WATER SUPPLY AND SEWAGE SERVICES REGULATION INDICATORS IN POVERTY AREAS: STRUCTURE AND APPLICATION PROCESS IN CUBATÃO-SP, BRAZIL[1]

DENISE RASERA[2]
TASSIA GASPAR MENDES[3]
TIAGO BALIEIRO CETRULO[4]
MARIA PAULA CARDOSO YOSHII[5]
TADEU FABRÍCIO MALHEIROS[6]
RODRIGO MARTINS MOREIRA[7]
ALEJANDRA DANIELA MENDIZÁBAL-CORTÉS[8]
ESTER FECHE GUIMARÃES[9]

1. Introduction

Water Supply and Sewage Services (WS&SS) regulation was institutionalized in Brazil through the National Guidelines for Basic Sanitation Law and through the service-regulating decree (BRASIL, 2007, 2010). The main goal of such process was to develop mechanisms to help inspecting and controlling the quality of the services and to set rules for their provision.

After the sanitation regulation was institutionalized in the country, the WS&SS operators became accountable for meeting targets set by independent and non-attached entities known as regulatory entities (CNI, 2014). These entities (agencies), in turn,

1. The authors are grateful to: Sao Paulo Research Foundation (FAPESP), grant 2015 / 23382-1; Coordination for the Improvement of Higher Education Personnel (CAPES); National Council for Scientific and Technological Development (CNPq).

2. Master's Degree in Environmental Engineering Science (University of São Paulo). E-mail: deniserasera@yahoo.com.br.
3. PhD student in Environmental Sciences (University of São Paulo). E-mail: tassiagaspar@gmail.com.
4. PhD student in Environmental Engineering Science (University of São Paulo). Professor at Mato Grosso State University (UNEMAT - Universidade Estadual do Mato Grosso), Nova Mutum unit. E-mail: tiagocetrulo@usp.br.
5. PhD student in Environmental Engineering Science (University of São Paulo). E-mail: mpyoshii@usp.br.
6. PhD in Public Health (University of São Paulo). Professor at São Carlos Engineering School – University of São Paulo. E-mail: tmalheiros@usp.br.
7. PhD in Environmental Engineering Science (University of São Paulo). Professor at Mato Grosso do Sul State University (UEMS - Universidade Estadual de Mato Grosso do Sul), Coxim unit. E-mail: rodrigo.mart@usp.br.
8. PhD in Environmental Engineering Science (University of São Paulo). E-mail: mendizabal@sc.usp.br.
9. PhD in Environmental Engineering Science (University of São Paulo). Regulatory affairs advisor at SABESP. E-mail: feche.guimaraes@gmail.com.

became responsible for setting parameters for the quality of services provided to the population, for determining the billing structure, for monitoring the infrastructure conditions (water distribution networks and sewage collection) and for the compliance with service contracts and with Basic Sanitation Plans, as well as for applying penalties whenever they are applicable (TUROLLA, 2002; MADEIRA, 2010).

Monitoring processes remain a challenge and lack appropriate methodologies in some situations such as the universal access to or, as advocated by Law N. 11.445, the "progressive expansion of the access of all occupied households to basic sanitation" (HOHMANN, 2012). The WS&SS services provided to populations living in subnormal[i] clusters in urban suburbs present peculiarities that require regulatory agencies to develop appropriate tools to monitor the contractual and planning goals of the aforementioned services in these areas.

One of the possible tools to do so refers to the use of indicators, which can be quantitative or qualitative measurements applied to a specific service, performance or standard aspect. When it comes to monitoring processes, these indicators can be used to analyze the historical evolution in the quality of the service or to compare the operator's current standards to pre-established values (ALEGRE *et al.*, 2004). According to the aforementioned authors, this tool certainly brings improvements when it is integrated to the regulation process.

In light of the foregoing, the aim of the current study was to prepare and present a system comprising indicators to be applied to water supply and sewage service regulation, more specifically to subnormal clusters. A mix encompassing traditional and participatory approaches was herein used to select the indicators. The application of this structure to Cubatão County (São Paulo State) was presented as case study.

2. Indicator-generating approaches

The traditional approach used to generate sustainable development indicators emphasizes formal indicator aspects such as their scientific validity and their potential to be transferable and generic (FERNÁNDEZ-SÁNCHEZ and RODRÍGUEZ-LÓPEZ, 2010; RAMETSTEINER *et al.*, 2011). A set of indicators may represent a given reality and allow making comparisons between regions, times, entities or governments, when it meets the aforementioned criteria (MASCARENHAS *et al.*, 2010; SHEN *et al.,* 2011). This type of indicator is often defined by experts and enables the numerical representation of a given situation in order to make it simpler for stakeholders.

On the other hand, a more participatory approach to the choice of indicators may incorporate the individual values of stakeholders to the decision-making process (CHAMARET *et al.*, 2007; MAGEE *et al.*, 2013), which is a fairer way to represent the interests of indicators' users (MAGEE *et al.*, 2013). This approach also allows weighing the local knowledge to be applied to the decision-making process. Other studies show the additional advantages of using such approach, such as conflict reduction and democracy empowerment (KURKA and BLACKWOOD, 2013; CHRISTOPOULOS and MARQUES, 2013; MAGALHÃES and DIAS, 2013).

Studies conducted by Doody *et al.* (2009), O'ryan and Pereira (2015), Roy *et al.* (2015), Barrett *et al.* (2015) and Huang *et al.* (2015) presented the advantages of strategies that combine the two approaches. They argue that the broad participation of experts from different scientific fields, as well as the participation of indicators' users, helps enhancing the effects on the quality of the final decision.

With respect to the sanitation sector, there is a range of indicators selected through the traditional way (VON SPERLING, T. and VON SPERLING M., 2013; SANTIAGO, 2012; TEIXEIRA and HELLER, 2001), whereas few of them are selected through a participatory way (MAGALHÃES and DIAS, 2013; MIRANDA and TEIXEIRA, 2004). However, there is lack of specific indicators capable of helping to monitor the contractual and planning goals of WS&SS provided to subnormal clusters. Accordingly, there are no indicators selected through the combination of traditional and participatory approaches.

