Patrícia Andressa de Ávila[1a]; Luiz Otávio Moras Filho[2a+]; Nathália de Paiva Mendonça[2b]; Luís Antônio Coimbra Borges[2c]; Lucas Rezende Gomide[2d]; Fausto Weimar Acerbi Júnior[2e]

RELEVANCE OF STRATEGIC ENVIRONMENTAL ASSESSMENT TO RIO GRANDE BASIN MANAGEMENT

HIGHLIGHTS

52.5% of Rio Grande basin in Minas Gerais was classified as good preservation condition.

Results indicate the need for effective measures for Rio Grande basin conservation.

Strategic Environmental Assessment (SEA) is a useful process to watershed management.

More comprehensive studies involving SEA should be developed in Rio Grande basin.

ABSTRACT

This research aims to identify the vulnerabilities of Rio Grande basin in Minas Gerais state as well as to investigate, through technical, legal, social, and governmental aspects, the relevance of SEA as an environmental tool for the conservation and preservation of watersheds. Rio Grande basin evaluation was performed by using this following database: soil classes, land use classification, water quality index, and economic ecological index. It was performed multi-criteria decision analysis based on analytic hierarchy process methodology. 52.5% of the studied area was classified as "good" preservation condition. Alto Grande (GD1), Mortes/Jacaré (GD2) and Furnas (GD3) units did not contain significant percentages of their areas corresponding to the preservation class "very good". In the studied area, 34.51% was classified as "medium" preservation condition, thus indicating the need for effective measures for the river basin conservation. These findings highlight the potential importance of including the SEA in the decision-making process for plans, policies and programs related to the integrated management of water resources.

+Correspondence:
jlomf22@gmail.com

[1] University of Sao Paulo, Piracicaba, São Paulo, Brazil - ORCID: 0000-0002-1130-112X[a]
[2] Federal University of Lavras, Lavras, Minas Gerais, Brazil - ORCID: 0000-0002-0906-5295[a], 0000-0002-7659-7371[b], 0000-0003-0344-5008[c], 0000-0002-4781-0428[d], 0000-0002-9553-0148[e]

INTRODUCTION

The uncontrolled and irresponsible use of water, and the lack of regulations in Brazilian legal system, has resulted in a scarcity of this resource. Due these circumstances, it is necessary to develop efficient actions to control and to improve the quantity and quality of water (Milaré, 2014), and the Strategic Environmental Assessment (SEA) has been described as a useful tool for water resources management (King and Smith, 2016; Coelho et al., 2017).

SEA is a systematic process used to assess the environmental consequences of proposed policies, plans or programs in their early stages, considering their social and economic impacts throughout the policy's application (Sadler and Verheem, 1996). The main objective of the SEA is to protect the environment and encourage sustainability (Therivel, 2010). Some countries, such as the United States, the Netherlands and Australia, have required SEA by law, or established SEA by administrative orders, as has occurred in Canada, Denmark and Hong Kong (Glasson et al., 2011). In Brazil, SEA is a voluntary process that is not regulated by law, but it has been applied to specific initiatives that require external financing of infrastructure projects (Santos and Souza, 2011) or government attempts to discuss the subject through the Ministries of Environment and Planning.

Sánchez (2017) has argued that there is considerable scope for using the SEA across all governmental levels and territorial scales in Brazil, because this strategic process may lead to the effective consideration of sustainability development in public and private decisions. Gullón (2005) and Milaré (2014) have stated that SEA may have great potential to identify the social and environmental impacts of projects related to water resources management, and have suggested that this process should primarily be applied in significant interventions in a watershed.

The overlay of techniques in a procedure that involves mapping data has played a central role in many Geographic Information Systems (GIS) applications. These applications, such as multi-criteria decision analysis (MCDA), are at the forefront of advanced analysis. Therivel (2010) has described the MCDA as one of the main methodologies that should be used in the SEA process because it allows several stakeholders with different goals and view to be involved in the process. Furthermore, this method reflects the fact that some issues matter more than others. It also allows for the comparison of alternatives, includes public participation, and can be used with quantitative and qualitative data.

