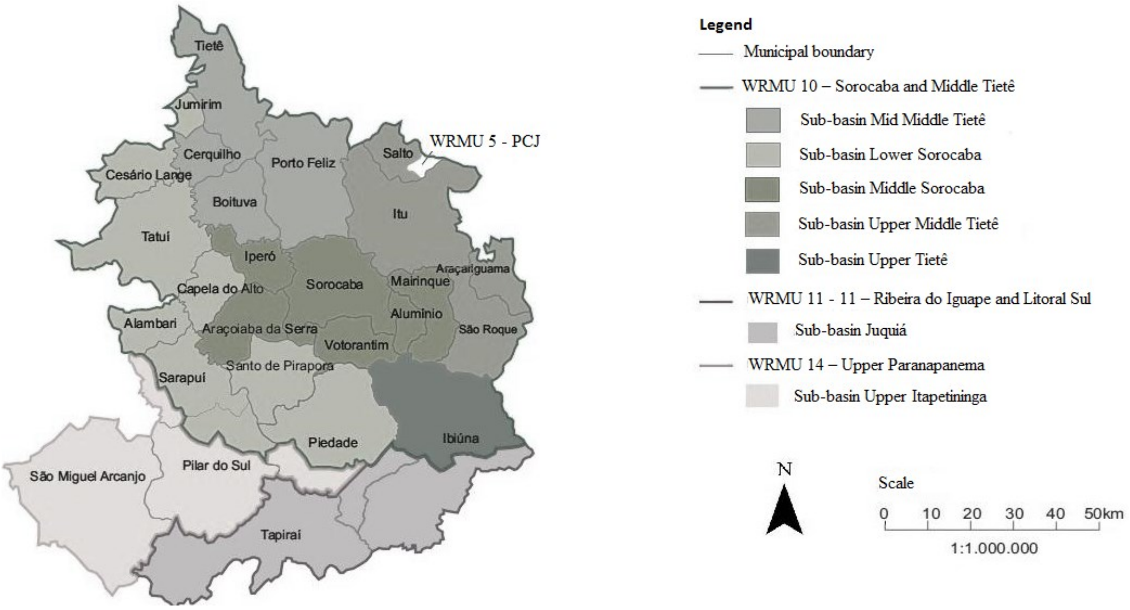
Methods

The study was conducted in the SMR, which was established by Law no. 1241 from 2014. The SMR encompasses an area of 9821.32 km^2, has a population of 1,805,473 inhabitants and is located near the São Paulo state capital (SÃO PAULO, 2014). The region is formed by 26 municipalities, and within its limits, there are three WRMUs.

WRMU 10 – Sorocaba and Middle Tietê is located in the most populous, urbanized and industrialized area of the SMR, and has the lowest percentage of plant cover (13.57% of its territory) and a 77% to 95% deficit of plant cover in its permanent preservation areas (CBH-SMT, 2013; SSRH, 2011). On the other hand, WRMU 11 – Ribeira do Iguape and Litoral Sul is located in a priority conservation area, and accordingly has a high percentage of natural vegetation cover (66.2% of the area), along with farming, mining and tourism activities (SSE, 2014).

Lastly, WRMU 14 – Upper Paranapanema has farming, forestry, extractivism, tourism and agribusiness activities, along with natural vegetation on 20% of its territory, 15% of which are protected by law; it is thus considered a conservation region (CBH-PCJ, 2014; CBH-ALPA, 2013).
The three WRMUs altogether encompass seven basins: Mid Middle Tietê, Lower Sorocaba, Middle Sorocaba, Upper Middle Tietê, Upper Sorocaba, Upper Itapetininga and Juquiá, all of which have different features. While some of those basins are essentially urban, showing high wealth due to industrial development, mining activity and presence of the service sector, others have low urbanization rates and high percentage of plant cover, being characterized by the presence of economic activities such as agriculture, cattle raising, reforestation and mining (Fig. 1).

