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What do local stakeholders think about the impacts of small hydroelectric plants? Using Q methodology to understand different perspectives

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A B S T R A C T

Researchers, politicians and investors are seeking to develop an agenda related to renewable energy technology and its greatest challenges and opportunities. The present study aims to analyze the perceptions of local stakeholders regarding the social, environmental and economic impacts of small hydroelectric plants. The use of Q Methodology revealed the existence of a range of perceptions among local stakeholders. Essentially, five groups with different perceptions were identified, namely: 'I'm critical', "I see regional benefits', 'I want more results', 'I want social well-being' and 'I weigh all sides'. The article recommends policy-makers should increase transparency and communication regarding the activities related to projects of this nature, in addition to emphasizing the need to review the policies that regulate the energy system.

1. Introduction

Today, finding solutions to the environmental problems faced by humanity is one of the challenges on the sustainable development agenda. Additional challenges involve the interaction of the environment with economic and social development, and the development of alternative energy systems. National renewable energy strategies are necessary to meet these challenges (Kousksou et al., 2015). While the use of renewable energy plays an essential role in the quest for sustainable development, there is uncertainty regarding the way such projects are perceived by the different stakeholders involved (Carrera and Mack, 2010; Chen et al., 2015).

Public reaction, coupled with the political interests of the stakeholders involved, is usually considered a key factor for the implementation – or otherwise – of a renewable energy project (Kaldellis et al., 2012). The perceived economic, environmental and energy impacts will, to a certain extent, determine whether a renewable energy project will be accepted (Stigka et al., 2014).

Del Río and Burguillo (2009) argue that most studies into the socioeconomic impacts and benefits of renewable energy projects, such as that conducted by Kousksou et al. (2015) which considered renewable energy at the national level, are very general. In the literature, there is a marked scarcity of studies that focus on regions, and more specifically the local communities directly affected by such projects. Local analyses are important because the impacts caused at the local level determine, fully or partially, the acceptance of renewable energy projects.

Considering the important role that renewable energy sources play in sustainable development and considering the key role played by local stakeholders in the implementation of such projects, this study aims to analyze the perception of such stakeholders regarding the environmental, social and economic impacts caused by small hydropower plants (SHPs).

Among the wide range of renewable energy sources, the present study has chosen to investigate SHPs for two main reasons. The first concerns the part played by water resources in the Brazilian energy matrix. While globally, the share of renewable energy does not surpass 14%, in Brazil it is 46%, with SHPs accounting for approximately 3.9% of the national hydro-electric matrix (Tiago Filho et al., 2011). The second concerns the argument that much greater circumspection is needed vis-a-vis SHPs than is currently being exercised (Abbasi and Abbasi, 2011). The authors believe that if pitfalls are foreseen before SHPs are put to widespread use, and suitable remedial measures are taken, considerable dissatisfaction and environmental damage can be avoided.

Using Q methodology, we identified five distinct perspectives reflecting local stakeholders´ perceptions regarding the impacts of SHPs. The perspectives were named according to the characteristics identified in each of them: (1) 'I am critical', (2) 'I see regional benefits', (3) 'I want more results', (4) 'I want social well-being' and (5) 'I weigh all sides'.

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The article is structured as follows. First, we review the literature regarding the role of energy in sustainable development, the stakeholders' perceptions and the impacts of renewable energy projects. Following this, we describe how we used Q methodology in our research. In Section 5 the data are presented and analyzed. We then present our results by describing the five perspectives. In the discussion section we highlight the key issues raised in those of perspectives. And, finally, in Section 8, we summarize the research contributions.

2. Energy and sustainable development

Sustainable development aims to achieve a balance between human needs and environmental integrity, a task made more difficult when resources are scarce (Wu, 2013). Inspired by the Brundtland Report, the term 'sustainability tripod' has been proposed to emphasize that economic activities have important social and environmental consequences and each organization must accept its share of responsibility (Elkington, 2004). In addition to the three dimensions of sustainability - social, environmental and economic, inspired by the Brundtland Report, Dincer and Rosen (2005) suggest another dimension: energy and resource sustainability. The authors point out that "renewable energy can play an essential role in sustainable development, in the search for solutions to the current problems involving ecology, economy and development." Energy is also considered the main generator of prosperity and a significant factor in economic development (Kalogirou, 2004).

A variety of natural resources found in the most diverse regions can be used as major sources of renewable and sustainable energy. Such sources are considered complementary in the energy mix policy (Hosseini et al., 2013; Tahseen and Karney, 2016). For Islam et al. (2014), hydroelectric power is one of the most promising sources of energy, since its source is regenerative and ecologically correct. This type of energy has an essential role in the search for clean and renewable sources of energy generation to satisfy a series of human needs (Omer, 2008). The management of water resources, including the provision of safe drinking water and sanitation, ecosystem conservation, disaster mitigation and risk management, has led to the recognition of the role of water as one of the most renewable and cleanest energy sources. Moreover, its potential should be seen as being environmentally sustainable and socially acceptable (Omer, 2008).