MCDA is an environmental evaluation tool that may be defined as any structured approach used in determining overall preferences among alternative options that accomplish different objectives (Eales et al., 2003). This methodology has frameworks that can range from using very little information to very sophisticated methods based on mathematical programming techniques, which require extensive information (Greening and Bernow, 2004). This type of composite indicators methodology is considered an innovative approach for evaluating sustainable development (Herva and Roca, 2013). In MCDA approaches, values for alternatives are assigned for a number of dimensions, which are multiplied by weights and finally combined to produce a total score (Huang et al., 2011). The analytic hierarchy process (AHP), pioneered by Saaty (2008), is one of the most used methods in solving decision-making problems to assign weights to prioritize alternatives. AHP is based on pairwise comparisons of criteria that ask how much more important one element is than another (Huang et al., 2011), and the strength of the preference between two elements is established on the basis of Saaty's scale from 1 to 9 (Herva and Roca, 2013).

In water resource evaluation, the watershed should be used as the management unit because it indicates all necessary geographical considerations (Brasil, 1997). The watershed is an area defined by hydrological linkages, and optimal management requires the coordinated use of natural resources by all users, as well as the use of water, which depends on physical factors, land use, and actions of social groups that live in the region.

The Rio Grande basin is located in southeast Brazil and includes 393 municipalities in São Paulo and Minas Gerais states, encompassing 7.7 million inhabitants. The region deserves special attention because of its large area, biodiversity, electricity production and population density. Recently, the Institute of Minas Gerais for the Management of Waters (Portuguese acronym, IGAM) has declared water use restrictions due to water scarcity in the state (IGAM, 2015). This situation may compromise water distribution, because the irrigation of crops affects the public water supply, thus resulting in economic, environmental and social damage. In this way, the use of strategic processes that allows the integrated management of watersheds is required to aid in decision-making.

This research aims to identify the vulnerabilities of Rio Grande basin in Minas Gerais state as well as to investigate, through technical, legal, social, and governmental aspects, the relevance of SEA as an environmental tool for the conservation and preservation of watersheds.

MATERIAL AND METHODS

The Rio Grande basin (RGB) is located in southeastern Brazil and is approximately 143,437.79 km^2, with 57,092.36 km^2 (39.80%) located in São Paulo state and 86,345.43 km^2 (60.20%) located in Minas Gerais state. The rural and urban populations include 7.7 million inhabitants and 393 municipalities. The biomes of the watershed area are Cerrado and Atlantic Forest.

The RGB is divided into 14 management units: six units in São Paulo and eight in Minas Gerais. The Rio Grande management units (Portuguese acronym, GD) in Minas Gerais were the focus of this study, which are: Alto Grande (GD1), Mortes/Jacaré (GD2), Furnas (GD3), Verde (GD4), Sapucaí (GD5), Mogi-Guaçu/Pardo (GD6), Médio Grande (GD7) and Baixo Grande (GD8), according Figure 1.

The study area was described through the following database: soil classes, land use classification, water quality index, and economic ecological index.

Soil classes data were sourced from the "Soil Map of Minas Gerais State" published in 2010 and developed through a partnership among Brazilian universities (Federal University of Lavras and Federal University of Viçosa), the Environmental State Foundation (FEAM), the Technological Center Foundation of Minas Gerais (CETEC), and the government of Minas Gerais. The first categorical level (soil order) of the updated version of the Brazilian System of Soil Classification from EMBRAPA (EMBRAPA 2006) was used. Ultisols, Inceptisols, Glei soils (Aquoll and Aquox), Oxisols, Entisols, Alfisols, Plintosols (Plinthic Oxisols) and Outcrop Rocks were identified in the study area.