Figure 1 - The Water Resources Management Units (WRMUs), their corresponding basins and the SMR municipalities, Sorocaba, São Paulo State, southeastern Brazil.



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Basin assessment

The selected indicators had to meet two criteria: they should be applied to the analysis of water resource status in all WRMUs (basic parameters), and they should show values that would enable basin classification into reference ranges established either by data-producing government agencies or by the São Paulo State Regional Council for Water Resources.

Thus, 23 indicators were selected from the Indicator Database and were classified into the following categories: Driving Force (five indicators of demography and social responsibility), State (13 indicators of water quality, water supply and demand, and sanitation) and Response (five indicators of basic sanitation). Understanding the inter-relationships between these indicator categories enables us to propose ways of reducing direct pressures or indirect effects on the environment status (SIGRH, 2013). The categories Pressure and Impact were not adopted since together they did not have basic parameters that would be applicable to all basins or values that would enable their classification into the reference ranges.

Driving-Force indicators of demography were calculated by the method described in the Indicator Database and classified according to the reference ranges. For the analysis of the São Paulo State Index of Social Responsibility (SPSISR), we calculated the modal value of results obtained for the basin constituent municipalities (Table 1).

Within the State category (Table 2), in order to analyze water quality indicators, we considered the results obtained from the monitoring points present in the Report on the Quality of Surface Waters in São Paulo State (CETESB, 2014a).

To analyze water supply and demand (Table 3), we used data on the permitted water demands (surface waters and groundwaters), based on consultations made to the Water Permit Database of the São Paulo State Department of Waters and Electricity (DAEE, 2015). Reference flow-rate data on the basins were not available in the 2004-2007 São Paulo State Plan of Water Resources; thus, we used the Hydrological Regionalization Software (SIGRH, 2015) as an alternative tool to calculate such data.

Based on values of Q_{mean} (mean water flow on the basin during the year), $Q_{95\%}$ (flow rate associated with a 95% permanence in time) and $Q_{7,10}$ (minimum surface flow recorded along seven consecutive days over a 10-year return period), we performed calculations following the method described in the Indicator Database.

Table 1. Driving-Force indicators of demography and social responsibility applied to sub-basins of the Sorocaba Metropolitan Region, São Paulo state, southeastern Brazil.

Indicator	Reference range	Assessment criterion
Geometric Annual Growth Rate (GAGR): represents the mean growth of the population residing in a given region over a given period, indicating the rate at which population grows (SEADE, 2014a).	< 0 ≥ 0 and < 0.6 ≥ 0.6 and < 1.2 ≥ 1.2 and < 1.8 ≥ 1.8 and < 2.4 ≥ 2.4 and < 3 ≥ 3% per year	-
Total Population: the total number of individuals that reside in a given region (SEADE, 2014b).	≤ 50,000 > 50,000 and ≤ 100,000 > 100,000 and ≤ 500,000 >500,000 and ≤1,000,000 > 1,000,000	-
Population Density: the number of inhabitants residing in a given geographic region at a given moment in relation to the area of that region, indicating the intensity with which the territory is occupied (SEADE, 2014c).	≤ 10 > 10 and ≤ 30 > 30 and ≤ 50 > 50 and ≤ 70 > 70 and ≤ 100 > 100 and ≤ 1,000 > 1,000 inhab/km²	-
Urbanization Rate: the percentage of urban population in relation to the total population (SEADE, 2014c).	≤ 70% > 70% and ≤ 80% > 80% and ≤ 90% > 90%	-
São Paulo State Index of Social Responsibility (SPSISR): an index that measures human development in the municipalities of São Paulo state by using municipal wealth, schooling level and longevity to assess the life conditions of the population (SEADE, 2014d).	Group 1	- High wealth level/good social indicators
	Group 2	- High wealth level/poor social indicators
	Group 3	- Low wealth level/good social indicators
	Group 4	- Low wealth level/average social indicators
	Group 5	- Low wealth level/poor social indicators

Source: Adapted from SEADE (2014a), SEADE (2014b), SEADE (2014c), SEADE (2014d)

Table 2. State indicators of water quality applied to sub-basins of the Sorocaba Metropolitan Region, São Paulo state, southeastern Brazil.

