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Systematization of Actions and its Respective Sustainability Indicators as Part of the Development of a Support Tool for Water Resources Management in Watersheds

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Abstract

The present article aims to present the methodology proposed to development of a Water Resources Management Support Tool (denominated FAGRH) to River Basins, supplying decision process with subsidies correlated to sustainability concept, integrating different dimensions (ecological, economical, social, cultural and politics). The sustainability main concept that oriented the research was, "the development that foresees satisfies the needs of the present generation without compromising the chance for future generations to satisfy their" (Brundtland Report, 1987).

The FAGRH will be composed by Sustainability Indicators (SI), related to conditions or situations correlated to water resources management. The SI are tools that can be used as support to systematize existing information and to evaluate water resources situation at specific moments, allowing to foresee tendencies to future, to analyze sceneries, compare them in time and space, and, finally, to collaborate in decision processes.

The FAGRH should be structured based in Decision Support Systems (DSSs) concepts, considering the consent that DSSs were adapted for water resources planning and management. The multi criteria analysis method was capable to aid choice process, alternatives ordination or classification and also to incorporate multiple aspects. This method will make possible join diversified problematic conditions, several sustainability dimensions, as well as integrate different stakeholders' opinions.

The FAGRH will correlate some conditions previously measured by SI and potentials actions to mitigate, to correct or to prevent them. The alternative selection should attend previously defined goal for Basin Committee, and will be proceed through stakeholders' analysis about aspects as social, economic and environmental benefits, legal and institutional constraints, among others. Finally, the FAGRH should guarantee wide participation of Basin Committee actors' at decision process.

In this way, the tool should still be accessible, comprehensible for technicians, as for users and all society members; and it will be structured in an electronic spreadsheet, simplifying its application and modification along the process. he FAGRH intend to collaborate in basin water resources situation diagnosis, and to elaborate prognostics and programs, projects and actions, composing or providing information for Basin's Plans composition.

Keywords: *water resources management, sustainability indicators, basin and support tool.*

1. Introduction

In Brazil, the water resources management has been discussed since promulgation of the Waters Code in 1934 (Ordinance n. 24.643 on July 10, 1934) that has a centralized vision emphasizing electric power generation.

Recently, the Water Resources National Politics (Federal Law n. 9.433 of January 08, 1997), restructured and decentralized, created instruments to water management, as described:

- Water Resources Plans;
- Formulating water bodies in classes, according to the importance of water use;
- Grants rights for the use of water resources;
- Levy collection for the use of water resources;
- Compensation to municipal districts;
- Water Resources Information System.

About the sustainability concept, Melloul and Collin (2003) detach the importance of population affected expectations and concerns, proposing the attendance of these needs in several levels (individual, local, regional etc.). This way, the tool's development should involve Basin Committee managers' participation. It is recalled that, the sustainability concept has been introduced as guidelines to natural resources management since 1972, when the document "Limits to Growth" (a report to the Club of Rome) was produced.

The SI use as a decision process tool was proposed in the Report "Our Commom Future" and "Agenda 21", other important documents to natural resources management. Bazzani (2005) reminds that the use of indicators makes possible better forms of analyzing the actions alternatives by several dimensions (social, economical, environmental, cultural and political).

Another important tool that has been used in water resource management is the Decision Support System (DSS) or Multi-criteria Methods. These methods should provide to technicians and other actors, mainly managers and staholders, of reliable and enough information in decision process (Georgakakos apud Castelletti and Soncini-Sessa, 2007).

Bazzani (2005) detach those multi-criteria methods allow the participation of several individuals and, therefore, integrate specific knowledge to discuss a problem or situation and to propose strategic actions.

As mentioned by several authors, like Labadie et al (1989), Panty, Barbosa and Nakayama (1998), among other (LIMA, 2007), the water resources management could use Decision Support Systems (DSSs) concepts in its process decision. And, this article aims to present a Water Resources Management Support Tool (denominated FAGRH), using SI to monitor and interpret problems in Basin Committees and to support stakeholders with guidelines to act.

The FAGRH development will use SSDs concepts and other available resources, such as, electronic spreadsheets and GIS – Geographic Information System, to interpret and process all information.

The objective of the tool is provide reliable information with a accessible language to stakeholders, and collaborate with the natural resources protection, the universal access to the environment and basic sanitation, the appropriate budget employment in basin committees, the conflicts reduction, the expenses reduction with corrective actions to mitigate critical events, among other benefits environmental, social and economical.

The proposed tool will be available basin committee members, and intend to collaborate in problems identification, as well as in the prognostic and proposition of programs, projects and actions related; necessary information to support the elaboration of the Situation Reports and Basin Plans.

2. Methods

In the first stage, it was identified problematic conditions in water resources management, using a previous list built in a research involving the members of the Basin Committee of the Tietê-Jacaré Rivers, in São Paulo State-Brazil, (Corrêa, 2007).

This preliminary list were updated using data obtained in the characterization of others committees, also located in São Paulo-Brazil and by the review of water resources literature.

