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Training watershed committee members to aid on the decision-making process for the execution program of the framework of water bodies

Capacitação de membros de comitê de bacia hidrográfica para auxílio à decisão sobre o programa de efetivação do enquadramento dos corpos d'água

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ABSTRACT

According to the National Water Resources Council 91/2008, the approval of the action plan of the framework of water bodies should be carried out through a decision-making process along the participation of the Watershed Committee (CBH). However, decision-making processes involving multiple stakeholders are vulnerable to flaws that can lead to mistrust among members and lack of commitment with the decisions taken. Some of these failures refer to the absence of information, transparency and lack of knowledge of the object of decision. In this context, the use of technological tools as a means to expand social participation has increased considerably. Among these, it is possible to mention the Information and Communication Technologies (ICTs). This paper presents a study about the use of Information and Communication Technologies (ICTs) to aid watershed committee members on deciding about the set of actions for the execution of the framing of water bodies, having the Salitre River Watershed as a study case. To support the decision on selecting the best action plan the Analytic Hierarchy Process (AHP) multi-criteria analysis method was used, for which a Distance Learning course (DL) within the free platform of "facebook" was developed. The analysis of the results showed that through the expansion of online communication and the creation of open forums through websites and social networks, the discussions among the watershed committee members may extend beyond the plenary meetings that occur not very often throughout the year. The application of ICTs presented some advantages regarding to the decision-making process within the CBH, such as: more time to discuss and obtain consensus; increasing access and exchange of information and experiences; transferring of technical information more clearly; and solving problems like inability to travel by the CBH members.

Keywords: *Framework of Water Bodies. Multiple Criteria Analysis. Information and Communication Technology.*

RESUMO

De acordo com a Resolução do Conselho Nacional de Recursos Hídrico 91/2008, a aprovação do programa de efetivação do enquadramento dos corpos d'água deve ser realizada através de um processo decisório, com a participação do Comitê de Bacia Hidrográfica (CBH). Porém, processos decisórios que envolvem múltiplos atores sociais são suscetíveis a falhas que podem gerar desconfianças entre os membros e falta de compromisso com as decisões aprovadas. Algumas dessas falhas referem-se à ausência de informação, de transparência e desconhecimento do objeto da decisão. Nesse contexto, a utilização de ferramentas tecnológicas para ampliar a participação social vem crescendo consideravelmente. Dentre essas, pode-se citar as Tecnologias da Informação e Comunicação (TIC). Este artigo apresenta um estudo sobre a utilização de TIC com o objetivo de auxiliar membros de comitês de bacia hidrográfica na tomada de decisão sobre o conjunto de ações para efetivação do enquadramento dos corpos d'água, utilizando como área de estudo a Bacia Hidrográfica do Rio Salitre. Para auxiliar a decisão na seleção do conjunto de ações efetivas foi utilizado o método de análise multicritério Analytic Hierarchy Process (AHP), para a qual foi realizado, dentro da plataforma livre do "facebook", um curso de Ensino à Distância (EAD). A análise dos resultados demonstrou que as discussões entre os membros de um CBH podem se estender para além das reuniões plenárias, que ocorrem com pouca frequência durante o ano, através da ampliação da comunicação online e da criação de fóruns abertos por meio de sites e redes sociais. A aplicação das TIC apresentou algumas vantagens em relação ao processo decisório no âmbito dos CBH's: como maior tempo para discussões e obtenção de consensos; aumento do acesso e intercâmbio de informações e experiências; transferência de informação técnica com maior clareza; e solução de problemas como a falta de mobilidade dos membros dos CBH's.

Palavras Chave: *Enquadramento dos corpos d'água. Método Análise Multicritério. Tecnologia da Informação e Comunicação.*

INTRODUCTION

The degradation of water bodies due to the deterioration of river quality has as its main cause the effluent emissions from homes, industries and agriculture. The rise in population and the expansion of economic activities, according to Zandonadi, Mendonça and Reis (2015), have intensified the conflicts over water use, regarding to quality and quantity of water bodies. In semi-arid regions, where prevails intermittent rivers with insufficient conditions for transport, mixture and natural dilution of effluents, the resolution of conflicts is a constant challenge.

Cech (2013) alerts that poor water quality derived from population growth, from inadequate infrastructure in undeveloped countries and frequent droughts, will produce an intense pressure on water resources in the next 100 years, inevitably increasing the conflicts between states, provinces, territories and countries.

The mediation of conflicts and the construction of consensus between decision-making groups on the choice of actions to prevent and control pollution are necessary in order to solve the problems concerning water use. The construction of consensus is a process of finding the unanimous agreement, which is reached by the effort to meet every part that is interested in the subject (LAWRENCE SUSSKIND, 1999 apud VAN DE KERKHOF, 2006). On the water resources management, the search to find consensus is complex because it involves many people with divergent interests and opinions (CARR; BLÖSCHL; LOUCKS, 2012).

The effective management of water must occur in a decision context that involves public participation. The legitimate participation involves a transparent and democratic process (VAN DE KERKHOF, 2006). Therefore, it is required dialogue and interaction about the information between everyone who is involved.

Carr, Blöschl and Loucks (2012) asserts the importance of training people or groups for equity on the decision-making process in the water resources management.

For Ridder et al. (2005), information performs extraordinary power on the decision process, such as the way that it is transferred to the participants. Thus, according both authors, it is indispensable that information be available on different levels of complexity and depth, adequate to different actors and public involved.

The participatory decision processes are becoming progressively important in the natural resources management (NEWIG et al., 2008), and have increased considerably in several countries (CHARNLEY; ENGELBERT, 2005).

Some conventions and declarations concerning water have recognized public participation as the main key to environmental and water resources management, such as, the European Water Framework Directive (EU); the Federal Clean Water Act from the United States of America (USA); the World Commission on Environment and Development that called attention for the role of the community involvement on the decision making of the United Nations; the Dublin Statement on Water and Sustainable Development that includes the participation as one of its guiding principles; the Rio Declaration on Environment and Development that recognized participation as essential for the environmental management, and the Aarhus Convention on Access to Information, from Europe (CARR; BLÖSCHL; LOUCKS, 2012).

In the EU, the member countries follow the Water Framework Directive (WFD), whose objective is to establish and guarantee water quality in physical, chemical, as in ecological character (EUROPEAN UNION, 2000). Under the WFD, every country has the freedom to develop and deepen their systems of participation, and the population is informed and consulted concerning the Watershed Management Plans (CORREIA, 2005). By the public participation and the investment in programs to eliminate pollutant loads, the EU has achieved satisfactory results on the restoration of their watercourses (MACEDO; CALLISTO; MAGALHÃES, 2011).

In Brazil, the decisions referring to water management occur in the jurisdictions that integrate the National Water Resources Management System (BRASIL, 1997). From these jurisdictions, the Watershed Committee (CBH) is the consultative and institutional deliberative body, integrated by different parts concerning the watershed (public power, civil society and users), in order to assure that the decision process is democratic and representative for society.

Among the CBH's attributions, according to the National Water Resources Policy (PNRH), include: to promote the debate about questions relating to water resources; to arbitrate, in first administrative instance, the conflicts regarding to water resources; to approve and monitor the execution of the Water Resources Plan of the watershed; to propose to the National Council and to the State Water Resources Board the accumulation, derivation, catchment and low expressive emissions, for purposes of exemption from compulsory grant of water use rights, according to their domains; to establish charging mechanisms on the water use and to suggest the values to be charged; to establish criteria and to promote the apportionment of costs regarding to the structures of multiple use, of mutual interest or collective (BRASIL, 1997).