Indicator	Reference range	Assessment criterion
Water Quality Index (WQI): indicates contamination of water bodies by domestic effluents (CETESB 2014a).	$79 < WQI \leq 100$ $51 < WQI \leq 79$ $36 < WQI \leq 51$ $19 < WQI \leq 36$ $WQI \leq 19$	EXCELLENT GOOD REGULAR POOR VERY POOR
Quality Index of Gross Waters for Public Supply (WPI): index formed by a ponderation of WQI and the index of organoleptic toxic substances; evaluates the toxic compounds and the variables that affect water organoleptic quality, which are mainly derived from diffuse sources (CETESB, 2014a).	$79 < WPI \leq 100$ $51 < WPI \leq 79$ $36 < WPI \leq 51$ $19 < WPI \leq 36$ $WPI \leq 19$	EXCELLENT GOOD REGULAR POOR VERY POOR
Water Quality Index for Aquatic Life Protection (ALI): water quality for protection of fauna and flora, considering the presence and concentration of toxic contaminants as well as their effect on aquatic organisms (CETESB, 2014a).	$ALI \leq 2.5$ $2.6 < ALI \leq 3.3$ $3.4 < ALI \leq 4.5$ $4.6 < ALI \leq 6.7$ $ALI \geq 6.8$	EXCELLENT GOOD REGULAR POOR VERY POOR
Trophic Status Index (TSI): indicates the degree by which the water is enriched with nutrients (or 'trophic degree' of the water body) as well as the effect related to excessive growth of algae and infestation by aquatic macroalgae (CETESB, 2014a).	$TSI \leq 47$ $47 < TSI \leq 52$ $52 < TSI \leq 59$ $59 < TSI \leq 63$ $63 < TSI \leq 67$ $TSI > 67$	ULTRAOLIGOTROPHIC OLIGOTROPHIC MESOTROPHIC EUTROPHIC SUPEREUTROPHIC HIPEREUTROPHIC

Source: Adapted from CETESB (2014a)

Table 3. State indicators of water supply and demand applied to sub-basins of the Sorocaba Metropolitan Region, São Paulo state, southeastern Brazil.

Per capita supply – Q_{mean} in relation to the total population: the water potential, in terms of per capita volume or social reserves, that allows for correlating water supply in relation to the total population, characterizing the degree to which a given region is rich or poor in water (DAEE, 2015 and SEADE, 2014b).	$Q_{mean} > 2,500$ $2,500 \geq Q_{mean} \geq 1,500$ $Q_{mean} < 1,500$ (m^3/inhab.year)	GOOD ATTENTION CRITICAL
Total Surface Water and Groundwater Demand ($TSGD_{Q95\%}$) in relation to $Q_{95\%}$ supply: the balance between total demand (surface water and groundwater) and the $Q_{95\%}$ supply (DAEE, 2015).	$TSGD_{Q95\%} < 30\%$ $50\% \geq TSGD_{Q95\%} \geq 30\%$ $TSGD_{Q95\%} > 50\%$	GOOD ATTENTION CRITICAL
Total Surface Water and Groundwater Demand ($TSGD_{Qmean}$) in relation to supply: the balance between total demand (surface water and groundwater) and the Q_{mean} supply (DAEE, 2015).	$TSGD_{Qmean} < 10\%$ $20\% \geq TSGD_{Qmean} \geq 10\%$ $TSGD_{Qmean} > 20\%$	GOOD ATTENTION CRITICAL
Surface Water Demand ($DSurf_{Q7,10}$) in relation to the minimum surface flow $Q_{7,10}$: the balance between surface water demand and the $Q_{7,10}$ supply (DAEE, 2015).	$DSurf_{Q7,10} < 30\%$ $50\% \geq DSurf_{Q7,10} \geq 30\%$ $DSurf_{Q7,10} > 50\%$	GOOD ATTENTION CRITICAL
Groundwater Demand ($Dground_{expl}$) in relation to exploitable reserves: the balance between groundwater demand and groundwater supply (DAEE, 2015).	$Dground_{expl} < 30\%$ $50\% \geq Dground_{expl} \geq 30\%$ $Dground_{expl} > 50\%$	GOOD ATTENTION CRITICAL