The final problematic conditions list regards quali-quantitative situations, basin committees' management conditions, as well as, foreseen Water Resources Politics instruments implementation difficulties.

For each condition identified as potential problem was defined a sustainability indicator, to monitor them; using as reference the proposals of PERH (2004-2007) and the group of SI previously systematized by Corrêa, 2007, for Basin Committee of Tietê-Jacaré Rivers. The SI was characterized, identifying the proposition source and the available official data source to calculate them, recommending a methodology to this process.

It was identified also actions that could be employed to solution or mitigate the potential problems; using as source the Basin Plans already developed by the Basin Committees in São Paulo-Brazil. The actions alternatives should be preventive actions (structures or no-structural) or correct actions (structures or no-structural); and recommended to short, medium or long term.

The tool development should be participative, and to guarantee the drought to stakeholder's participation, the proposed problems, SI and actions could be modified or complemented along de process of its implementation.

The FAGRH allows to the stakeholder or other users to select the indicators that will be used, and based on the results of the IS calculated for a Basin Committee, they should point out goals to short, medium and long term.

Finally, the stakeholders or users should analyze several criteria and the FAGRH will process this information and propose the actions that better adapt to the Basin Committee needs.

This process stage of the FAGRH used a Multi-criteria Method to evaluate the attributes of each one of the criteria, or sustainability dimensions. The expectations is that, this tool should make possible the diagnosis of management problems and facilitate the decision process in the basin committee; providing easy understanding information for users and stakeholders, and actions recommendation, based in goals previously analyzed close to the members of the respective Basin Committee.

3. Results

The problematic conditions identified in the water resources management and respective SI selected to monitor them, are presented in the Table 1.

Table 1: Problematic Conditions and Sustainability Indicators.

Problematic Conditions	**Sustainability Indicators**
Amount of Riparian Vegetation	Proportion of riparian area declared by farmers in relation to the total areas of their properties by the competent environmental agency (%)
Changes in the use and occupation of land in rural and urban areas	Proportion of area with native vegetation in relation to the total area (%)
Occurrence of areas susceptible to erosion	Ratio of basin area not classified as highly critical related to erosion (%)
Surface water availability	Proportion of reserve surface water Q7,10 related to global demand (%)
Exploitation of groundwater	Ratio of exploitable reserves available from underground waters (%)
Pollution and contamination of water resources	Proportion of "excellent" and "good" classifications in the monitoring points according to IQA - Water Quality Index (%)
Balneability (saltwater)	Proportion of monitored coastal beaches that remained "suitable" during the entire year (%)
Balneability (freshwater)	Proportion of monitored freshwater beaches that remained "suitable" during the entire year (%)
Pollution and contamination of water sources	Quality Index for Raw Water Supply Public - IAP (0-100)
Collection System	Proportion of domestic sewage wastewater collected in relation to the total generated wastewater (%)
Sewage Treatment System Domestic	Proportion of treated wastewater reuse in relation to the total generated wastewater (%)
Efficiency of domestic wastewater treatment	Reduction of pollution in terms of organic domestic charge (%)
Solid waste disposal	Proportion of solid waste disposed in landfill classified as "adequate" (%), according IQR – Landfill Quality Index
Distribution system of water supply network	Proportion of households served by the public water supply (%)
Losses in the system water	Proportion of water collected and effectively distributed in the water supply system (%)
Treatment System Public Water Supply	Index of compliance of standards for drinking water (parameter: total coliforms) (%)
Rainwater drainage	Proportion of municipalities with no reported incidents of flooding / inundation in urban areas (%)
Waterborne diseases	Deaths from waterborne diseases (diarrhea, intestinal infectious diseases and bacterial) (n. of cases/1000 hab.ano)
Pollution and contamination of water resources caused by industries	Density of contaminated Indexed (number/1000km2)
Remediation of contaminated areas remediated	Proportion of areas in relation to contaminated areas Indexed (%)
Network monitoring water quality monitoring	Network density of water quality (number/1000 km2)
Network monitoring hydrological (rainfall stations)	Density of rainfall monitoring network (number/1000km2)
Hydrological monitoring network (gauged stations)	Density monitoring network fluviometric (number/1000km2)
Legal Instruments	Proportion of municipalities that include specific aspects for environmental control in their municipal legal instruments (%)

Problematic Conditions	Sustainability Indicators
Plans and projects for water resource management	Ratio between the goals of the Basin Plan, using FEHIDRO and pleaded with the goals effectively achieved (%)
Environmental Education Programs	Proportion of shares pled effectively completed projects for environmental education (%)
Instruments of management of water resources (surface water grants rights)	Proportion of water availability grantable (50% of Q7, 10) with grants rights (%)
Instruments for water management (granting of groundwater)	Ratio of exploitable reserves with the grant rights (%)
Instruments for water management (payment for the use of water resources)	Ratio between effectively paid amounts and total potential amount to be paid (%)
Hydroelectric water bodies in the river basin	Installed power capacity in relation to the number of inhabitants (W / inhabitant)
Demand for irrigation sector	Proportion of water demand for irrigation in relation to the demand for all uses registered in UGRHI (%)
Social inequality (HDI) among municipalities components of river basin	Proportion of municipalities with high HDI (between 0.801 to 1.000) (%)
Civil society participation in decision-making of the Watershed Committee	Number of civil entities registered as a member on the committee that effectively participate in plenary meetings (%)
Network stretches suitable for navigation	Tons of products transported by waterway (ton / km.ano)
Reuse and recycling of solid wastes	Proportion of recycled solid waste in relation compared to total generation (%)
Reuse of wastewater effluents	Proportion of reused or recycled after treatment compared to total waste water generation (%)

According presented at methodology, for each one of potential problematic condition it was proposed some potential actions, using recommendations of the Basins Plans of the Committees of the State of São Paulo and other proposals observed at bibliographical revision.