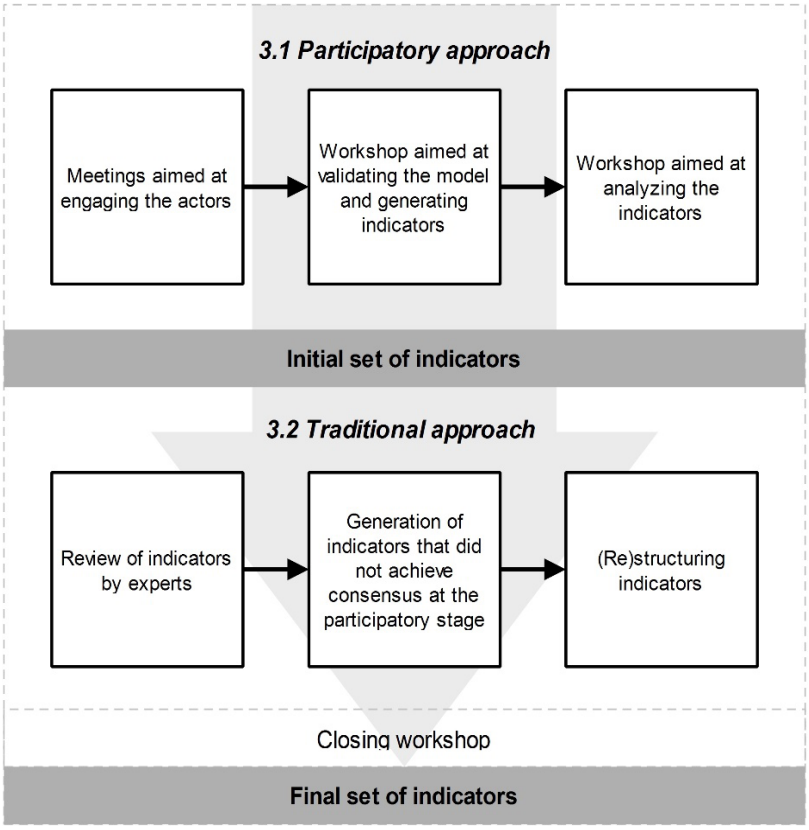
3. Developing the indicators' system to monitor WS&SS provided to subnormal clusters

Indicators were selected through the combination of participatory and traditional approaches. First, the participatory approach was applied to potential indicators' users in order to select the dimensions, criteria and indicators to be adopted in the monitoring of WS&SS goals and plans for subnormal clusters. The quality of the selected indicators was assessed according to criteria set by Malheiros *et al.* (2006), also in a participatory way.

Next, the traditional approach, which comprised interviews and workshops conducted with specialists in the field, was applied to select the indicators, as well as to revise and reformulate the already selected indicators, according to criteria set by Quiroga-Martinez (2001).

The aforementioned stages are explained in Figure 1, which presents a graphical summary of the methodology adopted in the current study; subsections 3.1 and 3.2 explain, in details, the indicator selection stages through the participatory and traditional approaches, respectively.

Figure 1 – Graphical summary of the methodology adopted in the selection of indicators for sanitation regulation in subnormal clusters.



Source: Prepared by the authors

3.1 The selection of indicators: participatory approach

The selection of and the quality analysis applied to the indicators were carried out through the participation of WS&SS-related institutions, mainly through the participation of potential users of the indicators to be selected. These collective elaborations took place in workshops conducted with the São Paulo State regulatory agency[ii] and with service providers.

Seminars and meetings were previously held to mobilize and prepare workshop participants. The workshops were attended by representatives of the following institutions: São Paulo State water supply and sewage regulation agency, water supply and sewage companies, nongovernmental organizations, water and sewage service departments, São Paulo State Sanitation and Water Resources Department, Brazilian Sanitary Engineering Association (ABES), universities, Paulista Foundation for Data Analysis (FPAD), and United Nations Educational, Scientific and Cultural Organization (UNESCO).

Subsection 3.1.1 presents the dimensions, criteria and indicators selected through this approach.

3.1.1 *Selected dimensions, criteria and indicators*

Meetings and seminars, which were held according to recommendations by MORRIS *et al.* (2011), allowed aligning the ideas, as well as preparing and mobilizing participants in relation to fundamental aspects of the topic, and helped assessing the different realities these participants lived in.

After the mobilization was concluded, a workshop was held with 45 participants: 22 representatives of different operators, seven representatives of the Regulatory Agency, three representatives of Paulista Sanitation and Water Resources Bureau (SPSRH), three representatives of the organized civil society, five representatives of FPAD, and five researchers. The initial conceptual model of the indicator system (dimensions) was presented and discussed in the workshop. This workshop allowed delimiting eight dimensions and twelve indicators able to help monitoring WS&SS provided to subnormal clusters. The aforementioned dimensions, as well as the adopted criteria and indicators, are described below:

Institutional Dimension

According to the involved actors, institutional relations may help managing and improving the services. The indicator selected to represent the dimension was:

1. Partnerships between agencies linked to subnormal clusters.

Water Resources Dimension

It was possible identifying the need of assessing the amount of sewage collection and treatment that does not fully meet people's needs, as well as the amount of water informally provided to vulnerable populations. The herein selected indicators were:

2. Sewage collection in subnormal clusters.
3. Sewage treatment in subnormal clusters.
4. Water waste in subnormal clusters.

Economic Dimension

This dimension took into consideration five criteria:

a) analyzing revenue losses resulting from frauds or from inappropriate service use, as well as losses related to the informality of services provided to the population;

b) investigating investments made by the operator to serve vulnerable populations. Workshop participants understood that the investments made by operators in vulnerable areas could be a key step towards improvement, since larger investments mean stronger supplying interest or the existence of a social policy;

c) checking the cost resulting from offering services to populations living in places where there is no water supply. Identifying the real value to be invested in order to serve these areas or the necessary subsidies to be allocated in order to do so; it includes values calculated for the operators and for the portion of the population that is formally linked to the networks, which indirectly bear the costs;

d) investigating whether the operators provide incentives (subsidies) to encourage subnormal cluster populations to use their services; for example, by paying the cost of connecting the house to the network and by offering differentiated prices to subnormal cluster populations. In other words, assessing whether the operators have incentives to subsidize services.

e) comparing the amount of water used by subnormal cluster populations that have formal access to water supply to that of populations that do not live under these conditions.

These criteria allowed selecting the following indicators:

5. Water billing losses in subnormal clusters.
6. *Investments made in services to be provided to populations served by welfare programs.*
7. *Connection costs to the operator in subnormal clusters.*
8. *Connection costs to users in subnormal clusters.*
9. Water consumption in subnormal clusters.