Land use classification data were provided by the Laboratory of Studies and Projects on Forest Management (Portuguese Acronym, LEMAF), from Federal University of Lavras, as a result of a partnership with the Energy Company of Minas Gerais (CEMIG) for the development of the project "Revitalization of Permanent Preservation Areas in Rio Grande Basin". The classification found areas of agriculture, water, eucalyptus plantations, native vegetation, exposed soil (including urban areas) and veredas (Cerrado wetlands).

The water quality index (WQI) data were provided by IGAM. The institute has 71 monitoring stations in the RGB, which are strategically located in Minas Gerais. The determination of the average value of the WQI for each GD was conducted in three stages and was based on the applied methodology of the Technological Research Institute (IPT, 2008) with some adjustments. First, the annual average of each monitoring station of each GD on the basis of the quarter values of WQI was calculated. Second, the WQI average between 2009 and 2014 for each monitoring station of each GD was estimated. Finally, the average value of WQI for each GD between 2009 and 2014 was calculated. As a result, on the basis of the 2009 to 2014 series, the average value of WQI in each GD was determined.
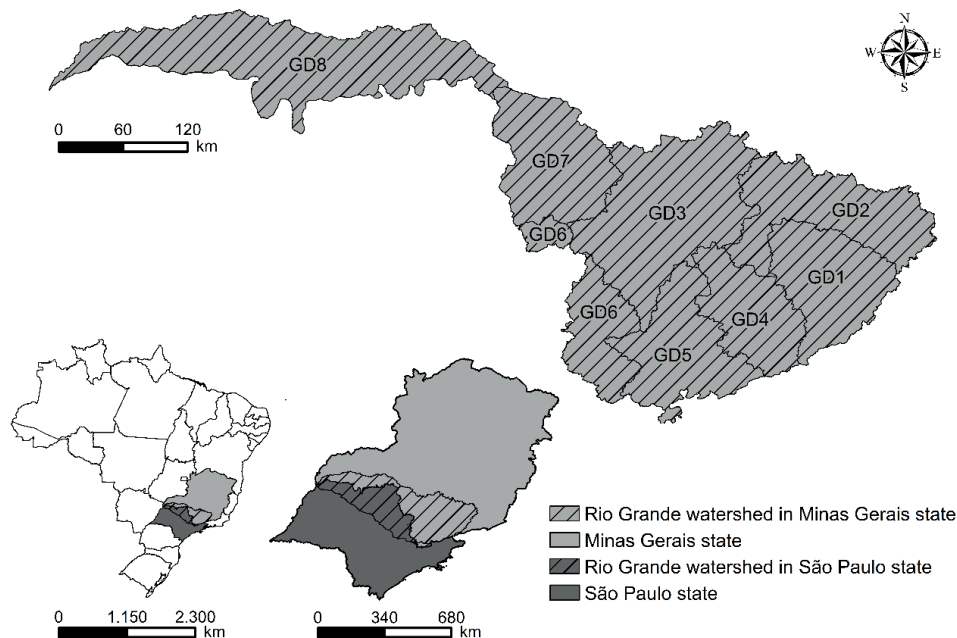

FIGURE 1 Management units of Rio Grande basin in Minas Gerais state.

RELEVANCE OF STRATEGIC ENVIRONMENTAL ASSESSMENT TO RIO GRANDE BASIN MANAGEMENT · CERNE

The economic ecological index (EEI) is based on the combination of several measures of social potential and ecological vulnerability. The EEI is one of the main results of Economic Ecological Zoning (Portuguese acronym, ZEE). The Minas Gerais ZEE was carried out by the Federal University of Lavras in cooperation with the Secretary of the Environment of the State (SEMAD). The results identified six development zones for the EEI in the area of study: AA, AB, BA, BB, CA and CB. AB represents areas with low ecological vulnerability and high social potential, whereas CA describes areas with a high ecological vulnerability and a low social potential.