Beyond those attributions, according to the National Water Resources Council Resolution (CNRH) nº 91/2008, the execution program of the framework of the water bodies must be approved by the WC and the CONAMA Resolution 357/2005 (BRASIL, 2005)sets that the priority actions of prevention, control and recovery of the water quality of the watershed must be in consonance with the progressive targets established by the respective WC in their Water Resources Plan, or in the execution framework program.

According to the National Water Agency (ANA, 2012), in Brazil, considering the watersheds under the States' domain, a few obtained progresses on the implementation of the water bodies framework instrument, having more development on the watersheds under the domain of the Federal Government. Some factors initiated this scenario, such as, not knowing this instrument, methodological difficulties for its implementation (COSTA; CONEJO, 2009), lack of improvement on the technical and legislative areas for its application and, consequently, supporting the committees (BRITES, 2010).

The procedures to implement the framework of water

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bodies in classes are described in the CNRH Resolution nº 91/2008, which institutes: diagnosis; prognosis; proposition of water quality targets and execution program or action plan.

The water quality targets are defined by the watershed stakeholders, according to the present and future uses in every river segment. The action plan, aiming to meet these targets in a progressive way, from the intermediate steps to reaching the final objective of water quality, must be submitted to the approval of the watershed committee. Thus, the effective participation of the stakeholders presents as a great challenge to the water quality management of water bodies.

The choice for the best alternative or set of strategic actions to be implemented in the watershed must be accomplished through a decision process, with the involvement of the Watershed Committee members. However, failures are common in decision processes that involve multiple stakeholders. Some of these failures are associated to the lack of information and transparency on the decision processes, as well as loss of confidence among the members that induced them to assume long-term commitment. Therefore, the access of information and the training of the watershed committee members are essential prerequisites to develop the necessary abilities for their effective participation on the collective decision-making.

In order to take decisions, the members of a CBH need to have knowledge about the object and the objectives of the decision. Besides knowledge, the members need time to mature and mediate eventual conflicts of interest and, finally, obtain consensus.

In this sense, the use of technological tools to expand social participation on the decision processes has been increasing considerably. Among those, it is possible to mention the Information and Communication Technologies (ICTs).

ICT is understood as all technological resources that intervene on the informational and communicative processes of society. The consolidation of computers and the popularization of the Internet subsidized the growth of the use of these technologies (CASTELLS, 2003).

The European Environmental Agency/ EEA (2014) presents some study cases, with EU countries, that obtained success on the application of different methodologies that help the public participation on the water resources management. The main tools that were used in these studies include the creation of websites; the use of radio and television broadcasts; workshops; online communication; the creation of cognitive maps; interviews with people involved; informal short-term work groups, conferences and meetings (EEA, 2014).

This present study used the ICTs aiming to increase the participation of the CBH members on the decision process concerning the control and reduction of pollutants in their water bodies, to facilitate and to simplify the communication between the watershed committee members and to assure the exchange of information and knowledge efficiently, in order to make the process more transparent and consistent.

Given the above, this paper presents a study about the use of ICTs as supporting tool for the framework of water bodies, for the purpose of helping the members of a watershed committee on the decision-making about the selection of the best alternative to integrate the execution program.

MATERIALS AND METHODS

The procedure adopted in this study follows the steps of the water bodies framework defined by the National Water Resources Council (BRASIL, 2008), emphasizing its last stage, the Execution Program. On the following items, it is presented the structure of decision process concerning the selection of management actions, by the CBH members, to integrate the Framework Execution Program.

Study area

The study was applied in the Salitre River Watershed (BHS) (Figure 1), located in semi-arid Bahia. This watershed was elected because it has a structured watershed committee, also because it concentrates, in its territory, many of the typical issues of semi-arid regions from northeastern Brazil, for example, the enormous water scarcity and the occurrence of a large number of conflicts derived from intensive water use in agriculture, and in continuation of previous research (MEDEIROS, 2003; MEDEIROS et al., 2009; OLIVEIRA; CAMPOS; MEDEIROS, 2010; SILVA, 2011; DAMASCENO, 2013; PESSOA, 2013) that helped on the production of knowledge about the area, the community and their organizations.

The Salitre River emerges on the county of Morro do Chapéu – BA and disembogues into the São Francisco River near the county of Juazeiro – BA, passing by nine counties: Campo Formoso, Jacobina, Juazeiro, Miguel Calmon, Mirangaba, Morro do Chapéu, Ourolândia, Umburanas, Várzea Nova.

The Salitre River watershed has approximately 14 (fourteen) tributaries considering its banks, right and left, being practically all intermittent. The biggest discharge contribution comes from the Pacuí River, located near the fluviometric station of Abreus (in the county of Juazeiro). The Pacuí River presents an average discharge of 0,25m^3/s connecting to the 218,9 Km extension of the Salitre River, measuring from its headwaters.

The BHS is geographically located in a tropical semi-arid area, having a quite irregular distribution of rainfall, being influenced by cold fronts associated to low atmospheric pressures. It is totally inserted in the Drought Polygon in the territory of Bahia, located in one of the regions of conflicts related to the water resources, mainly because it is an intermittent river.

The major problem regarding water scarcity present in this region is not only related to low rainfall rates, high evaporation rates and high salinity content, but also to high pollution levels and to the indiscriminate use of water and soil (MEDEIROS, 2003). The shapefiles for the construction of maps were obtained from the National Water Agency (ANA) database and from the Brazilian Institute of Geography and Statistics (IBGE) database.

It is worth mentioning that the BHS has not been framed yet and that this study case limits to propose the framing for the main river, hypothetically.