Vulnerability-Identification Dimension

The herein adopted criterion helped identifying populations presenting sanitary vulnerability in subnormal clusters. The principle of the current dimension lies on mapping vulnerable populations and on calculating the proportion of populations presenting sanitary vulnerability. The number of families enrolled in government welfare programs would be used as proxy to obtain this information. The herein selected indicator was:

10. Families enrolled in welfare programs.

Education and Citizenship Dimension

The goal of this dimension is to observe educational activities promoted by operators focused on basic sanitation, mainly on the conservation of water resources, on loss control and on sewage network connection. In addition, it aims at observing how much money and time operators invest in this type of activity, as well as at assessing citizens' participation in these activities. The herein selected indicators were:

11. Educational programs developed by operators.
12. Population participation in educational programs developed by operators.

Management, Social and Operational Dimensions

It was not possible reaching consensus about the criteria and indicators of these dimensions during the workshops.

Each selected indicator was subjected to quality analysis, as presented in subsection 3.1.2.

3.1.2 *Joint analysis applied to indicators*

Each indicator was analyzed according to criteria set by Malheiros *et al.* (2006). The analysis was carried out in a second workshop held with 22 participants: eight representatives from operators, three from the Water Resources Sanitation Bureau (SSRH), four from São Paulo State regulatory agency, one from the organized civil society, one from FPAD, and five researchers. Results are shown in Table 1.

It was suggested to exclude indicator 2 from the system after the analysis was concluded. In addition, it was recommended to modify other indicators and the recommended indicators, which were not part of the initial set but should be elaborated and detailed in the traditional stage, were generated.

Table 1 - Result of the participatory analysis applied to the quality of selected indicators.

	Indicators											
Analysis criteria	1	2	3	4	5	6	7	8	9	10	11	12
1. Understandable and interesting	○	●	○	○	○	O	O	O	○	O	○	O
2 . Relevant	O	●	O	○	O	O	O	O	O	O	O	O
3. Viable	O	●	O	O	○	○	O	O	O	O	O	O
4. Sufficient	○	O	O	O	O	O	○	○	O	O	O	O
5. Timely	O	●	O	O	O	O	O	O	O	O	O	O
6. Appropriate in scale	O	○	O	O	O	O	○	○	○	O	O	O
7. Democratic	O	O	O	○	O	O	○	O	O	O	O	O
8. Measurable	●	○	O	○	○	O	O	O	O	O	O	O
9. Preventive and proactive	O	O	O	O	O	O	O	O	O	O	O	O
10. Not tight	O	O	O	O	O	●	○	O	O	O	O	O
Legend:	O Meet				○ Partially meet					● Do not meet		

Source: Prepared by the authors based on the workshop.

3.2 The selection of indicators: traditional approach

The process described above was reviewed by specialists in sanitation regulation, in the generation of indicators and in sanitation in poverty areas (university professors and seven professionals from national and international regulatory agencies) during the present stage. The goal was to select indicators that did not reach consensus in the participatory stage and to perform the technical (re)structuring of the already selected indicators based on the methodological chart by Quiroga-Martinez (2001).

During this process: a) indicators of the Portuguese Water and Waste Services Regulatory Entity (ERSAR) were adapted to the 'Social', 'Management' and 'Operational' dimensions; (b) a new dimension was created, whereas another one was withdrawn; c) indicators were reallocated between dimensions; d) two indicators (*Families enrolled in welfare programs* and *Water consumption in subnormal clusters*) were excluded from the study; and finally e) indicators were renamed, and received description and calculation formulas in order to fulfill the criteria set in the methodological chart by QUIROGA--MARTINEZ (2001),

The final set of indicators, as well as their identification, description, formula and desired direction are explained in Table 2. It is worth highlighting that a closing workshop was held with the regulator agency ARSESP (potential user) and with the operator SABESP (potential audited company) before the final definition of the indicators to be applied to WS&SS regulation in subnormal clusters.

Table 2 - Indicators applied to WS&SS regulation in subnormal clusters.

	Identification	Name	Description	Formula	Desired direction
Social	1	Restricted service	Restricted WS&SS provision in subnormal clusters due to irregular housing	$\frac{\text{D. I. A. S.}}{\text{D. T. A. S.}} * 100$	↓
	2	Water service	Water coverage in subnormal clusters	$\frac{\text{D. C. R. A. A. S.}}{\text{D. T. A. S.}} * 100$	↑
	3	Sewage service	Sewage coverage in subnormal clusters	$\frac{\text{D. C. R. E. A. S.}}{\text{D. T. A. S.}} * 100$	↑
Operational	4	Water network expansion	Water network expansion in subnormal clusters	$C.T.R.A - C.T.R.A.A$	↑
	5	Sewage network expansion	Sewage network expansion in subnormal clusters	$C.T.R.E - C.T.R.E.A$	↑
	6	Presence of artesian wells	Artesian wells in subnormal clusters	$\frac{\text{D. A. S. A. P. A.}}{\text{D. T. A. S.}} * 100$	↓
	7	Presence of septic tank	Sanitary sewage through septic tanks in subnormal clusters	$\frac{\text{D. A. S. A. F. S.}}{\text{D. T. A. S.}} * 100$	↓
	8	Accession to the sewage network	Accession to the sewage network in subnormal clusters	$\frac{\text{E. A. E. A. S.}}{\text{E. A. A. I. A. S.}} * 100$	↑
	9	Accession to the water network	Accession to the water network in subnormal clusters	$\frac{\text{E. A. A. A. S.}}{\text{E. A. A. I. A. S.}} * 100$	↑
Management	10	Investment in ST&I	Financial investment in ST&I research aimed at serving subnormal clusters	$\frac{\text{I. C. T. I. A. S.}}{\text{I. C. T. I.}} * 100$	↑
	11	Human Resources	Human resources entrusted with WS&SS provision to subnormal clusters	$\frac{F.E.A.S.}{\text{F. T.}} * 100$	↑
	12	Communication	Responses to complaints and suggestions coming from subnormal clusters	$\frac{N.R.}{\text{N. R. S. A. S.}} * 100$	↑
Institutional	13	Institutional partnerships	Institutional partnerships related to WS&SS universalization	$Number\ of\ partnerships$	↑
Water Resources	14	Sewage collection	Ratio between sewage collection and consumed water volume in subnormal clusters	$\frac{\text{V. E. C. } A.S.}{V.A.C.A.S.} * 100$	↑
	15	Sewage treatment	Ratio between treated sewage volume and total collected volume in subnormal clusters	$\frac{\text{V. E. T. A. S.}}{\text{V. E. C. } A.S.} * 100$	↑