Source: Adapted from DAEE (2015), SEADE (2014b)

River basins were then classified into the reference ranges established by SIGRH (2013), considering the results obtained for the following indicators: per capita surface water supply – Q_{mean} in relation to the total population, total surface water and groundwater demand in relation to $Q_{95\%}$ ($TSGD_{Q95\%}$), total surface water and groundwater demand in relation to Q_{mean} ($TSGD_{Qmean}$), surface water demand in relation to $Q_{7,10}$ ($DSurf_{Q7,10}$), and groundwater demand in relation to exploitable reserves ($Dground_{expl}$).

State indicators of sanitation (Table 4) were obtained based on the results compiled in the Diagnosis of Water and Sewerage Services of each municipality (SNIS, 2012).

Response indicators of basic sanitation services (Table 5) were obtained from the Report on the Quality of Surface Waters in São Paulo State (CETESB, 2014a). After calculations were made, basins were classified into the reference ranges established by SIGRH (2013).

Table 4. State indicators of sanitation applied to sub-basins of the Sorocaba Metropolitan Region, São Paulo state, southeastern Brazil.

Indicator	Reference range	Assessment criterion
Coverage of Waste Collection Services (CWC): the estimated percentage of total population granted access to services of domestic solid waste collection in relation to the total population (SNIS, 2012).	CWC ≥ 90% 90% > CWC ≥ 50% CWC < 50%	GOOD REGULAR POOR
Coverage of Sewerage Services (CSS): the estimated percentage of total population granted access to wastewater collection services in relation to the total population (SNIS, 2012).	CSS ≥ 90% 90% > CSS ≥ 50% CSS < 50%	GOOD REGULAR POOR
Index of Losses in the Water Distribution System (ILW): the estimated percentage of losses in the public system of water supply (SNIS, 2012).	25% ≥ ILW > 5% 40% > ILW > 25% ILW ≥ 40%	GOOD REGULAR POOR

Source: Adapted from SNIS (2012)

Table 5. Response indicators of basic sanitation applied to sub-basins of the Sorocaba Metropolitan Region, São Paulo state, southeastern Brazil.

Indicator	Reference range	Assessment criterion
Landfill Quality Index (LQI): an index obtained by evaluating the facilities of waste treatment or final waste disposal, in terms of both operation and structure (CETESB, 2014b).	$0 < LQI \leq 7.0$ $7.0 < LQI \leq 10$	INADEQUATE ADEQUATE
Ratio of Collected Domestic Effluents (CDE) in relation to the total domestic effluents produced: the percentage of collected domestic effluents in relation to the domestic effluents generated (CETESB, 2014a).	CDE < 50% 90% > CDE ≥ 50% CDE ≥ 90%	POOR REGULAR GOOD
Ratio of Treated Domestic Effluents (TDE) in relation to the total domestic effluents produced: the percentage of treated domestic effluents in relation to the domestic effluents generated (CETESB, 2014a).	TDE < 50% 90% > TDE ≥ 50% TDE ≥ 90%	POOR REGULAR GOOD
Ratio of Domestic Organic Loading Rate Reduction (OLR): the percentage of domestic polluting organic load removed by treatment in relation to the total domestic polluting organic load (CETESB, 2014a).	OLR < 50% 80% > OLR ≥ 50% OLR ≥ 80%	POOR REGULAR GOOD
Index of Collection and Treatability of Sewage from the Municipality's Urban Population (ICTSM): allows for establishing a global comparison of the efficiency of the sanitary sewage system (collection, farness, treatment and treatment efficiency, and quality of the water body that receives the effluents) (CETESB, 2014a).	0 < ICTSM < 2.5 2.6 < ICTSM< 5.0 5.1 < ICTSM ≤ 7.5 7.6 < ICTSM ≤ 10	VERY POOR POOR REGULAR GOOD