The factors of land use, soil class, water quality index and economic ecological index were the necessary criteria to characterize watershed suitability according to the most relevant aspects of this study.

The standardization of data allows different units to be made uniform and to be used in the same mathematical model. Each criterion of each factor is quantified to confirm its importance in the decision process (Martins et al., 2014). In this way, each unit of data was classified according to its importance to the watershed conservation in a range of classification, using the comparison table developed by Tomas L. Saaty (1980), which is in a range between "1" and "9". Values closer to "1" represent areas with lower environmental protection, and values closer to "9" represent areas with higher environmental protection (Table 1).

Through the software ArcGIS 10.3.1 (ESRI, 2015), we used additive multicriteria decision analysis to overlap the data proposed by Silva and Zaidan (2004). Grades and weights were added to a decision algorithm (1), where A_{ij} is a raster cell, n is the number of layers, P is the weight of each factor (values between 0 and 1), and N is the grade of each criterion classification in the standardization.

$$A_{ij} = \sum_{k=1}^{n} \left[P_k \cdot N_k \right] \qquad [1]$$

Each factor received a weight of importance according to its relevance to watershed conservation (2). The weights were defined by the pairwise comparison methodology suggested by Saaty (2008) by using AHP, where WC = watershed conservation; LU = land use, weight 0.41; WQI = water quality index, weight 0.3012; SC = soil class, weight 0.1709; and EEI = economic ecological index, weight 0.1178.

$$WC = \left(0.41 \cdot LU \right) + \left(0.3012 \cdot WQI \right) + \left(0.1709 \cdot SC \right) + \left(0.1178 \cdot EEI \right) \qquad [2]$$

TABLE 1 Standardization of soil class, land use, water quality index, and economic ecological index.

Criterion	Classification	Importance in watershed conservation
Soil Class		
Oxisol	9	*High*
Utisol	8	
Alfisol	7	
Inceptisol	6	
Glei soil	5	
Entisol	4	
Plintosol	3	
Outcrop rock	2	Low
Land Use		
Native vegetation	9	High
Water	9	
Vereda	8	
Plantations	6	
Agriculture	5	
Exposed soil	1	Low
Water quality index		
Excellent	9	High
Good	7	
Medium	5	
Poor	3	
Very poor	1	Low
Economic ecological index		
AA	9	High
AB	7	
BA	5	
BB	4	
CA	3	
CB	1	Low

RESULTS

As a result of data overlapping, we obtained a final map of Rio Grande basin in Minas Gerais state showing the combination of the factors of land use, class soil, water quality index and economic ecological index (Figure 2). According to the data standardization performed previously, the classes of preservation were subdivided in a range between "1" and "9", with values closer to "1" indicating areas with lower environmental protection, and values closer to "9" indicating areas with higher environmental protection.

The distribution of percentage area in each preservation class in RGB is presented in Table 2. Although more than 50% of the watershed area was considered "good", 34.51% of the area showed a medium value. This result reveals the necessity of developing prevention and compensation measures for RGB.

TABLE 2 Area (%) of each preservation class in Rio Grande basin, Minas Gerais state.

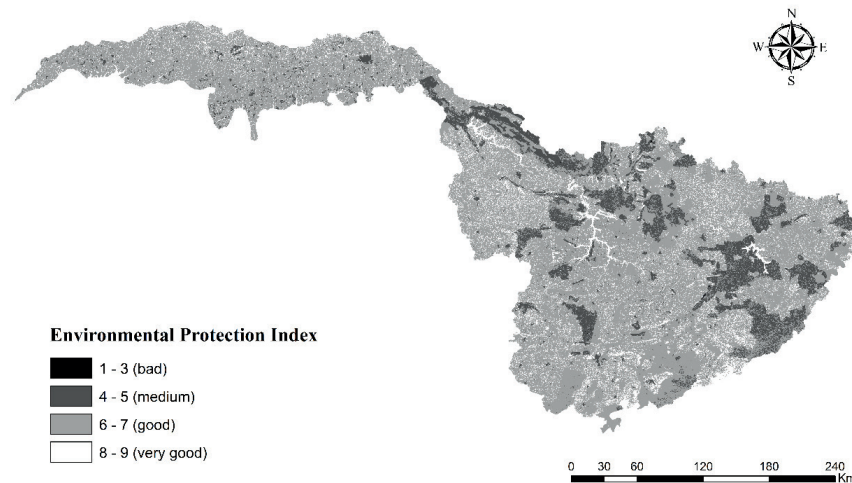| Classes	Preservation conditions	Area (%)
1 - 3	Poor	0.43
4 - 5	Medium	34.51
6 - 7	Good	52.52
8 - 9	Very good	12.56
Total		100.00