	16	Physical water losses	Volume of supplied water, but not used by subnormal clusters.	$\frac{V.A.F. - V.A.C.A.S.}{V.A.F.} * 100$	↓
Financeira	17	Financial water losses	Billing losses due to informally consumed water in subnormal clusters	$\frac{V.O.U.A.S.}{V.A.F} * 100$	↓
	18	Financial investments in the area	Financial investments aimed at serving subnormal clusters	$\frac{I.A.S.}{I.T.} * 100$	↑
	19	Specific subsidy on water connections	Subsidy on water connections in subnormal cluster areas.	$100 - \frac{C.M.L.U.A.S}{C.M.L.O.A.S}$	↑
	20	General subsidy on water connections	Subsidy on water connections for general users	$100 - \frac{C.M.L.U.G}{C.M.L.O.G}$	↓
	21	Social tariff	Families paying Social Tariff in areas presenting vulnerable populations	$\frac{D.T.S.A.S.}{D.C.R.A.A.S.} * 100$	↑
Education and Citizenship	22	Educational programs	Educational programs developed by operators.	$N.P.R.O.C$	↑
	23	Adherence to programs	Participation level in the offered programs, meetings, workshops, and courses.	$\frac{N.P}{N.P.R.O.C}$	↑

Source: Prepared by the authors based on the participatory and traditional stages.
Notes:
D.I.A.S.: Irregular households in subnormal clusters (n.)
D.C.R.A.A.S.: Households connected to the water network in subnormal clusters (n.)
D.T.A.S.: Total households in subnormal clusters (n.)
D.C.R.E.A.S.: Households connected to the sewage network in subnormal clusters (n.)
C.T.R.A.: Total water network length in subnormal clusters (m)
C.T.R.A.A.: Total water network length in subnormal clusters in the previous year (m)
C.T.R.E.: Total sewage network length in subnormal clusters (m)
C.T.R.E.A.: Total sewage network length in subnormal clusters in the previous year (m)
I.C.T.I.A.S.: Investment in specific ST&I research focused on subnormal clusters (R$)
I.C.T.I.: Total investment in ST&I research by the operator (R$)
F.E.A.S.: Specific employees serving subnormal clusters (n.)
F.T.: Total number of employees in the operator (n.)
N.R.: Number of responses (n.)
N.R.S.A.S.: Number of complaints and suggestions coming from subnormal clusters (n.)
V.E.C.A.S.: Collected sewage volume in subnormal clusters (m^3)
V.A.C.A.S.: Consumed water volume in subnormal clusters (m^3)
V.E.T.A.S.: Treated sewage volume in subnormal clusters (m^3)
V.A.F.: Supplied water volume in subnormal clusters (m^3)
V.O.U.A.S.: Other water-use volumes in subnormal clusters (m^3)
I.A.S.: Operators' investment in subnormal clusters (R$)
I.T.: Total operator's investment (R$)
C.M.L.U.A.S.: Mean connection costs to subnormal cluster users (R$)
C.M.L.O.A.S.: Mean connection costs to the operator in subnormal clusters (R$)
C.M.L.U.G.: Mean connection costs to general users (R$)
C.M.L.O.G.: Mean connection costs to the operator in the county (R$)
D.T.S.A.S.: Households paying social tariff in subnormal clusters (n.)
D.A.S.A.P.A.: Households served through artesian wells in subnormal clusters (n.)
D.A.S.A.F.S.: Households served through septic tanks in subnormal clusters (n.)
E.A.E.A.S.: Active sewage savings in subnormal clusters (n.)
E.A.A.I.A.S.: Active and inactive water savings in subnormal clusters (n.)
E.A.A.A.S.: Active water savings in subnormal clusters (n.)
N.P.R.O.C.: Number of offered programs, meetings, workshops and courses (n.)
N.P.: Number of participants (n.)

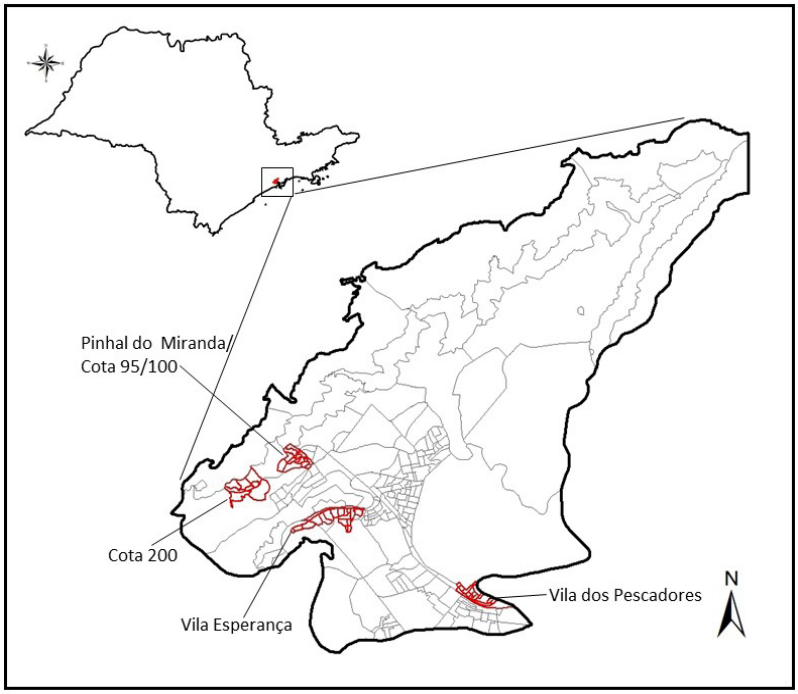
4. The application of the structure to Cubatão county (Case Study)

4.1 Site characterization

Cubatão County is located in the central area of Baixada Santista Metropolitan Region, in São Paulo State coastal area. It is an important Brazilian industrial pole to the petrochemical, steel and fertilizer sectors. Its GDP[iii] per capita - R$ 52,772.36 - is significantly higher than that of São Paulo State - R$ 32,454.91 (IBGE, 2012).

The Gini index in Cubatão County is 0.45, which is very close to the index in São Paulo State - 0.474 (IBGE, 2012). The mean human development index is 0.737, and this value places the county as the 850th in the national ranking (PNUD, 2013).

Figure 2 - Location of the herein studied subnormal clusters.



The last census conducted in the county recorded total resident population of 118,720 inhabitants: 65,573 of them live in subnormal clusters distributed in 19 precarious or squatter settlements (four of them are located in the State Park of Serra do Mar, six are located in mangrove areas and nine, in public urban areas) (IBGE, 2010a).

The current study investigated the following areas in Cubatão County: Vila Esperança (19,414 inhabitants), Vila dos Pescadores (11,255 inhabitants), Cota 200, Cota 95/100 and Pinhal do Miranda/Grotão (20,941 inhabitants). The sum of the populations

living in these areas represents 78.3% of the population living in subnormal clusters in the county. Figure 2 shows the location of each area.