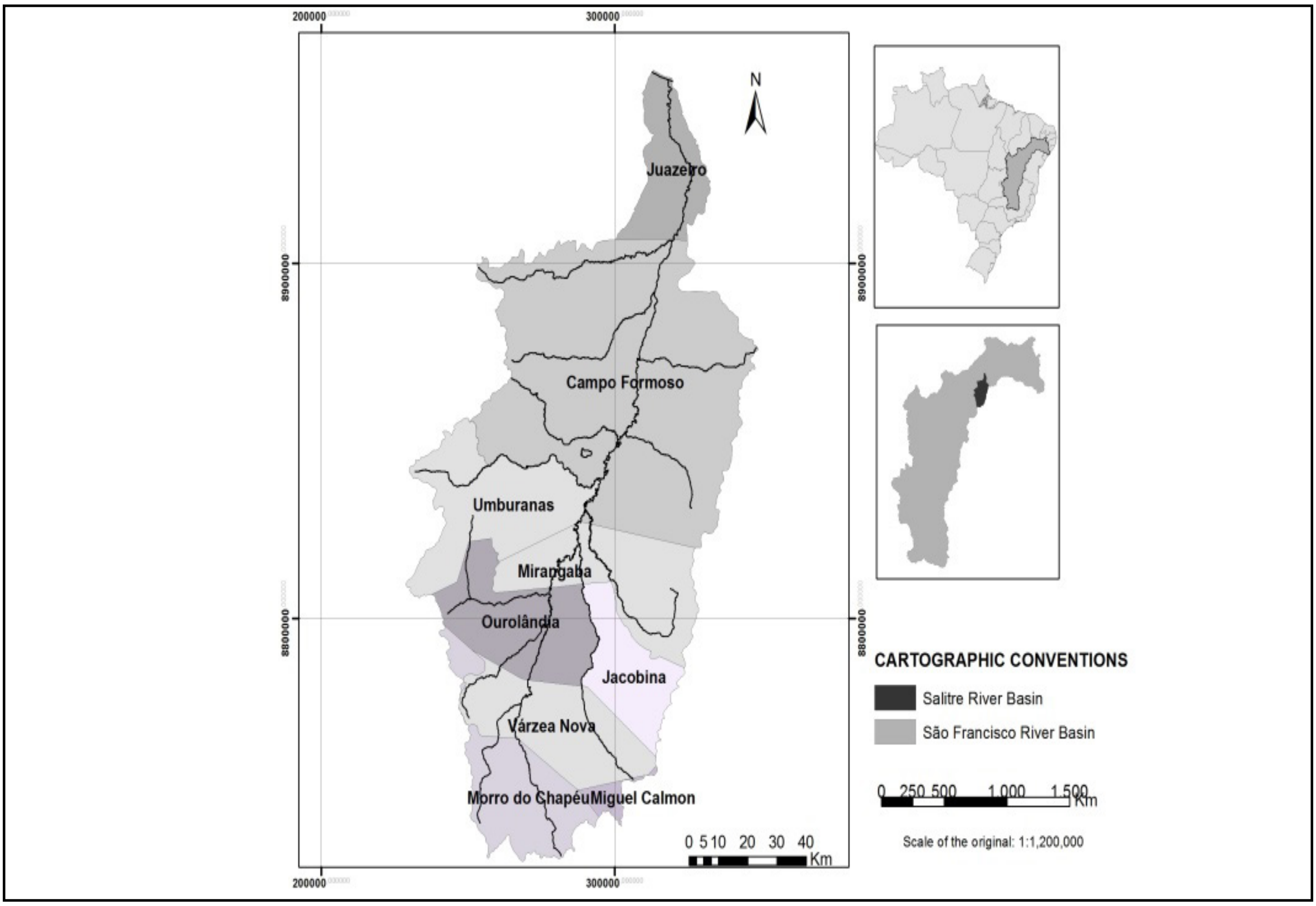

Figure 1 - Salitre River Watershed in Bahia, Brazil

Definition of the progressive targets and the end goal for the water quality

Initially, it was made the data collection on the watershed characteristics, including pollution sources and water uses (both current uses as the desired for the population).

Socioeconomic and environmental characterization

The counties where the BHS is located present different social and economic conditions; that is due to an uneven development process and low investments on infrastructure and on basic sanitation services. About the economic scenario, the counties of this watershed have as supporting economic activities: irrigated agriculture, mining, bovine livestock and subsistence farming. The watershed doesn't have big industries in it. The main economic activity along the watershed is the irrigated agriculture, being shared in permanent and temporary crops. The most used irrigation method is the furrow, being it an outdated technology that causes a considerable waste of water.

Main pollution sources

The data collection on the main pollution sources obtained from previous studies developed in the Salitre watershed presents: solid waste; sewage; mining; agro-pastoral activities; washing up of clothes and household utensils on the bank of the river. The issue on the sewage is a critical problem along the entire watershed. In the counties of Várzea Nova, Mirangaba, Miguel Calmon, the prefectures are responsible for the implementation of the sewage collection network, but, from the systems already implanted, only a few part of the population is attended.

Water uses

The main uses of water identified were: watering animals, primary contact recreation and irrigation. Human supply is the one that least uses the water from Salitre River. Most of the main districts uses water sources from neighboring watersheds and the other towns use rainwater harvesting systems or consume water provided by water tank trucks (MEDEIROS et al., 2009).

Dividing the river in segments -

The division of the segments was developed following the recommendations described on the CNRH Resolution nº 91/2008, where it presents in its Art. 2 that "the process of framing can determine different classes by a segment or by a portion of the same water body, that corresponds to the requirements to be met or kept according to the conditions and the quality patterns associated to them".

As figure 2 shows, the main river was divided into three segments. The first one comprises the segment from the river headwaters to the Ouro Branco dam, in Ourolândia. The second segment proceeds from that dam to the river confluence

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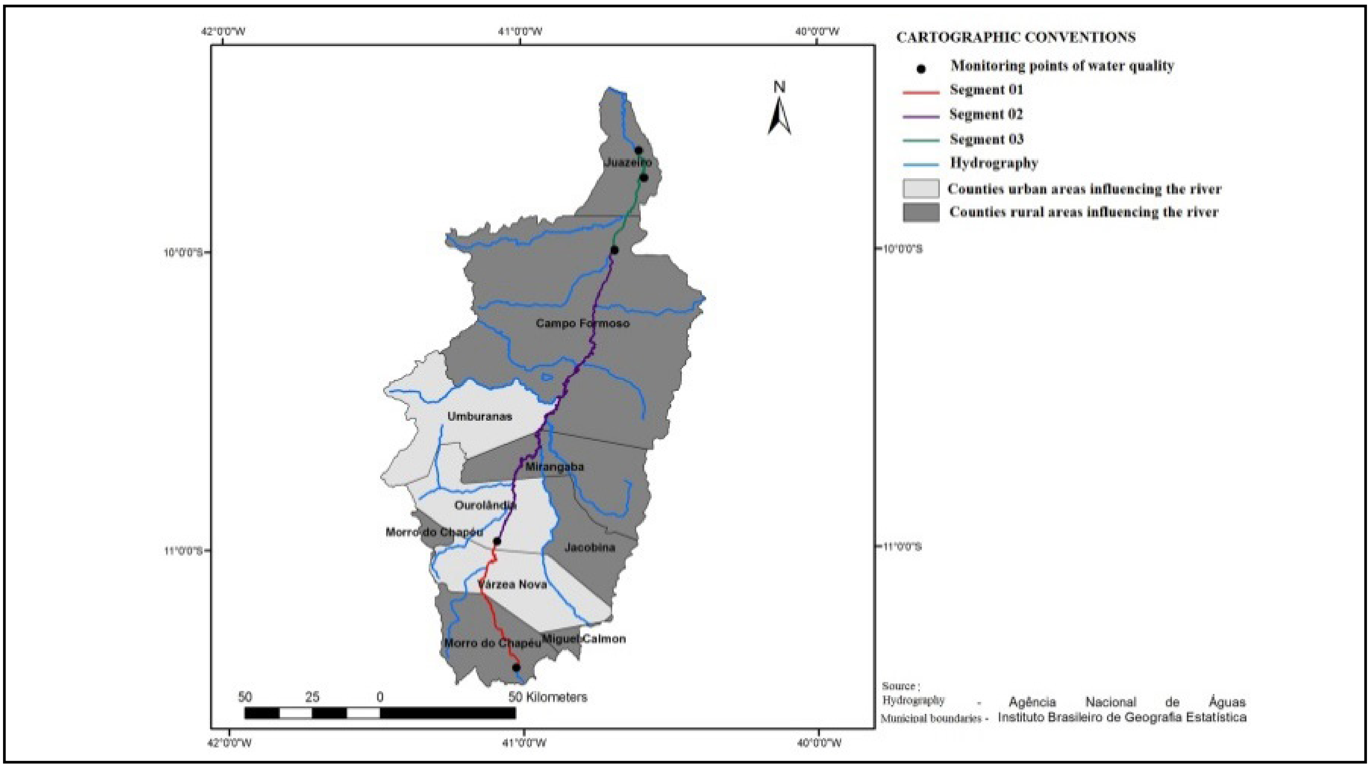

Figure 2 - Division of the Salitre River in segments

with Pacuí River, in Campo Formoso, being it the tributary of highest discharge contribution for the Salitre River. The last segment follows that confluence to the county of Junco, near the river mouth, in Juazeiro.