FIGURE 2 Combination map of the factors: soil class, land use classification, water quality index and economic ecological index, generated through multi-criteria decision analysis in Rio Grande basin, Minas Gerais state. Values closer to 1 indicate areas with lower environmental protection, and values closer to 9 indicate areas with higher environmental protection.

In Table 3, the percentage area of each preservation class in each management unit is presented separately. The management units GD1, GD2 and GD3 did not contain significant area in the preservation class "very good". In the GD1 management unit, more than 40% of the area was classified as "medium", and 4.23% was classified as "poor". Soil erosion caused by inappropriate soil use is considered one of the main problems in this management unit, which has the lowest municipality human development index of all watersheds (IPT, 2008). Pinto et al. (2009) has studied the water resources of three sub watersheds in this management unit and has found elevated values of fecal coliforms, phosphorus and biochemical oxygen demand (BOD), thus corroborating the proposed classification.

TABLE 3 Area (%) of each preservation class in Rio Grande basin, Minas Gerais state.

Management Unit	Area (%)			
	Poor (1-3)	Medium (4-5)	Good (6-7)	Very Good (8-9)
GD1	4.23	41.86	53.91	0.00
GD2	0.13	30.62	69.25	0.00
GD3	0.73	82.19	17.09	0.00
GD4	0.21	23.17	68.91	7.71
GD5	0.20	22.62	67.92	9.26
GD6	1.81	17.80	56.50	23.89
GD7	0.08	23.05	53.77	23.10
GD8	0.15	21.13	43.99	34.73

In GD3 management unit, more than 80% of the area was classified as "medium". The largest areas of anthropic field (pasture) of RGB are in this management unit (IPT, 2008), which had the lowest water quality index value. Menezes (2008), using the multicriteria methodology, has defined GD3 as a region that should be kept under surveillance, given the presence of pesticides in superficial water. The same author has noted that regions considered by law as permanent preservation areas have been used as agriculture areas in this management unit.

The GD4 and GD5 management units had intermediate values, with approximately 23% of the area classified as "medium", 68% classified as "good", 8% classified as "very good", and approximately 0.20% classified as "poor". In GD6 and GD7, approximately 23% of the area was in the class "very good", and GD8 had 34.73% of its area in this class. Studying the water resources in the municipality of Uberaba in the GD8 region, Noronha (2012) have indicated that water quality is directly related to land use, with agriculture and industrial activities being the main sources of problems related to the studied parameters.

DISCUSSION

Strategic Environmental Assessment applied to the conservation of water resources

The SEA process aims to protect the environment and develop sustainability through several tools (Therivel, 2010). The concept of sustainable development has been linked to water resource management by including economic, environmental and social aspects in the decision process (Gullón, 2005). In this context, SEA has been suggested to be a useful tool for the integrated management of water resources. SEA may contribute to this sector by identifying strong and weak features of environmental questions related to the implementation of programs, plans and policies; finding different options to achieve the desired results; and considering direct and

indirect impacts in the medium- and long-term (Pizella and Souza, 2014).