4.2 Results of the indicators applied to Cubatão

The structure of indicators applied to WS&SS regulation in subnormal clusters was also applied to Cubatão County; results are shown in Table 3.

Table 3 – Results of the indicators applied to WS&SS regulation in subnormal clusters and calculated for Cubatão County in 2014.

	Number	Name	Results
Social	1	Restricted service	*
	2	Water service	82.73%
	3	Sewage service	0%
Operational	4	Water network expansion	*
	5	Sewage network expansion	*
	6	Presence of artesian wells	0.24%
	7	Presence of septic tank	1.86%
	8	Accession to the sewage network	0%
	9	Accession to the water network	92.56%
Management	10	Investment in ST&I	*
	11	Human Resources	10%
	12	Communication	*
Institutional	13	Institutional partnerships	3
Water resources	14	Sewage collection	0%
	15	Sewage treatment	0%
	16	Physical water losses	16.79%
Financial	17	Financial water losses	46.89%
	18	Financial investments in the area	*
	19	Specific subsidy on water connections	50.66%
	20	General subsidy on water connections	56.09%
	21	Social tariff	26.36%
Education and citizenship	22	Educational programs	*
	23	Adherence to programs	*

Note: Indicators flagged with * were not calculated due to lack of data.

For comparison purposes, 87.34% of the population living in Cubatão County can count on water supply and 46.8% count on sanitary sewage coverage. In addition, 100% of the collected sewage is treated. The financial water loss index in the county is 29.67% (SNSA, 2010). Clearly, indicators referring to subnormal clusters in Cubatão County present worse results than those recorded for the county average.

4.3 Post-implementation analysis of indicators

Although twenty-three indicators were generated in order to regulate sanitation in subnormal clusters, only fifteen were calculated in the present case study due to lack of data. However, other counties may have enough data to allow calculating all indicators. In addition, the regulator should pressure the operators to collect these data due to the relevance of the matter.

Indicators such as *Water Service* and *Sewage Service* are based on the number of households recorded by IBGE, although this number is generally underestimated. The number of employees responsible for providing services to vulnerable population areas is also an estimated data resulting from fieldworks. It is necessary assessing whether the operators are willing to differentiate the activity performed by their employees and to formalize it in order to help calculating indicators.

The number of institutional partnerships was investigated by means of an interview; signed contracts were not assessed. It is suggested that these partnerships should be documented and standardized in order to be properly assessed.

It is also suggested to choose one indicator between *Sewage service* or *Sewage collection* in subnormal cluster areas, since both services present similar goals. In addition, the indicator *Sewage treatment* should be excluded, because it is not possible distinguishing the sewage treatment rate in subnormal clusters from that recorded in other county areas.

It is essential estimating just the social water-use volume in the *Other water-use volume* parameter in order to calculate billing losses derived from informally consumed water.

It would be interesting for the regulatory agency to work with indicators such as the number of artesian wells and septic tanks, which should be registered and monitored by sanitation bodies such as São Paulo State Environmental Company (CETESB)

Indicators such as *Social tariff*, *Accession to the sewage network* and *Accession to the water network*, which were calculated through operational data provided by the operator, were considered the most accurate and reliable ones.

5 Discussion

5.1 About the application of indicators for WS&SS regulation in subnormal clusters

Regulators must have appropriate tools to help monitoring and confirming operators' compliance with sanitation plans in subnormal clusters. The herein performed review showed that indicators may be interesting tools, since they allow a) assessing the histori-

cal evolution in the quality of services provided by the operator; b) comparing results to pre-established standards; (c) comparing the operator to other companies.

Thus, the selected indicators can be used by regulators to assure compliance with the conditions and targets set in service contracts and in Municipal Basic Sanitation Plans. In addition, they can be part of the standards and norms prepared by regulators to assure the adequate provision of services and users' satisfaction[iv], as well as to set progressive service quality and expansion targetv. However, it is worth pointing out that the collection and monitoring of these data by regulators would be quite complex due to the large amount and variety of subnormal clusters. It happens because most of the data used to calculate indicators are collected in a primary way, as well due to asymmetric information about secondary data, fact that would result in a great demand for human and financial resources.

The presence of irregular areas in subnormal clusters is another issue limiting the use of these indicators for comparison purposes. The regulation loses its meaning when it is used to compare performance results or to penalize the operator for the absence of or precariousness in the service provided to these places, since the operator may need the authorization from the Public Prosecutor's Office to provide WS&SS in subnormal clusters undergoing irregular situation

This issue was considered complex in the legal analysis applied to *Trata Brasil* report, since squatter settlements are often located in Permanent Preservation Areas (PPAs) and in non-compliance with the municipal land-use and occupation legislation. Thus, there are conflicts between constitutional rights and principles, whether they are focused on protecting ecologically balanced environments, on the right to proper housing, on the dignity of the human person, or on the right to life, to property and to the social function of property (TRATA BRASIL, 2016).

In such cases, it is recommended using indicators for Sunshine[vi]-type regulations, in which the regulator would publish the results recorded for the indicators of service providers under its control.

If one takes into consideration that the Sunshine regulation is based on performance-improvement encouragements, it is possible saying that the presence or lack of authorization may work as context factor at the time to assess the operator's results. Thus, even if there is no authorization, it is believed that the public exposure of the service delivery situation may encourage initiatives from other actors working in the sanitation sector to find appropriate solutions within their competencies.

Therefore, the Sunshine regulation may give visibility to necessary requirements to achieve satisfactory results in the delivery of services in subnormal clusters. It is believed that the Sunshine regulation may be a way to consolidate the culture of information and transparency in the provision of services in these areas, although the improvement opportunity depends on actions taken by the operator and by other actors.

With respect to the experiences reported in the case study conducted in Cubatão County, it is necessary evaluating the possibility and the effectiveness of comparing providers that do not present similar contexts. It is estimated that there is management quality diversity in different counties. Every county presents WS&SS management

particularities such as multiplicity of managerial and urbanization formats, as well as of population and territorial dimensions. Thus, comparisons should be made, for example, between counties belonging to a single metropolitan region or to a group of counties that could be compared to each other.

On the other hand, instead of grouping all the subnormal clusters of a given county to calculate the indicators, one can compare intramunicipal areas in order to deeply investigate local weaknesses and good practices. This procedure would be especially important in metropolitan contexts presenting conurbation of counties, interconnection between water and sewage systems, and large poor population areas.

5.2 About the indicator selection approach

According to the participatory approach, the generated indicators reflected interests and viewpoints of different participants, as already reported by Gallopin (1997), Meadows (1998), Bossel (1999), Santos (2004), Malheiros *et al.* (2006) and Reed (2008).