The counties of Várzea Nova (Segment 01), Umburanas and Ourolândia (Segment 02) have their urban areas influencing the Salitre River, the others counties have their rural areas influencing the river. The limits of the segments are marked by sampling points of water quality.

The classification on the condition of the current water quality was obtained comparing the values for the water quality parameters observed at the sampling points, with the reference values defined by the CONAMA Resolution 357/2005 (BRASIL, 2005) for those respective parameters. On this classification the following parameters were used: Biochemical Oxygen Demand (BOD); Dissolved Oxygen (DO); Nitrogen and its fractions (Nitrite, Nitrate, Ammoniacal and Organic) and Fecal Coliforms (FC).

The representative data for water quality of every segment were obtained through two sampling campaigns conducted one in a dry period (October) and the other in a wet period (June). The sampling points are presented on table 1 and are illustrated on figure 2.

The classification for the water quality condition was defined for every parameter individually, considering the conditions for fresh water and brackish water in function of the characteristics of the semi-arid region. The final classification for each segment was defined for the dry period, adopting the worst water quality class in function of the parameters analyzed. It was considered the most critical situation in terms of water quantity and quality for this classification.

Table 1 - Geographic coordinates of the water quality sampling points in the Salitre River

Water sampling points	Coordinates
P1 (Morro do Chapéu)	S 11°24’02” W 41° 09’20”
P2 (upstream Ourolândia Dam)	S 10°58’35” W 41° 05’13”
P3 (Abreus)	S 10°00’08” W 40° 41’05”
P4 (Alegre/Juazeiro)	S 9°45’36” W 40° 35’04”
P5 (Junco/Juazeiro)	S 9°40’08” W 40° 36’02”

The definition of the standard class (desired condition) was obtained from studies by Medeiros (2007), where there had been identified, besides the most frequent uses on the watershed (irrigation, watering animals and primary contact recreation), least frequent uses (human consumption). According to the CONAMA Resolution 357/2005 (BRASIL, 2005), the framing of water bodies must comply with the most restrictive uses, which in this case is human consumption, thus, the desired water quality class must be 2 or 3, at least, for fresh water condition, and class 1 for brackish water condition. Table 2 exhibits the current and the desired conditions of water for the three segments of the Salitre River.

Table 2 - Current and desired classification for the Salitre River

Segments	Current condition		Desired condition	
	Fresh water	Brackish water	Fresh water	Brackish water
Segment 01	4	3	2	1
Segment 02	4	3	2	1
Segment 03	3	2	2	1

Structuring of the decision process

The structuring of the decision process involves the knowledge of the objective of decision, the variables (criteria, subcriteria and alternatives), and actors (analyst, facilitator and decision maker) involved in the process.

Defining the objective of decision

Objective is the target or the purpose that is desired to achieve. The establishment and judgment of the criteria and alternatives aim to reach the objective that was established on the decision process and this element represents the highest level of hierarchy. Once changed the objective of the decision, it begins a new decision process.

For this study area two objectives were considered:

- Objective of decision 1: To select the collective wastewater treatment system in order to reduce pollution and improve water quality in the river.

- Objetive of decision 2: To select the individual system (decentralized) for wastewater treatment and the best alternative for efficient water use in agriculture in order to reduce pollution and improve water quality in the river.

Objective 1 aims for actions on sewage in urban areas of the counties, and objective 2 is aimed for rural areas of the counties, for actions on the sewage structure and also on the soil management in agriculture.

Definition of actors

The decision makers are the actors who are involved the most with the decision process. The decision makers are members of the watershed committee and are responsible for the choice of management actions to integrate the execution process of the framework of water bodies.

Definition of alternatives

The alternatives are a set of management actions to control pollution in each segment of the river; they are defined subjectively, according to the physical, social, environmental and economic characteristics of the watershed.

The management actions (alternatives) were determined according to the problems identified during the diagnosis, considering that they were associated to the pollutant sources. From the study area characteristics, forward alternatives were formulated for basic sanitation (wastewater treatment processes) and for agriculture (better efficiency on the water use in agriculture), being these recurring problems on the majority of watersheds of Brazil. To select alternatives, available solutions in the literature and meetings with experts on the subject were considered.

Thus, the alternatives were divided into two groups, as it is presented on table 3. The first group is composed by the management actions directed to the counties with urban areas that have been identified to have influence on the water body. The second group is integrated by actions directed to the counties with rural areas that have been identified to have influence on the water body.

Table 3 - Actions to control and reduce pollution

Group 1: Centralized actions of wastewater treatment	**Alternative 1:** UASB Reactor + Constructed wetlands.
	Alternative 2: UASB Reactor + Polishing ponds in series.
	Alternative 3: Primary Facultative pond + Maturation Pond in series.
Group 2: Decentralized actions of wastewater treatment + Actions of efficient use of water in agriculture	**Alternative 1:** Septic tank + Anaerobic Filter + Intermittent Sand Filter / Proper Management of irrigation + Educational Campaigns.
	Alternative 2: Septic tank + Anaerobic Filter + Slow infiltration / Use of more efficient irrigation systems and substitution of the less efficient irrigation systems.
	Alternative 3: Septic tank + Anaerobic Filter / Technical support and orientation to farmers program + Incentivizing farmers to cultivate crops that demand a less amount of water.

Table 4 - Rainfall and Weather Monitoring Stations used on the hydrological modeling

Station		Coordinates	
Name/Code	Type	Latitude	Longitude
Mirangaba (1040033)	Rainfall	10°57'11"	40° 34' 23"
Olho d'água (1040034)	Rainfall	10°41'55"	40° 36' 00"
Taquarendi (1138028)	Rainfall	10° 53' 31"	40°41' 08"
Abreus (1040028)	Rainfall	10°06' 00"	40° 41'00"
Lajes (1040036)	Rainfall	10° 11' 07"	40° 57' 31"
Ourolândia (1041013)	Rainfall	10° 58' 57"	41° 05' 17"
Delfino (1041015)	Rainfall	10° 27' 15"	41° 12' 22"
Tombador Araújo (1140040)	Rainfall	11°10' 01"	40° 40' 09"
Abreus (47900000)	Fluviometric	10°00' 37"	40°41' 43"
Petrolina (940031)	Weather	09°23' 00"	40°29' 00"
Jacobina (1140013)	Weather	11°11' 00"	40°298 00"
Morro do Chapéu (1141003)	Weather	11°33' 00"	41°13' 00"

Fonte: ANA (2013)