The Table 2 presents the potential actions divided in four alternatives, referring to preventive actions (structural or no-structural) or correctives actions (structural or no-structural); and for three different terms (short, medium or long). This table systematizes an example of as the potential actions should be presented; reminding that for the development of FAGRH, it should be proposed actions for all the 40 potential problems identified previously.

The FAGRH intends to subsidize the Committees and Agencies of Basin, mainly in the development of Situation Reports and Basin Plans, collaborating with the systematization of the Water Resources Information System; using electronic spreadsheets in its development, to facilitate the data updating and the use of the tool by technicians and other members of basin committees.

The tool will organize and present to users all information to the processes, returning the results obtained, like, prioritized problems and corresponding SI with its results to the basin committee in study.

The electronic spreadsheets facilitated the manipulation of information and the introduction of new information that the tool requested, for example, to definition of goals to short, medium and long term to the basin committee.

Table 2: Potential Actions related to problematic conditions.

Problematic Condition	Alternative 1	Alternative 2	Term	Action Proposed
Amount of riparian vegetation	Preventive	Estructural	Short	Promote the maintenance of the riparian areas and other protected areas existent
			Medium	Promote the recovery of areas of riparian vegetation, of legal reservations and of corridors that are presenting degradation sign
			Long	Install and to maintain centers for forest replacement and control of activities with negative potential impacts to the biotic
		No-estructural	Short	Motivate the elaboration of plans for preservation of nascent and for the increase of the protection around them.
			Medium	Motivate the fiscalization, that could be executed by the municipal districts or by the state, on riparian areas and nascent
			Long	Discuss and to propose subsidies for incentives to legalize forest areas in private property.
	Corrective	Estructural	Short	Recover riparian vegetation
			Medium	Motivate the recovering of priority areas and of protected areas.
			Long	Promote the popularization of the Law no. 9.866/97, gone back to recovery and protection
		No-estructural	Short	Motivate the definition and mapping, in each municipal district of the basin, of respective riparian vegetation area related to it specific characteristics
			Medium	Accomplish risings of the environmental liability, mainly with relationship to the areas of riparian vegetation, and to create actions and proposed its recovering
			Long	Formulate guidelines for recovery of degraded areas

In this stage, the FAGRH will present reference values to goals obtained in the Basin Plans and will allow that the user modified these values according to their perspectives or necessities.

The tool request in the sequence, that the user attribute values to the criteria of analysis of the goals correlated to the sustainability dimensions (economical, social, politics, cultural and environmental), as specified below:

1. economical dimension: Provide resources for implementation and / or maintenance actions;

2. political dimension: Perform legal change and / or institutional;

3. cultural dimension: Promoting acceptance by various actors;

4. social dimension: Expand the scope of social benefits;

5. environmental dimension: Expand the scope of protection and restoration of natural resources.

The goals and the analysis of the respective criteria of them will provide to the FAGRH information to develop a multi-criterion analyses, in which the action that better adapts to the needs of the committee in subject will be recommended to the user. And the final result of FAGRH will be the actions recommended to mitigate or solve the priority problematic conditions of a river basin.

4. Conclusion

A set of sustainability indicators structured in the context using potential problematic conditions enables the stakeholder to consider specific localities, hence facilitating information and systematization to an appropriate scale.

The methodology proposed to calculate or obtain these indicators could help basins committees to systematize their Water Resources Information System, as recommend the National Politics (Federal Law n. 9.433/97), and based on this information makes possible the elaborate of Situation Reports.

The development of the FAGRH intends to provide the basins committees of information to elaborate of Basin Plans, observing potential problematic conditions that should be monitored, calculate the sustainability indicators to verify the situation of the quality and quantity of water, and other situations in water resources management.

Added this, the FAGRH propose the participation of members of basin committee or other actors in water resources management to define goals in short, medium and long terms to mitigate or solve the priority problems in a basin committee, that will be used to calibrate the tool. To each goal the FAGRH propose also that the stakeholder analyses some criteria, based on sustainability dimensions (economical, social, politics, cultural and environmental).

This criteria will provide to the tool the information necessary to promote a multi-criteria analyses evaluate, based on the results obtained calculating the IS, the actions that could be recommended to mitigate or solve the prioritized problematic conditions to the basin committee, and consequently collaborate to organize or to evaluate Basin Plans.

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