On the basis of the literature and the present study, the main problems related to environmental issues in Rio Grande basin in Minas Gerais state are: a) need to improve the water quality index values; b) inadequate land use; c) breaches of Brazilian environmental law; d) absence of social participation in the decision-making process; e) problems using water for energy production; f) Leisure activities; and g) need for improving procedures and tools related to water resources management. Teixeira (2008) has suggested that technical, legal, governmental and social aspects should be analyzed to identify opportunities for SEA application.

Technical aspects

The appropriate use of the land is a crucial question that should be considered when making decisions about environmental viability. Tundisi (2003) has explained that the two main sources of pressure on water resources are increase of population and higher urbanization level, resulting in a higher demand for irrigation and food production. These aspects affect the volume and quality of water available in rivers, and consequently affect the watershed. An integrated approach that considers environmental issues in decisions related to land use is required. In Brazil, approximately 53% of native forests are located on private rural property (Soares Filho et al., 2014), thus indicating the importance of compliance with environmental law. Brazilian Forest Code (Law no. 12651/2012) is the main law related to the appropriate management of land use, but its implementation remains challenging.

In this context, the SEA could be used in land use processes by replacing isolated actions with integrated management across several government agencies, thus resulting in higher viability in socioeconomic development and environmental protection. As a result, the SEA process may strengthen the organization of all sectors involved.

Legal aspects

SEA implementation requires an effective system based on environmental law. Laws allow higher flexibility in the SEA process, thus enabling a more appropriate adaptation of strategic actions in the planning context without being limited by specific rules (Therivel, 2010). In Brazil, the National Policy of Water Resources (Portuguese acronym, PNRH), Law no. 9433/1997, defines the watershed as a basic territorial unit in the

implementation of the law (Brasil, 1997). The PNRH is a rare example in which the vertical articulation among policy, plan and program defines the programmatic actions; the programs to achieve the plan's objectives are further composed of sub-programs that give rise to several projects.

In spite of some government efforts to disseminate SEA in the country, Brazil does not have a specific law focused on the application of this process (Pellin et al., 2011). There is still a considerable lack of integration in Brazilian environmental law, thereby resulting in an insufficient approach and insufficient political support. Thus, it is suggested that responsible sectors of water resources conservation have a reference framework of guidelines and procedures related to SEA application, including its relation to other processes, and defining deadlines, responsibilities and legal principles that support this process.

Governance structure

SEA application in the decision-making process requires integration of the institutional structures responsible for water resource management. In Brazil, the Watershed Committees (Portuguese acronym, CBH) are responsible for bringing decisions to the local level and defining the agents that will participate in the development and monitoring of watershed plans (Pizella and Souza, 2014). Owing to these responsibilities of the CBH, SEA might aid in help with the identification of conflicts among the principles that support the water policy in Brazil and the sectoral plans and programs related to water resources, as well as the land use, resulting in the intersectoral communication to reach common objectives.

The sectoral plans, programs and policies are directly related to watershed plans, which thus making effective communication among the national, state and municipality levels essential for making appropriate decisions. SEA may be a useful tool in this process because it allows for better and more integrated consideration of all the possible alternatives of plans, programs and policies in water resource management for medium- and long-term deadlines.

Participation and social control

Participation and social control comprise the less advanced aspect of SEA application in the integrated management of water resources in Brazil. Social participation should be present in the process, mainly in the initial steps, when the relevant factors

and objectives of SEA are identified (Teixeira, 2008). The interaction of the population in the process would allow for different views of the same problem beyond just the technical views, thereby improving dialogue among decision-makers and specialists and allowing the population to reach a common objective (Vicente and Partidario, 2006). Social participation could be carried out effectively through mechanisms such as public consultations, hearings, interviews, seminars, discussions, and thematic working groups (Costa et al., 2009). Social actors have the opportunity to integrate public policy management councils, such as Watershed Committees. Additionally, an appropriate flow of information and collective understanding might enhance the possibilities for collaborative planning and decision-making as well as social network relations (Rozas-Vásquez, 2017).