To evaluate the performance of the structural actions proposed to control pollution, it was decided to use simulation modeling for pollution load reduction. Thus, the SMAP rainfall-discharge model (LOPES, 1999) and the QUAL-UFMG water quality model (VON SPERLING, 2007) were used. The monitoring stations, rainfall and/or weather, used for the hydrological modeling are exhibited on table 4, and the parameters applied on the water quality modeling were BOD; DO; thermotolerant coliforms; Nitrogen and its fractions. The simulations were developed for all structural actions of wastewater treatment, represented by the alternatives on table 4, considering 100%

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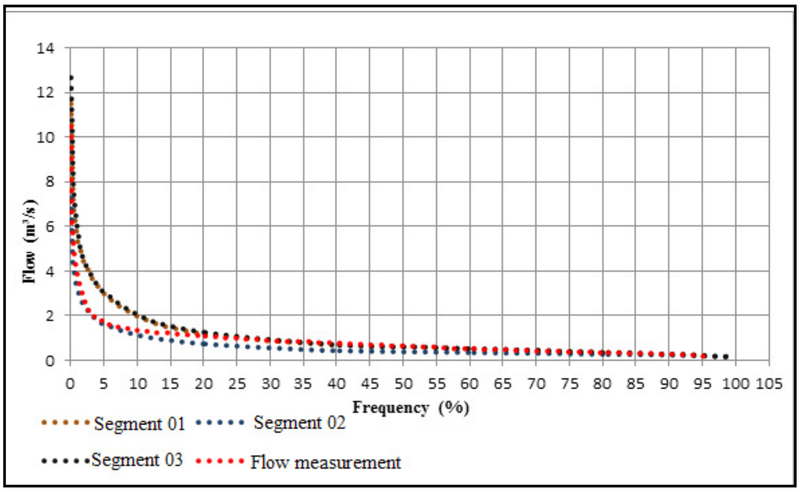

Figure 3 – Flow duration curve for the three segments of the Salitre River

of population coverage.

The reference discharges were found through the Flow Duration Curve (Figure 3) by the Q95 (95% of discharge duration) method, from the hydrologic simulation and they were used on the water quality modeling: 0.28 m^3/s, 0.18 m^3/s and 0.3 m^3/s, for segments 01, 02 and 03, respectively.

Definition of criteria for selecting the alternatives

The criteria have to be able to evaluate every alternative proposed. As the alternatives were divided in two groups, the selection of criteria followed the same principles, so, they were divided in two groups.

- Criteria to evaluate the alternatives of Group 1:

It was listed a set of criteria from literature (CAMPOS, 2011; GÓMEZ-LÓPEZ et al., 2009; JORDÃO; PESSÔA, 2009; VON SPERLING, 2005), covering basic sanitation on the following aspects: environmental, social, technical and economic. Posteriorly, consultations with experts were done on basic sanitation to help to rank the criteria in order of importance, attributing a score from 0 to 100, as presented on table 5.

Table 5 - Criteria to evaluate the alternatives of Group 1

Criteria	Description	Score
Efficiency on reducing pathogen load	Performance of a determined treatment on removing pathogens. Expressed in percentage.	**44,63**
Efficiency on reducing nutrients	Performance of a determined treatment on removing nutrients. Expressed in percentage.	**43,0**
Efficiency on reducing organic load	Performance of a determined treatment on removing organic load. Expressed in percentage.	**41,0**
Cost of operation and maintenance	Costs for functioning and maintenance of the implanted system. Expressed in monetary value per inhabitant year (R$/inhab.year).	**32,13**
Cost of implantation	Financial resources needed to implant a determined wastewater treatment. Expressed in monetary value per inhabitant (R$/inhab).	**28,7**
Demand by area	Area needed to implant treatment system. Expressed in $m^2/$inhab.	**28,65**
Generated waste	Sludge volume generated by the treatment system. Expressed in L/inhab.year.	**26,4**

To evaluate the alternatives, it was chosen the criteria that obtained the five best scores by the experts, from the hierarchy constructed on table 5.

- <u>Criteria to evaluate Group 2</u>: For this group of alternatives, the criteria selected were grounded on economic, environmental and technical aspects, defined on the study by Silva (2011) and are presented on table 6. The hierarchy was not determined on these criteria once all were used on this study.

Table 6 - Criteria to evaluate the alternatives of Group 2

Criteria	Description
Water quality	It indicates how much each alternative can contribute to improve the quality of the water.
Soil conservation	It indicates the level of contribution of the alternative for the conservation of the soil.
Profitability or economic viability	It corresponds to an analysis of the economic viability on implanting the alternative.
Technical/operational feasibility	It takes into account the functionality and the facility on operating the alternative.

Source: Silva (2011)

To qualify each criterion presented on table 6, ordinal qualitative categories that facilitate the evaluation of alternatives were used. The ordinal categories have a scale which varies from 1 to 5: Very low (1); Low (2); Intermediate (3); High(4); Very high (5) (SILVA, 2011).

Decision process on the selection of management actions

After identifying the management actions and simulating the reduction of pollutant loads, a selection to define the best alternative was made for every segment of the river based on the needs of each segment to reduce pollution sources. Therefore, the Analytic Hierarchy Process (AHP), developed by Thomas L. Saaty, in the mid-1970s (SAATY, 2003), was used to support the decision. The AHP was utilized to obtain a hierarchy for the alternatives in light of the decisions made by the participants in the process. Its application was conducted using surveys.

In order that the members of the Salitre River Watershed Committee (CBHS) could achieve the best decision on choosing the management actions, it was necessary before, to provide information about the current diagnostic of the river, and about the instrument of framework for the water bodies. Being provided with information, the CBHS members would have a better and comprehensive understanding about all the decision process in question. Therefore, Information and Communication Technologies (ICTs) were used through the method of Distance Learning (DL) done with the aid of social networks.

The use of DL had as main objective to enable the CBHS members to participate on the decision process about the action plan for the effectuation of the framework; making them conscious of their roles and of the stages of the process, enabling the access to information and communication.

The training had as its theme: "Management actions for pollution control on watersheds" and it was conducted through the free platform "facebook". The selection of this platform took into account its great expansion and acceptation worldwide as a social net, promoting its use as a means of access and sharing of information in an educational process of water management.

The DL course lasted two months and it was split into four modules according to the themes of interest aiming the comprehension about the framing of water bodies. Each module was composed by a video lesson, a tutorial (supporting material) and an evaluation activity. The videos were posted on the social network "YouTube" and the link was generated and inserted in the course's platform (Table 7).

Table 7 - DL course modules

Module	Themes discussed
01: Framework of water bodies	Procedures for the framework and the participation of the CBH in its stages. Video:https://www.youtube.com/watch?v=VeYxyBkyvGw
02: Basic sanitation – Wastewater treatment processes	Wastewater collection, transport, treatment and final disposal. Centralized and decentralized processes of wastewater treatment. Video:https://www.youtube.com/watch?v=Ie4A1oUF4l8
03: Efficient use of water in agriculture	Alternatives to improve water use efficiency in agriculture. Video:https://www.youtube.com/watch?v=sPF-iwNRiEY
04: Aid on decision-making - Multicriteria Analysis Methods	Decision process; Elements of the decision-making process; AHP Multicriteria Analysis Method. Video:https://www.youtube.com/watch?v=IVg-Jwj2c5mc

All the courseware was constructed in a simple language, respecting the differences on the levels of degree of the CBHS members, using in its structure several illustrations, figures, maps, short texts from authors on the field of knowledge in question and many flowcharts.