The participatory generation of indicators encouraged the mobilization and contributed to the understanding of good practices in the sector. The participatory process, although essential, presented limitations that had to be overcome in each process, namely: a) the need of having more time to discuss about, evaluate and prepare indicators; b) the need of having participants adhering to the process; c) and the need of having institutional partnerships.

Therefore, it was possible understanding that the application of these indicators and the discussion about them are essential to the sector, if one takes into consideration the importance of universalizing and providing WS&SS to poor populations. The collective proposition of dimensions, criteria and indicators was an essential process, since it triggered dialogues, the integration of actors working in the sector, and the positioning of decision makers.

In addition, the implementation of the participatory process allowed including indicators consistent with reality; consequently, these indicators were more likely to be used, since they were selected by actors who will really use them. However, it is recommended making a public consultation with populations living in subnormal clusters, who are directly affected by decisions made, before applying these indicators.

One of the main issues related to the participative approach applied to the selection of indicators lies on the lack of scientific validity and on its inability to be transferable and generic (DOODY *et al.,* 2009). Thus, the research conducted to generate the herein investigated indicators also adopted a traditional approach, which was carried out by specialists, in order to remedy the aforementioned issues. The technical review applied to the indicators allowed accurately defining their purpose based on a conceptual framework, without losing the local scope scale. The experts gave scientific character to the indicators and enabled them to be applied to different counties and realities by using the principles set by Quiroga-Martinez (2001).

Thus, the participatory/traditional approach mix allowed keeping the positive points of each approach, as well as overcoming the negative ones. The system also allowed

developing focused and useful indicators able to meet users' needs, according to the goal of regulating WS&SS in subnormal clusters.

5.3 About the indicators

The WS&SS already have indicators, which were historically developed and applied to evaluation processes in Brazil. There are indicator systems such as the National Sanitation Information System (SNIS), which has been using approximately 80 indicators in diagnosis procedures since 2002 (SNSA, 2010); the National Sanitation Quality Award, which adopts an evaluation system based on 79 indicators (PNQS, 2011); among other official data collection systems such as SEADE and IBGE, and state regulatory agencies.

Although the routine use of important indicators has been adopted by regulatory agencies and operators to evaluate service performance, this evaluation is not sufficient to measure and monitor the WS&SS universalization process.

The indicators proposed in the current study aimed at representing the need to universalize WS&SS, according to the sustainability perspective, by focusing on indicators able to be linked to one another. It is not the purpose of the present research to propose complete and tight indicators. These indicators are expected to be improved, replaced and even excluded if they do not meet the goal of regulation for universalization purposes.

The herein proposed indicator system enables the simple visualization of the issue, but it can also show its complexity, since it depicts different faces and dimensions of the aforementioned issue in a holistic way. The model helped bringing together in the same system different visions and problems, which also require different information. The herein recorded results allowed inferring that the indicators have the potential to show and measure the WS&SS situation in subnormal clusters.

In case the legal difficulty in providing WS&SS to irregular households is overcome, regulatory agencies may use the proposed indicators as tools to monitor service contracts and to assure compliance with Basic Sanitation Plans. In order to do so, the regulator must also define desirable quality standards for each proposed indicator. Subsequently, it is necessary encouraging the incorporation of these measures. Finally, the regulator must determine the best monitoring processes and systematically review the indicators.

5.4 About data availability to calculate the proposed indicators

The lack of information to fill up the indicators was a significant indication that operators do not have data on subnormal clusters. It was anticipated by the participants during the development of indicators; however, all indicators were maintained due to the need of evaluating this information. It was possible collecting 24 data, 21 of them were directly provided by the operator. Three data were collected at IBGE database; however, this data source should be replaced, since data used to calculate the indicators need to present frequency higher than that provided by IBGE. A single datum was found in SNIS; it happened because, although the system provides several variables to compose

the indicators, these variables are not applicable to subnormal clusters, since they present municipal unit format.

Nineteen out of twenty-one data collected at the operator were gathered in interviews conducted with the manager of the local operator in Cubatão County. The remaining two data were collected by e-mail at the Regional Superintendence, which is located in São Paulo City. The data collected in Cubatão County were discussed during the interview; therefore, they could be better understood and adjusted, according to considerations presented by the interviewee. Data sent by electronic mail could not be discussed, fact that limited the final analysis of the corresponding indicator. Thus, the interview was the most adequate way to collect data, since it allowed understanding fundamental aspects about the collected data, as well as understanding particularities concerning the delivery of services in subnormal clusters.

One of the most important aspects enabling the collection of most data lied on the fact that the subnormal clusters are sectored in Cubatão County. It was the only way to have data restricted to the study areas and to calculate the indicators.

It was not possible collecting nine data. Among them, six are recorded by the operator, although as general information about the county. Thus, these indicators could not be specifically calculated for subnormal clusters. Therefore, in case one shows interest in calculating the aforementioned indicators, information systems should be adapted to generate such data in the proposed format. Two other data were not collected due to lack of formal record about the activities when they were carried out, so it would be possible obtaining them if these activities started being recorded. In other words, most of the data could be generated if the operator adapted the information to subnormal clusters.

Another limitation in the current research lied on the fact that data collection was just carried out in Cubatão County, in a São Paulo operator unit focused on the operation of the water and sewage system in the county. Since it is a regional operator unit, certain functions end up being developed in other company sectors. Therefore, unavailable data in Cubatão County may be collected in other company units or in other counties.

6. Final considerations

The sectorization and measurement of variables in subnormal clusters precede the implementation of indicator systems able to contribute to technical efficiency management and regulation processes.

Calculating indicators based on variables derived from measurements, rather than from estimates, enables a quality jump in the services, since these calculations provide information that may help the Public Power and service providers to take actions.

The indicators defined in the system proposed an innovative diagnostic model for the universalization of services, since they can point out what other systems have not yet revealed. Well-analyzed indicators allow identifying subnormal cluster populations who are not regularly and continuously served by WS&SS.

The potential gains in using these indicators are directly related to the improvement of services resulting from a specific regulation focused on subnormal clusters. In

addition, they can be seen through comparisons between operators or between results and pre-established standards. These results can be used, for example, to set billings, thus generating incentives to operators presenting good performance in subnormal clusters or disincentives, and even penalties, to those that do not present good performance.

Indicators may also be adopted in a Sunshine regulation model in order to expose the quality of the services provided by operators in subnormal clusters, thus encouraging society to make pressure towards the improvement of services.