In this context, it is important that CBH and other environmental government sectors alert citizens in an effective way about the relevance of participating in decisions about water resources, mainly watersheds, including information about the conscious use of water. Social participation during SEA introduces a new viewpoint into the process because it incorporates real information about the consequences of each decision.

CONCLUSIONS

Multicriteria analysis is an appropriate tool to identify priority areas for conservation and preservation of Rio Grande basin. More than 50% of the watershed area is classified as "good", but 34.51% is classified as "medium". The GD1, GD2 and GD3 management units do not contain significant percentages of area corresponding to the preservation class of "very good".

SEA was shown to be useful in the decision-making process of plans, policies and programs related to the integrated management of water resources, mainly through analysis of technical, legal, governmental and social aspects. It is recommended that more comprehensive studies involving SEA should be developed in Rio Grande basin.

ACKNOWLEDGEMENTS

REFERENCES

BRASIL. **Lei n. 9.433**, de 8 de janeiro de 1997. Brasília: Presidência da República, 1997.

COELHO, R. S.; COELHO, P. S.; RAMOS, T. B.; ANTUNES, P. Use of indicators in River Basin Management Planning and Strategic Environmental Assessment processes. **Impact Assessment and Project Appraisal**, p. 01-18, 2017.

EALES R.; SMITH, S.; TWIGGER-ROSS, C.; SHEATE, W.; ÖZDEMIROGLU, E.; FRY, C.; TOMLINSON, P. Integrated Appraisal Methods: R&D Technical Report E2-044/TR. **United Kingdom Environment Agency**, 2003. 115p.

ESRI. **ArcGIS 10.3.1** for Desktop. Environmental Systems Research Institute, 2015.

GLASSON, J.; THERIVEL, R.; CHADWICK, A. Introduction to Environmental Impact Assessment. **Taylor & Francis Group**, 2011. 416 p.

GREENING, L. A.; BERNOW, S. Design of coordinated energy and environmental policies: use of multi-criteria decision-making. **Energy Policy**, v. 32, n. 1, p. 721-735, 2004.

GULLÓN, N. Links between the water framework directive and SEA. In: SHMIDT, M.; JOÃO. E. Implementing strategic environmental assessment. **Springer-Verlag**, 2005. p. 513-522.

HERVA, M.; ROCA, E. Review of combined approaches and multi-criteria analysis for corporate environmental evaluation. **Journal of Cleaner Production**, v. 39, n.1, p. 355-371, 2013.

HUANG, I. B., KEISLER, J., LINKOV, I. Multi-criteria decision analysis in environmental sciences: ten years of applications and trends. **Science of the Total Environment**, v. 409, n. 19, p. 3578-3594, 2011.

IGAM - Instituto Mineiro de Gestão das Águas. **Declaração de situação de escassez hídrica ajuda a racionalizar o uso da água**. 2015. Available at: http://www.agenciaminas.mg.gov.br/noticia/declaracao-de-situacao-de-escassez-hidrica-ajuda-a-racionalizar-o-uso-da-agua. Accessed in: 20 June 2017.

IPT - Instituto de Pesquisas Tecnológicas. Diagnóstico da situação dos recursos hídrico na Bacia Hidrográfica do Rio Grande (BHRG) – SP/MG. 2008. Available at: http://www.grande.cbh.gov.br/_docs/outros/DiagnosticodaSituacaodosRHnoRioGrande.pdf. Accessed in: 20 June 2017.

KING, H.; SMITH, L. Many Rivers to Cross: Evaluating the Benefits and Limitations of Strategic Environmental Assessment for the Koshi River Basin. **Journal of Environmental Assessment Policy and Management**, v. 18, n. 2, p. 01-21, 2016.

MARTINS, F. C. M.; ANDRADE, L. C. R.; CALIJURI, M. L.; BARROS, K. O.; BARRETO, E. M. Multicriteria analysis and geoprocessing for conservation of unpaved roads. **Revista de Ciências Agrárias**, V. 37, N. 2, p. 162-170, 2014.