Initially, an invitation was sent to the CBHS members via e-mail and that was called to attention by phone. After confirmation from the interested members about joining the DL course, an invitation was sent via the platform "facebook". Lastly, having all participants integrated to the platform, the online lessons were started.

After the training, every CBHS member, that was participating in the DL course, when finishing it they answered a survey and got a certificate of participation (attendance over 75%). All the surveys received were tabbed and transformed into input data of the matrices that integrate the Software of the AHP "Expert Choice" method for the simulation on the multicriteria decision analysis and obtaining data. figure 4 ilustrates the methodology stages of this study.

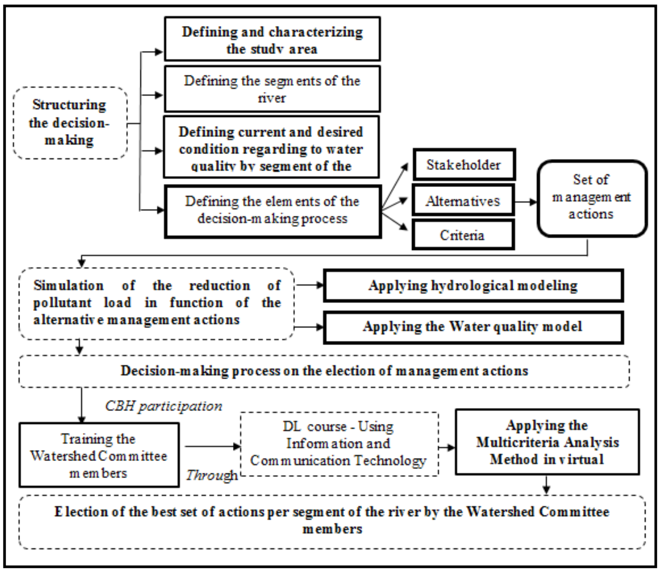

Figure 4 - Methodology stages

RESULTS AND DISCUSSION

Execution program for the framing of water bodies

The execution program is built based on the intended uses of water bodies relating to the proposed framework. For this research, it was only considered the proposition of actions and the verification of attending the targeted class.

By using mathematical modeling it was possible to simulate the actions relative to wastewater treatment, aiming to ascertain the river behavior after the release of generated effluents. Therefore, alternative actions were determined for each segment of the river.

Relation of the alternatives per segment of the river

- Segments 01 and 02 of the Salitre River (Applying the alternatives from Group 01): The alternatives defined for these segments of the river are directed to the centralized processes of

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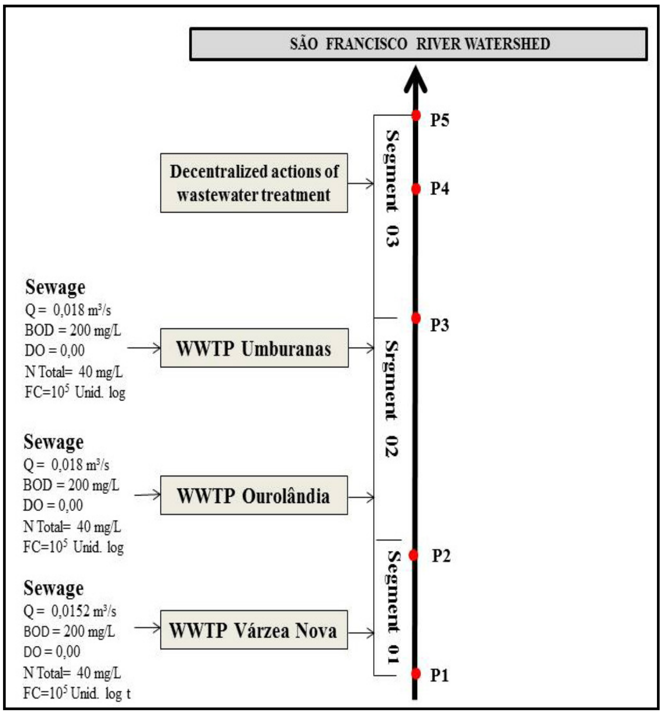

Figure 5 - Linear diagram of the Salitre River Watershed
Observation: (P1, P2, P3, P4 and P5 = Monitoring points of water quality).

wastewater treatment. Segment 01 contemplates the implantation of a Wastewater Treatment Plant (WWTP) located in the county of Várzea Nova, and segment 02 contemplates the implantation of two WWTPs, one in the county of Ourolândia, and the other one in the county of Umburanas, as it is shown on figure 5.

All the other counties that are part in these two segments have adopted individual (decentralized) wastewater treatment systems, due to its influence on rural areas. For these counties, a new decision process was not constructed, once the alternatives to be selected for them can correspond to the same ones elected for segment 03 of the river (also characteristics of rural areas).

The centralized treatments of wastewater were selected aiming simplicity in operating them, minimizing energy consumption and other inputs, minimizing generated waste, minimizing the costs with the implantation and maximizing the efficiency on removing pollutants.

- Segment 03 of the Salitre River (Applying the alternatives from Group 02): Differently from the other two segments, segment 03 excels because it has rural areas of the counties directly influencing the Salitre River. This segment is characterized by having a great influence from agriculture and by the deficiency on the wastewater systems. Due to its specificities, the priority management actions proposed for this segment match with decentralized processes of wastewater treatment, because it is a rural area and some actions of efficient use of water in agriculture, once the waters of Salitre River are used in a deregulated way in irrigation.

Simulation on the reduction of pollutant load

The simulations were made based on the efficiency of each treatment proposed for the reduction of pollutants and the reach of the targeted water quality class. The results were compared to the release patterns from the CONAMA Resolution 430/2011 (BRASIL, 2011).

Wastewater discharges in water bodies from inefficient wastewater treatment systems can cause negative effects on aquatic ecosystems and on riverine communities.

According to the simulations conducted in the study area with the wastewater treatment systems, only the treatments that did not release their effluents in the river course were able to achieve the desired quality that was targeted. The discharge of effluents from Wastewater Treatment Plants (WWTP), even being developed accordingly the standards from the CONAMA Resolution 430/2011 (BRASIL, 2011), tends to cause a great rise on pollutants concentration in the water body. The simulations results are typical for intermittent rivers, as in the study case.

In total, 9 (nine) simulations were done, three for each segment of the river. Table 8 shows the simulations results for segment 01, considering the first group of alternatives (centralized actions on wastewater treatment), for fresh water condition.

Table 8 - Definition of parameters extension within each class of quality for Segment 01 (Fresh water)

Alternatives	Class	BOD	DO	Coliforms	NTotal	Resulting Class
1	01	0,00	94,85	0,86	100,00	4
	02	0,00	4,72	13,30	0,00	
	03	33,48	0,43	0,00	0,00	
	04	**66,52**	0,00	**85,93**	0,00	
2	01	0,00	94,85	58,37	100,00	4
	02	0,00	4,72	41,63	0,00	
	03	30,47	0,43	0,00	0,00	
	04	**69,53**	0,00	0,00	0,00	
3	01	0,00	94,85	58,37	100,00	4
	02	0,00	4,72	41,63	0,00	
	03	27,90	0,43	0,00	0,00	
	04	**72,10**	0,00	0,00	0,00	

From table 8, it is possible to notice that none of the defined treatments for this segment results on desirable quality conditions for the population, satisfactory standards for human consumption. Segment 02 obtained similar behavior as segment 01, and the same group of alternatives was simulated.