It is worth emphasizing that indicators are not the solution to the problem concerning the universalization of water and sewage services in poor population areas; however, they are robust instruments able to help improving planning and management strategies. In addition, they promote information transparency and enable dialogue between actors working in the sanitation sector in order to allow measuring the operator's readiness to address the universalization issue and improve governance. The use of the indicators presented in the current study may promote important quality jumps, as well as actions that are more inclusive and less alienated from the reality experienced in Brazilian urban areas.

Notes

i "A set consisting of at least 51 housing units, most lacking essential public services, characterized by property trespassing (public or private), and with unplanned and dense distribution" (IBGE, 2010b).

ii ARSESP – São Paulo State Sanitation and Energy Regulatory Agency.

iii Gross Domestic Product.

iv Item I in Article 22 of Law 11.455

v Item III in Article 22 of Law 11.455

vi The strategy adopted by this regulatory regime is based on the public exposure and on the comparison of a set of indicators concerning the efficiency and effectiveness of services provided by water and sewage companies.

7. References

ALEGRE, H. et al. **Performance indicators for water supply services**. Londres: IWA Publishing, 2004.

BARRETT, J. et al. Development of an estuarine climate change monitoring program. **Ecological Indicators**, v. 53, p. 182–186, 2015.

BOSSEL, H. **Indicators for sustainable development: theory, method, applications**. Winnipeg: International Institute for Sustainable Development, 1999.

BRASIL, **Lei nº 11.445**, de 5 de Janeiro de 2007. Estabelece diretrizes nacionais para o saneamento básico. **Diário Oficial da União**, Brasília-DF, 2007.

BRASIL, **Decreto nº 7.217**, de 21 de Junho de 2010. Regulamenta a Lei no 11.445, de 5 de janeiro de 2007, que estabelece diretrizes nacionais para o saneamento básico, e dá outras providências. **Diário Oficial da União**, Brasília-DF, 2010.

CHAMARET, A.; O'CONNOR, M.; RECOCHE, G. Top-down/bottom-up approach for developing sustainable development indicators for mining: Application to the Arlit uranium mines (Niger). **International Journal of Sustainable Development**, v. 10, p.161-174, 2007.

CHRISTOPOULOS, T. P.; MARQUES, T. C. A. Formulação de indicadores de impacto para microfinanças. **Revista de Políticas Públicas**, **São Luís, v.16, p. 105-114**, 2013.

CNI - CONFEDERAÇÃO NACIONAL DA INDÚSTRIA. **Saneamento: oportunidades e ações para a universalização**. Brasília-DF: CNI, v. 17. 2014.

DOODY, D.G.; KEARNEY P.; BARRY J.; MOLES R.; O'REGAN B. Evaluation of the Q-method as a method of public participation in the selection of sustainable development indicators. **Ecological Indicators**, v. 9, p. 1129–1137, 2009.

FERNÁNDEZ-SÁNCHEZ, G.; RODRÍGUEZ-LÓPEZ, F. A methodology to identify sustainability indicators in construction project management: Application to infrastructure projects in Spain. **Ecological Indicators**, v. 10, n.6, p. 1193–1201, 2010.

GALLOPIN, G. C. Indicators and their use: information for decision-making. **SCOPE**, v. 58, p. 13-27, 1997.

HOHMANN, A. C. C. Regulação e Saneamento na Lei Federal nº 11.445/07. **Revista Jurídica da Procuradoria Geral do Estado do Paraná**, Curitiba, v. 3, p. 211-244, 2012.

HUANG, Z.; YU, H.; PENG, Z.; ZHAO, M. Methods and tools for community energy planning: A review. **Renewable and Sustainable Energy Reviews**, v. 42, p. 1335-1348, 2015.

IBGE - Instituto Brasileiro de Geografia e Estatística. **Censo 2010a**. http://www.censo2010.ibge.gov.br/sinopse/index.php?dados=P15&uf=00 (accessed November 1, 2015).

IBGE - Instituto Brasileiro de Geografia e Estatística. **Aglomerados Subnormais 2010b**. http://www.ibge.gov.br/home/estatistica/populacao/censo2010/aglomerados_subnormais/default_aglomerados_subnormais.shtm (accessed November 10, 2015).

IBGE - Instituto Brasileiro de Geografia e Estatística. **Pesquisa Nacional por Amostra de Domicílios 2012**. http://www.ibge.gov.br/home/estatistica/pesquisas/pesquisa_resultados.php?id_pesquisa=40 (accessed October 10, 2015).

KURKA, T.; BLACKWOOD, D. Participatory selection of sustainability criteria and indicators for bioenergy developments. **Renewable and Sustainable Energy Reviews**, v. 24, p. 92-102, 2013.

MADEIRA, R. F. O setor de saneamento básico no Brasil e as implicações do marco regulatório para a universalização do acesso. **Revista do BNDES**, v. 33, p. 123-154, 2010.

MAGALHÃES, P. S.; DIAS, S. M. F. Construção de uma matriz de indicadores para a avaliação de programas/projetos de educação ambiental em saneamento: Possibilidades metodológicas. **Revista Brasileira de Educação Ambiental**, v. 8, p. 47-62, 2013.

MAGEE, L. et al. Reframing social sustainability reporting: towards an engaged approach. **Environment, Development and Sustainability**, v. 15, p. 225–243, 2013.

MALHEIROS, T. F.; PHILIPPI JR, A.; COUTINHO, S. M. V. Interfaces dos serviços de água e esgoto. In: GALVÃO JÚNIOR, A. C; SILVA, A. C. (Editores). **Regulação: indicadores para a prestação de serviços de água e esgoto**. 2 ed. Fortaleza: Fortaleza Expressão Gráfica e Editora Ltda., 2006, p. 91-122.

MASCARENHAS, A. et al. The role of common local indicators in regional sustainability assessment. **Ecological Indicators**, v 10, p. 646–656, 2010.

MEADOWS, D. H. **Indicators and information systems for sustainable development**. Hartland Four Corners: The Sustainable Institute, 1998.

MIRANDA, A. B.; TEIXEIRA, B. A. N. Indicadores para o monitoramento da sustentabilidade em sistemas urbanos de abastecimento de água e esgotamento sanitário. **Engenharia Sanitária e Ambiental**, v. 9, p. 269-279, 2004.

MORRIS, J. B. et al. A framework for participatory impact assessment: Involving stakeholders in European policy making, a case study of land use change in Malta. **Ecology and Society**, v. 16, p. 12. 2011.

O'RYAN R.; PEREIRA M. Participatory indicators of sustainability for the salmon industry: The case of Chile. **Marine Policy**, v 51, p. 322–330, 2015.