Results and Discussion

The seven sub-basins indicators were calculated and summarized in Table 6.

Table 6. Socio-environmental indicators at each sub-basin of the Sorocaba Metropolitan Region (São Paulo state, southeastern Brazil): Mid Middle Tietê (MMT), Lower Sorocaba (LS), Middle Sorocaba (MS), Upper Middle Tietê (UMT), Upper Sorocaba (US), Upper Itapetininga (UI) and Juquiá (J).

	Indicator	Sub-basin						
		MMT	LS	MS	UMT	US	UI	J
Driving force	GAGR (% per year)	1.4	1.1	1.3	1.1	0.8	0.4	-0.6
	TP (x 1000 inhab)	183.3	259.6	851.2	371.3	73.31	58.8	7.8
	PD (inhab/km²)	137.0	104.7	628.9	303.1	69.3	36.5	10.4
	UR (%)	90.7	78.0	95.0	95.0	35.0	73.0	71.5
State	Q_{mean} (m³/inhab.year)	1215.4 ***	2355.8 **	323.9 ***	742.9 ***	2506.8 *	1469.4 **	29334.5 *
	$TSGD_{Q95\%}$ (%)	73.7 ***	32.8 **	119.0 ***	77.7 ***	3.7 *	33.6 **	0.4 *
	$TSGD_{Qmean}$ (%)	27.1 ***	12.1 **	43.8 ***	28.6 ***	1.38 *	14.1 **	0.2 *
	$DSup_{Q7,10}$ (%)	88.6 ***	52.0 ***	101.9 ***	104.3 ***	2.3 *	41.1 **	0.2 *
	$Dground_{expl}$ (%)	43.8 **	7.8 *	173.6 ***	24.8 *	2.9 *	14.6 *	0.3 *
	WSR (%)	87.5 **	86.2 **	97.0 *	85.8 **	39.9 ***	74.6 **	64.7 **
	CWC (%)	97.4 *	92.3 *	29.9 ***	100.0 *	98.2 *	100.0 *	90.2 *
	CSS (%)	82.6 **	68.2 **	92.5 *	79.4 **	19.4 ***	57.9 **	57.0 **
	ILW (%)	37.9 **	48.3 ***	35.4 **	46.0 ***	51.1 ***	37.3 **	39.4 **
Response	LQI	9.8 *	9.7 *	8.7 *	8.8 *	8.0 *	8.5*	9.0 *
	CDE (%)	95.3 *	78.3 **	71.3 **	77.8 **	55.0 **	75.5 **	73.0 **
	TDE (%)	39.6 ***	36.6 ***	25.4 ***	65.5 **	50.5 **	34.6 ***	56.1 **
	OLR (%)	60.1 **	57.5 **	38.8 ***	23.3 ***	49.5 ***	65.4 **	43.9 ***
	ICTSM	7.3 **	7.0 **	5.0 **	3.5 **	6.0 **	7.2 **	5.9 **

Assessment: *** poor/critical. ** attention/regular. * good.