On the above, it is recommended the use of individual wastewater treatment systems with high power for reducing pollutants (in this study case, it corresponds to alternatives 1 and 2 from Group 2: Septic tank + Anaerobic filter + Intermittent sand filter; Septic tank + Anaerobic filter + Slow infiltration, respectively), and centralized wastewater systems, on condition that the final effluent doesn't reach the river course, or that the generated effluents can be treated for agricultural reuse, considering how large areas of this activity affect the watershed in study.

By the simulations conducted for the Salitre River, this study corroborates with other studies such as Formigoni et al. (2011), Medeiros (2003) and Teixeira (2009), concerning the creation of an "Intermittent class" to fill the blank in the current legislation and direct more clearly the existing peculiarities on intermittent rivers that deserve specific attention from the managers and all society.

Application of Information and Communication Technologies (ICTs)

The proposal of the DL course, before it was started, was presented in reunion to the Baiano Watershed Committee Forum and to the Environmental and Water Resources Institute (INEMA). The divulgation of the course objectified to reach the highest number of the CBHS members possible.

In order to be able to expand the propagation, by sending the invitation for the CBHS Executive Secretary, via e-mail, a request was made for the members to forward the invitation to their respective members.

Regarding to the participants' schooling level, it varied from fundamental level (this level of education corresponds from the first to the ninth grade in the USA) to high education level. The BHS, mostly, has rural characteristics, so, some participants, for example, the representative of the Maroons, even having an active page on the platform of "Facebook", couldn't follow the course activities, mainly because of limitations on accessing the internet.

The structure of the DL course was divided in three stages, releasing two modules per stage and lasty releasing surveys referent to the application of the AHP method. A deadline of seven days was established per module for the students to study the subject and to hand in their activities. Although some participants had delivered their activities after the deadline, they still continued participating in the course since they could follow its development and finish the modules.

The DL course started having 49 people, whereas 29 people concluded the first module, 28 people finished the second module and 26 people concluded modules 03 and 04. The participants that didn't finish the modules meeting the deadlines and were not able to follow the progress of the course, they were disconnected from the platform.

All the doubts the participants had were clarified along the course dynamically through online communication and shared messages on the page of the platform.

It was verified a great interest from the majority of the participants concerning the subjects addressed. Figure 6 presents the performance from the course modules activities. In general, it was noticed that the participants got a good result.

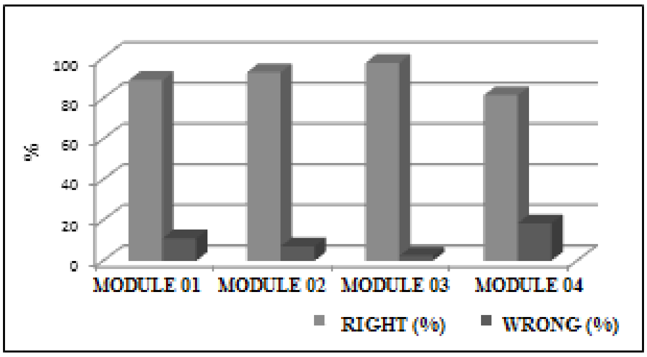

Figure 6 - Performance of the course modules activities

Regarding to the use of the platform of "Facebook" as a means to enable the watershed committee members, the outcome was a percentage of acceptance of 99.8% from the participants. Using this platform brought considerable advantages on the dissemination of information, such as: ease of communication along the students, fast support and exchange of information; ease of providing (uploading) the courseware; more control of all participants and ease of developing the discussion forums. The biggest disadvantage found on using this platform refers to difficulties found by some participants on downloading the courseware, in this case, the students preferred to receive the files via e-mail.

The platform of "Facebook" is increasingly present on the everyday of people's lives, being used to various purposes, from a social network to a means of divulgation and expanding information. Several pages created in this platform are utilized to publicize environmental campaigns, like some CBH that have nets on this platform, for example the São Francisco River Watershed Committee, the Contas River (BA) and the Recôncavo Sul (BA).

It is possible to realize from the exposed results that many times, the use of ICTs, directed to watershed committee members, is restricted mostly because of the access to internet which is still limited for some rural areas located in the watershed, being the biggest limitation the expansion of these technologies.

Comparing the results of this study with the work presented by the European Environmental Agency/EEA (2014), it is possible to infer that in both cases, the access and dissemination of information can promote open and transparent discussions within a decision-making group, improving trust among participants, leading to a more efficient process.

Application of the AHP Multicriteria Analysis Method

The AHP method was applied twice, one in order to select the alternatives correspondent to segments 01 and 02 united and the other to select the alternatives relative to segment 03 of the river. Aiming to attribute a value of relative importance for the alternatives, a supporting material was provided to the participants in which was contained the information necessary for the analysis of each alternative by criteria. The final classification is indicated on table 9.

Table 9 - Priority of alternatives

Segments of the Salitre River	Alternatives	Final Classification (%)
Segments 01 and 02 (Group 1 of alternatives)	1	30,0 (3rd)
	2	30,6 (2nd)
	3	39,3 (1st)
Segment 03 (Group 2 of alternatives)	1	46,0 (1st)
	2	31,5 (2nd)
	3	22,6 (3rd)

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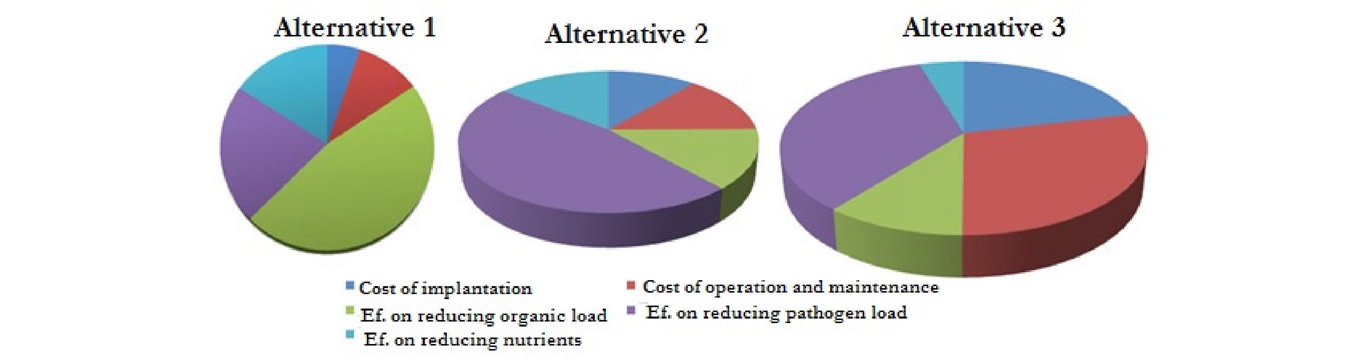

Figure 7 - Influence of criteria on the analysis of priority for the alternatives of segments 01 and 02

Analysis for Segments 01 and 02 of the Salitre River

According to table 8, among the alternatives presented, alternative 3 (Primary facultative ponds + Maturation ponds in series) was the most preferred by the decision makers with a percentage of 39.3%, followed by alternative 2 (UASB Reactor + Polishing pond) with 30.6% and alternative 1 (UASB Reactor + Wetlands) with 30.0%.