MENEZES, C. T.; HELLER, L. A method for prioritization of areas for pesticides surveillance on surface waters: a study in Minas Gerais, Brazil. **Water Science and Technology**, v. 57, n. 11, p. 1693-1698, 2008.

MILARÉ, E. **Direito do ambiente**. 9. Ed. Revista dos Tribunais, 2014. 1680 p.

NORONHA, C. V. **Qualidade da água dos reservatórios fio de água de Jaguára,Igarapava e Volta Grande e afluentes, Bacia Hidrográfica do Rio Grande, MG/SP.** 2012. 138 p. Dissertation. Pontifícia Universidade Católica de Minas Gerais, Belo Horizonte.

PELLIN, A.; LEMOS, C. C. de; TACHARD, A.; OLIVEIRA, I. S. D. de; SOUZA, M. P. de. Avaliação ambiental estratégica no Brasil: considerações a respeito do papel das agências multilaterais de desenvolvimento. **Engenharia Sanitaria e Ambiental**, v. 16, n. 1, p. 27-36, 2011.

PINTO, D. B. F.; SILVA, A. M. da; MELO, C. R. de; COELHO, G. Qualidade da água do Ribeirão Lavrinha na região Alto Rio Grande - MG, Brasil. **Ciência e Agrotecnologia**, v. 33, n. 4, p. 1145-1152, 2009.

PIZALLA, D. G.; SOUZA, M. P. de. Avaliação Ambiental Estratégica de Planos de Bacias Hidrográficas. **Engenharia Sanitária e Ambiental**, v. 18, n. 3, p. 243-252, 2013.

ROZAS-VÁSQUEZ, D.; FURST, C.; GENELETTI, D.; MUNOZ, F. Multi-actor involvement for integrating ecosystem services in strategic environmental assessment of spatial plans. **Environmental Impact Assessment Review**, v. 62, p. 135-146, 2017.

SAATY, T. L. Decision making with the analytic hierarchy process. **International journal of services sciences**, v. 1, n. 1, p. 83-98, 2008.

SADLER, B.; VERHEEM, R. **Strategic environmental assessment: status, challenges and future directions**. Ministry of Housing, Spatial Planning and the Environment, 1996. 188 p.

SANCHEZ, L. E. Por que não avança a avaliação ambiental estratégica no Brasil? **Estudos Avançados**, v. 31, n. 89, p. 167-183, 2017.

SANTOS, S. M.; SOUZA, M. P. de. Análise das contribuições potenciais da avaliação ambiental estratégica ao plano energético brasileiro. **Engenharia Sanitária e Ambienta**l, v. 16, n. 4, p. 369-378, 2011.

SILVA, J. X.; ZAIDAN, R. T. **Geoprocessamento e análise ambiental: aplicações**. Bertrand Brasil, 2004. 363 p.

SOARES-FILHO, B.; RAJÃO, R.; MACEDO, M.; CARNEIRO, A.; COSTA, W.; COE, M.; RODRIGUES, H.; ALENCAR, A. **Cracking Brazil's forest code. Science**, v. 344, n. 6182, p. 363-364, 2014.

TEIXEIRA, I. M. V. **O uso da avaliação ambiental estratégica no planejamento da oferta de blocos para a exploração e produção de petróleo e gás no Brasil: uma proposta**. 2008. 288 p. PhD thesis Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Therivel, R. **Strategic environmental assessment in action**. Routledge, 2010. 366 p.

TUNDISI, J. G. **Ciclo hidrológico e gerenciamento integrado**. Ciência e Cultura, v. 55, n. 4, p. 31-33, 2003.

VICENTE, G., PARTIDÁRIO, M. R. SEA–Enhancing communication for better environmental decisions. **Environmental Impact Assessment Review**, v. 26, n. 8, p. 696-706, 2006.