Mid Middle Tietê

This basin has a highly concentrated population as well as high population growth, and thus shows essentially urban features. The region is characterized by the predominance of municipalities that have low wealth but good social indicators. Expansion of the major SMR highways has fomented population growth, thereby increasing wealth compared with the 2008 and 2010 results. The per capita surface water supply is 30.6% lower than the one required per inhabitant. Total water supply is critical, especially in relation to the surface water demand, which during drought periods can reach values as high as 97.3% of the reference minimum flow rate. Groundwater demand also deserves a state of attention, as 43.8% of the total exploitable reserves are being consumed. In the stretch of Tietê river that runs within the limits of this basin, water quality shows a poor WQI, very poor ALI and hypereutrophic TSI, due to the low percentage of treated domestic sewage (39.6%). On the other hand, the Sorocaba river yielded good WQI due to natural water self-purification, yet it showed a poor WPI, regular ALI and oligotrophic TSI. This basin also receives untreated sewage from the Upper Middle Tietê and Middle Sorocaba.

Lower Sorocaba

Per capita surface water supply in this basin is 34.6% lower than the one required per inhabitant over a one-year period. Total water demand requires state of attention, especially in relation to surface water demand, which is critical during drought periods and may reach as much as 51.8% of the reference minimum flow rate, thus possibly leading to potential harm to the aquatic systems and to multiple water use. Groundwater demand also requires a state of attention, as 42.4% of the total exploitable reserves are being consumed. Some water bodies are polluted, owing to the low percentage of treated domestic sewage (36.6%). The Pirapora river, for instance, yielded regular WQI, regular PWI, regular ALI and mesotrophic TSI, which compromises water supply in several municipalities. The

Sarapuí river, on the other hand, showed good WQI, regular PWI, excellent ALI and ultraoligotrophic TSI.

Middle Sorocaba

We observed the predominance of municipalities with high wealth in the Middle Sorocaba, Upper Middle Tietê and Upper Sorocaba basins. However, none of these regions showed good social indicators, as economic development thereat was not followed by income distribution and social improvements. Only the municipalities of Sorocaba, Itu and Salto showed high wealth along with good social indicators, all that while also showing high population longevity. As for Araçoiaba da Serra municipality, it did not show high wealth, yet it did show good social indicators. Per capita surface water supply is 81.5% lower than the minimum required per inhabitant over a one-year period. During drought periods, surface water demand can exceed the reference minimum flow rate by 88.3%. As a consequence, granted water-use permits exceeded total exploitable reserves in 77.6%. Qualitative scarcity is another critical issue, since not only is the total water demand high, but the basin also showed regular WQI, poor ALI and points of eutrophic and super-eutrophic TSI along the Sorocaba river. Quality was regular with slight deterioration especially in the stretch that runs through Sorocaba and Votorantim municipalities, owing to the low percentage of treated domestic sewage (25.4%) and to the inflow of polluted waters from the Pirajibu river. The low coverage of waste collection services (29.9%) is yet another factor that aggravates sanitation conditions in the basin, which itself has the largest population in the entire SMR (ca. 50%); therefore, 7.5% of uncollected sewage in the basin represents the unmet demand of a population of 63,840 inhabitants. Water demand in the basin is chiefly met by the water produced in the Upper Sorocaba basin.

Upper Middle Tietê

Per capita surface water supply in this basin is 57.5% lower than the minimum required per inhabitant over a one-year period. Total water demand is critical, mainly for surface waters. During drought periods, such demand may exceed the reference minimum flow rate in 18.3%, which leads to water scarcity scenarios in the basin constituent municipalities. Water quality was regular in the stretch of Tietê river, yielding regular WQI, poor ALI and eutrophic TSI. Such regular water quality is due to the low removal of organic matter from treated domestic sewage (23.3%) as well as to the pollution received from the São Paulo Metropolitan Region and from the Jundiaí river.