Among the analyzed criteria, the most preferred by the decision makers was the "efficiency on reducing pathogens" (27.0%) and the least preferred was "efficiency on reducing nutrients" (15.1%).

It is worth highlighting that the alternatives that had the most efficient wastewater treatment systems were the ones that were the most pointed out by the decision makers, regardless of being the most expensive.

Figure 7 presents the contributions of each criterion on determining the priority of alternatives. It is possible to notice that Alternative 1 (UASB Reactor + Wetlands), the o criterion "efficiency on reducing organic load" obtained the highest score, followed by the criterion "efficiency on reducing pathogens", whereas this last one was the criterion with the highest score for both Alternative 2 (UASB Reactor + Polishing pond) and Alternative 3 (Primary facultative ponds + Maturation ponds in series).

Analysis for Segment 03 of the Salitre River

For this segment, "Septic tank + Anaerobic Filter + Intermitent Sand Filter/Proper management of irrigation + Educational campaigns" obtained the highest score (46%) among the proposed alternatives.

Alternative 3 composed for agriculture by the technical supporting program for farmers and the encouragement to farmers to cultivate a variety of crops that demand a less amount of water, are items very important for segment 03 of the river, once current crops in the region demand a great quantity of water and are less resistant to the water deficit, so, applying this alternative, besides reducing water consumption, it might increase production. However, the wastewater treatment system associated to this option has low efficiency on removing pollutants. In function of that, alternative 3 was placed in the last position among the alternatives, with 22.6%.

The proposed alternatives for this segment of the river are combined in some way; there are actions on basic sanitation field followed by actions on agriculture. The unique combination of these two fields (sanitation + agriculture) led to problems among the decision makers relating to the rank of the alternatives, considering that different arrangements of alternatives could promote a final hierarchy different from the result that was found. Meaning that if alternative 3 presented a decentralized wastewater treatment system of higher efficiency, the rank of the alternatives could be altered by preference of the decision makers.

Regarding to the criteria, those that obtained the highest score by the decision makers were "Soil conservation" with 35.3%, and "Water quality" with 32.8%. The criterion "operational technical feasibility" got the lowest score (13.3%). According figure 8, the criterion that presented the highest influence on the evaluation of scores of the alternatives were soil conservation and water quality and the one that presented the lowest influence was operational technical feasibility.

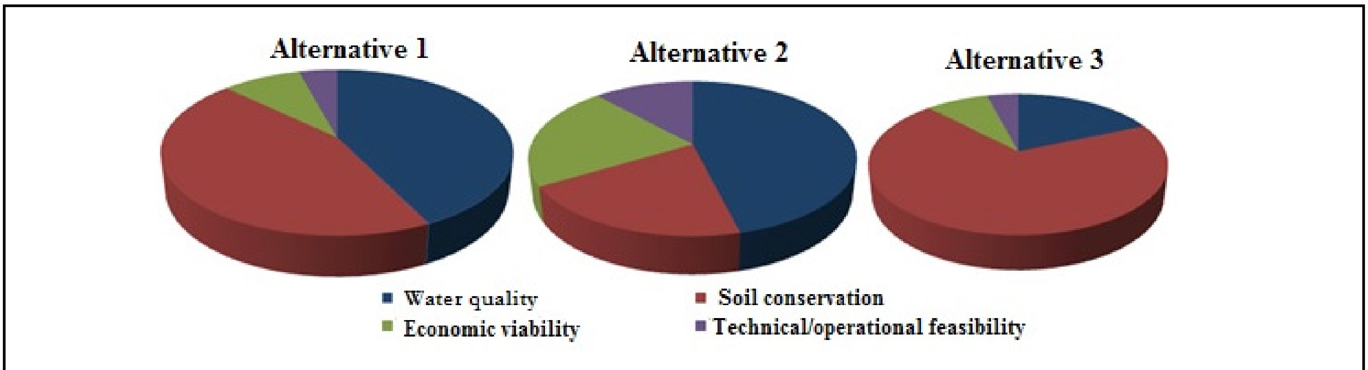

Figure 8 - Influence of criteria on the analysis of priority for the alternatives of segments 03

CONCLUSION

This study took the initiative to present the utility of Information and Communication Technologies (ICTs) within the CBH's decision processes, through the management instrument of framework of water bodies. The ICTs were used by means of a learning process, apprenticeship and distance training, DL, via the social network "facebook", broadly used worldwide. In this study, it is important to address that this approach, the use of ICTs, was developed in a punctual way, however, the training process of the CBH members must be continuous considering the turnover of its representatives.

On the management instrument of framework of water bodies, the CBH members hold important decision-making role on their choice of the action plan to be implemented on the watershed. The definition of these actions is a great challenge, mainly because they must respect the local specificities and be feasible on the economic, environmental and technical aspects. Therefore, it is necessary that the member of a committee have access to information clearly, have time to understand all the process and knowledge about the actions to be defined, to thereby be able to make a decision more carefully and critically. For this to occur, it is necessary to expand the means of communication and information of the CBH, including the use of ICTs.

The use of ICTs presented some advantages and limitations along the process. Within the main advantages, there are: more time to discuss and obtain consensus; increasing access and exchange of information and experiences; transferring technical information more clearly; knowledge on the whole complex decision-making system and solving problems, like the inability to travel by the CBH members. Among the main limitations, there are: restriction to access internet in some rural areas from the watershed and lack of mediation of conflicts on the decision process.

Associated with the use of ICTs, some methods were used to aid on the decision, being, multicriteria analysis method and qualitative and quantitative mathematical models for water bodies, important tools very used on developing some management instruments from the PBRH, for example the granting and the framing of water bodies. Though these tools hold a technical structure, they can be worked with the CBH members since their information be translated to a simpler language that meets the different levels of degree present on these institutional bodies.

The discussions between the members of a watershed committee may extend beyond the plenary meetings that happen not very often throughout the year, by expanding online communication and creating open forums via sites and social networks.

Digital information systems and online communication structures as interactive tools and social media are evolving rapidly across the world. Tendencies are that, with the Internet universalization, public participation progresses more and more on the use of these technologies in different areas of knowledge, being it political, socioeconomic or environmental; primarily because society is living in the so called "Digital Age". Using these technologies in a proper way, for example, a means of training watershed committee members, sharing of information and amplifying the time of discussion beyond the plenary meetings tend to conceive a breakthrough on the water resources management field.

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Contribuição dos autores

Yvonilde Dantas Pinto Medeiros: Seleção da bacia hidrográfica de estudo; construção das etapas do enquadramento dos corpos d'água na área de estudo; seleção de ações de gestão para redução da poluição em bacias hidrográficas; e construção do processo decisório.

Ilce Marília Dantas Pinto de Freitas: Auxílio na aplicação do método de análise multicritério Analytic Hierarchy Process (AHP) e do software "Expert Choice"; e auxílio na construção dos questionários.

Cássia Juliana Fernandes Torres: Modelagem hidrológica e de qualidade da água; auxílio na seleção de ações de gestão para redução da poluição; aplicação da Tecnologia da Informação e Comunicação (TIC) e dos questionários, acompanhamento do curso de capacitação mediante o comitê de bacia; e auxílio no processo decisório.

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