PNQS – PRÊMIO NACIONAL DE QUALIDADE EM SANEAMENTO. **Guia do Prêmio Nacional em Saneamento**. Belo Horizonte: Comitê Nacional da Qualidade, 2011.

PNUD – Programa das Nações Unidas para o Desenvolvimento. **O Índice de Desenvolvimento Humano Municipal Brasileiro**. Brasília: PNUD, Ipea, FJP, 2013.

QUIROGA-MARTINEZ. R. **Los indicadores de sostenibilidad ambiental y de desarrollo sostenible: estado del arte y perspectivas**. Santiago: CEPAL, 2001.

RAMETSTEINER, E. et al. Sustainability indicator development: Science or political negotiation? **Ecological Indicators**, v. 11 (1), p. 61-77, 2011.

REED, M. S. Stakeholder participation for environmental management: a literature review. **Biological conservation**, v. 141, p. 2417-2431, 2008.

ROY, R.; CHAN, N.W.; XENARIOS, S. Sustainability of rice production systems: an empirical evaluation to improve policy. **Environment, Development and Sustainability**, p 1-22, 2015.

SANTIAGO, L. S.; DIAS, S. M. F. Matriz de indicadores de sustentabilidade para a gestão de resíduos sólidos urbanos. **Engenharia Sanitária e Ambiental**, v. 17, p. 203-212, 2012.

SANTOS, R. F. **Planejamento ambiental: teoria e prática**. São Paulo: Oficina de textos, 2004.

SHEN, Y. et al. The application of urban sustainability indicators – A comparison between various practices. **Habitat International**, v 35, p 17–29, 2011.

SNSA - Secretaria Nacional de Saneamento Ambiental. **Sistema Nacional de Informações sobre saneamento: diagnóstico dos serviços de água e esgotos - 2008**. Brasília: SNSA, 2010.

TEIXEIRA, J. C.; HELLER, L. Modelo de priorização de investimentos em saneamento com ênfase em indicadores de saúde: desenvolvimento e aplicação em uma companhia estadual. **Engenharia Sanitária e Ambiental**, v. 6, p. 138-146, 2001.

TRATA BRASIL. **Pesquisa saneamento básico em áreas irregulares**: Relatório Brasil. São Paulo: Trata Brasil, 2016.

TUROLLA, F. A. **Política de saneamento básico: avanços recentes e opções futuras de políticas públicas** (Texto para discussão nº 922). Rio de Janeiro: IPEA, 2002.

VON SPERLING, T. L.; VON SPERLING, M. Proposição de um sistema de indicadores de desempenho para avaliação da qualidade dos serviços de esgotamento sanitário. **Engenharia Sanitária e Ambiental**, v. 18, p. 313-322, 2013.

Submitted: 08/02/2016
Accepted: 25/09/2017
http://dx.doi.org/10.1590/1809-4422asoc0020r4v2042017

WATER SUPPLY AND SEWAGE SERVICES REGULATION INDICATORS IN POVERTY AREAS: STRUCTURE AND APPLICATION PROCESS IN CUBATÃO-SP, BRAZIL

DENISE RASERA
TASSIA GASPAR MENDES
TIAGO BALIEIRO CETRULO
MARIA PAULA CARDOSO YOSHII
TADEU FABRÍCIO MALHEIROS
RODRIGO MARTINS MOREIRA
ALEJANDRA DANIELA MENDIZÁBAL-CORTÉS
ESTER FECHE GUIMARÃES

Abstract: The sanitation regulatory milestone in Brazil was established in 2007; regulatory agencies are responsible for assuring that service providers work in compliance with sanitation plans. The Water Supply and Sanitation Services (WS&SS) provided to subnormal clusters present peculiar features that require regulatory agencies to have appropriate tools to perform such monitoring. The aim of the current article is to build and present a system of indicators used for this purpose. A combination of traditional and participatory approaches was used to collect the indicators. Eleven indicators were proposed in the participatory approach and twelve were inserted in the traditional approach. These indicators were assessed by experts and applied to Cubatão County. Thus, a system comprising twenty-three indicators is herein presented to help monitoring the contractual and planning goals of WS&SS provided to subnormal clusters. The model is innovative and can be used in Incentive-based or in Sunshine regulations.

Keywords: Environmental indicators, water supply and sanitary sewage, squatter settlements and slums.

***Resumo*:** O marco regulatório do saneamento no Brasil foi instituído em 2007, cabendo às entidades reguladoras a verificação do cumprimento dos planos de saneamento por parte dos prestadores de serviços. Os serviços de esgotamento sanitário e abastecimento de água (SAA&ES) em aglomerados subnormais apresentam características peculiares que deman-

dam das reguladoras ferramentais apropriados para tal monitoramento. O presente artigo teve como objetivo construir e apresentar um sistema de indicadores para esse fim. Para a seleção dos indicadores utilizou-se uma combinação das abordagens participativa e tradicional. Onze indicadores foram propostos na abordagem participativa e outros doze foram inseridos na abordagem tradicional. Esses indicadores foram avaliados por especialistas e aplicados no município de Cubatão. Como resultado é apresentado um sistema com vinte e três indicadores para monitorar as metas contratuais e de planejamento dos SAA&ES para aglomerados subnormais. O modelo é inovador e pode ser utilizado pela regulação por incentivos ou *Sunshine*.

***Palavras-Chave*:** Indicadores ambientais, abastecimento de água e esgotamento sanitário, assentamentos irregulares e favelas.

***Resumen*:** El marco regulatorio del saneamiento en Brasil fue instituido en 2007, y las agencias reguladoras tienen la responsabilidad de verificar el cumplimiento de los planes de saneamiento por parte de los proveedores de servicios. Los Servicios de Abastecimiento de Agua y Saneamiento (SAA&S) para aglomerados subnormales tienen características peculiares que exigen de las agencias reguladoras instrumentos apropiados para monitoreo. El propósito de este artículo fue construir un sistema de indicadores para este propósito. Para la selección de los indicadores se utilizó una combinación de enfoques tradicionales y participativos. Se propusieron once indicadores en el enfoque participativo y doce en el enfoque tradicional. Estos indicadores fueron evaluados por expertos y aplicados en el municipio de Cubatão. Como resultado, se presenta un sistema con veintitrés indicadores para monitorear los objetivos de los SAA&S para aglomerados subnormales. El modelo es innovador y puede ser utilizado por la regulación de Incentivo o *Sunshine*.

***Palabra-Clave*:** Indicadores ambientales, abastecimiento de agua y saneamento, asentamientos precarios y favelas.