Upper Sorocaba

Similarly to the Upper Itaptininga and Juquiá basins, the Upper Sorocaba basin harbors preservation areas and supply springs, while also having a smaller, less dense population. At the upper Sorocaba basin, water quality in the Sorocabuçu and Sorocamirim rivers, both of which form the Itupararanga Reservoir, yielded good values of WQI and ALI, yet their PWIs were poor and regular, respectively. Water quality in the Itupararanga Reservoir was excellent (including for public supply). However, the issue that deserves the most attention in this basin is the pollution at the Una river, which receives effluents from slaughterhouses, beef jerky production, animal food production and mining activities (CETESB, 2015). Per capita surface water supply is 43.2% higher than that required per inhabitant over a one-year period. Total water demand is low compared with reference flow rate values. Surface water demand in drought periods may reach values as low as 4.4% of the reference minimum flow rate. Sanitation indicators are poor, yet as urbanization is the area is low the population that has access to alternative sanitation systems is not considered is those indicators; instead, such indicators consider only the urban population that uses the services provided by sanitation companies. Nevertheless, the low rates of urban wastewater collection (55.0%) and treatment (50.5%) represent an alarming issue, since the basin encompasses springs and preservation areas that are of pivotal importance to ensure water supply to the Middle Sorocaba basin.

Upper Itapetininga

Per capita surface water supply in this basin is 16.0% lower than that required per inhabitant over a one-year period. Total water demand requires state of attention, mainly in relation to surface waters, whose demand in drought periods may reach up to 40.1% of the reference minimum flow rate and might thus lead to potential harm being caused both to aquatic systems and to multiple water use. The basin showed good WQI and eutrophic TSI. However, the low percentage of domestic sewage treatment (34.6%) is a serious issue that must be addressed, as the basin is considered to be a natural area conservation region.

Juquiá

This basin shows some of the lowest values for both wealth and social indicators in the entire SMR. Per capita surface water supply is 1,676.3% higher than that required per inhabitant over a one-year period. Total water demand is negligible compared with reference flow rate values. Surface water demand in drought periods may reach only as much as 0.50% of the reference minimum flow rate. Although the scope of the present work considers only the sanitation indexes of Tapiraí municipality for this basin, the low ratio of domestic organic loading rate reduction (43.9%) is alarming, as the basin encompasses protected areas that play a major role in the preservation of ecosystems as well as in the maintenance of high water supply. The basin could not be analyzed for WQI, ALI, PWI and TSI, as it does not possess a monitoring point within the SMR limits.

Final Considerations

The SMR basins are highly diverse in terms of their indicators of demography, social responsibility, water quality, and water supply and demand, as well as of their State indicators of sanitation and Response indicators of sanitation services.

The Middle Sorocaba and Upper Middle Tietê basins showed poor results for both environmental and social indicators, as they have higher levels of urbanization, are more densely populated and have higher wealth than the other SMR basins.

The Mid Middle Tietê basin also yielded poor results for environmental indicators, yet it yielded good results for social ones. This basin showed the highest geometric annual population growth rate, and its demographic features are similar to those of the Middle Sorocaba and Upper Middle Tietê basins, i.e., increasing wealth along with decreasing values for social indicators.

Immediate actions are necessary in the Middle Sorocaba, Upper Middle Tietê and Mid Middle Tietê basins aiming to rationalize water use on them, by establishing impediments or restrictions to the granting of permits of surface water or groundwater use. Analogously, prompt responses aimed at improving the status and conditions of basic sanitation services thereat are imperative.

The Lower Sorocaba, Upper Itapetininga and Juquiá basins showed lower wealth, lower demographic density and lower urbanization rates than the other basins. Increased urbanization rate and population density without proper management of socio-environmental indicators were observed, for instance, in the Lower Sorocaba and Upper Itapetininga basins, which were revealed to be facing issues with water supply and demand, as well as compromised water quality in the Pirapora river, in the case of the former. It is pivotal that economic growth in those three basins is accompanied by good results on social and environmental indicators.

As the SMR basins have diverse features, their integrated management may pose a huge challenge, insofar as it should meet different social, economic and environmental needs that are necessary in order for development in the region to occur in a more just and well-balanced manner, thereby equating urban issues that have arisen from the lack of planning and from the high concentration of urban population.

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