However, concern for the environmental and social dimensions related to hydroelectric plants implies more than considering the benefits alone, since the environmental and social integration of such projects is highly complex and possible negative impacts cannot be ignored (Pang et al., 2015). Those potential negative impacts include the disruption of sediment transportation, fish migration, downstream flows, and of estuaries (Abbasi and Abbasi, 2011). Understanding the views of the local community and ensuring people are unaffected should be considered goals in SHP projects, thus avoiding foreseeable impacts (Siciliano et al., 2015). The main criticism concerns the lack of comprehensive analyses of the effects of SHPs, which limits the opportunity, not only to recognize their potential impacts, but also to counter any perceived disregard for sustainable development (Pang et al., 2015; Zhang et al., 2016). The growing demand for energy and the need for lasting economic growth raise concerns about energy efficiency, which is a complex set of social interactions involving various stakeholders (Christopoulos et al., 2016). Given that organizations relate with a wide range of interest groups, there is a need to understand the stakeholders' perceptions of those impacts.

3. The Stakeholders' perspectives and the impacts of renewable energy projects

According to Steurer et al. (2005), sustainable development can be sought through various means, including the management of stakeholder relations. Therefore, it is necessary to identify the stakeholder groups in order to understand and manage their expectations (Mahmood and Humphrey, 2013). The prerequisites for cooperation among different stakeholder groups include cohesion, the elimination of personal interests, transparency of information and representation, such as through the participation of all the stakeholders in the decision-making process (Zoellner et al., 2008). Decisions related to the use of natural resources may undermine the social well-being of a region if the results are perceived as unfair (Gross, 2007). Therefore, by developing a means of representing the perspectives of the stakeholders it should be possible to broaden these issues, facilitating discussion and supporting critical reflection regarding the rationale behind each position (Raadgever et al., 2008).

Wüstenhagen et al. (2007) pointed out that social acceptance has three interdependent dimensions: (a) socio-political acceptance, which is influenced by technological and political aspects, public opinion, key stakeholders and legislators; (b) market acceptance, influenced by consumer adherence, by investors (and also by consumers as investors), and by the internal aspects of organizations related to the allocation of investments in new technologies and political influence, and (c) community acceptance, which is influenced by how local stakeholders (residents and local authorities) perceive issues related to procedural justice, distributive justice, and trust. At the same time as public and private entities involved in the energy sector are invited to develop sustainable, economically vital and socially acceptable technologies (Stigka et al., 2014), the acceptance or rejection of a project by the local community is known to influence the degree to which that project succeeds or fails to contribute to local sustainability (Del Río and Burguillo, 2009). There is a wide variety of research in the literature on the potential barriers to renewable energy projects on how the public perceives and is affected by them (Stigka et al., 2014; Kousksou et al., 2015; Eyre and Baruah, 2015).

According to Del Río and Burguillo (2009), two perspectives must be considered regarding renewable energy deployment, namely: procedural sustainability and substantive sustainability. Procedural sustainability aims to emphasize that the opinions and interests of the different stakeholders must be taken into account, since the impacts are perceived differently and those perceptions may influence the acceptance – or otherwise – of the projects. Substantive sustainability refers to the impacts of renewable energy projects regarding the three dimensions of sustainability (economic, social and environmental). Thus, given the objective of analyzing the perception of local stakeholders regarding the social, environmental and economic impacts caused by SHPs, a search was conducted in the literature to identify such impacts. Fig. 1 constitutes the conceptual framework of this study, as it lists the articles found in the literature on the social, environmental and economic impacts of renewable energy projects and their respective authors.

Knowing the priorities of the stakeholders in relation to the multifaceted impacts of hydroelectric dams can offer useful insights for both decision makers and policy makers, when considering the design of strategies capable of meeting the needs of the different stakeholders (Siciliano et al., 2015). Although the literature contains reports on the impacts of SHPs (as shown in Fig. 1), no publication has analyzed the stakeholders' perspectives in relation to such impacts. Del Río and Burguillo (2009) give us a "big picture" showing the contribution of renewable energy sources to the economic and social dimensions of sustainable development, while Kaldellis et al. (2013) and Stigka et al. (2014) investigate the social acceptance of renewable energy projects, not specifically SHPs. Other studies have focused on SHPs, but not from the stakeholders' perspective. For example, Abbasi and Abbasi (2011) examine whether the prevalent belief in the environmental-friendliness of SHPs is really justified and Tsoutsos et al. (2007) describe the procedures involved in the installation and deployment of an SHP. Finally, whereas Arabatzis and Myronidis (2011) and Siciliano et al. (2015) report on communities and residents (local stakeholders) with SHPs, in each case, the focus differs from that of the present study: Siciliano et al. (2015) focus on the social priorities of affected communities and

Potential impacts	Authors
Social	
Social cohesion	Del Río and Burguillo (2009)
Conflicts with the local population and relocation of populations	MME (2013); Sternberg (2008); Evans et al. (2009); Zhang et al. (2016).
Education (training)	Del Río and Burguillo (2009)
Income generation	Arabatzis and Myronidis (2011); Del Río and Burguillo (2009); Jobert et al. (2007); Siciliano et al. (2015)
Job creation	Arabatzis and Myronidis (2011); Del Río and Burguillo (2009); Stigka et al. (2014); Siciliano et al. (2015)
Installation of a leisure area	Arabatzis and Myronidis (2011); Kaldellis et al. (2013)
Use of aquatic infrastructure	Höffken (2014)
Demographic changes	Del Río and Burguillo (2009)
Tourism	Arabatzis and Myronidis (2011); Del Río and Burguillo (2009); Jobert et al. (2007); Siciliano et al. (2015)
Economic	
Variation in the cost of the energy produced	Arabatzis and Myronidis (2011); Kaldellis et al. (2013)
Technological development	Kaldellis et al. (2013)
The diversification of production	Del Río and Burguillo (2009)
Regional and rural development	Arabatzis and Myronidis (2011); Del Río and Burguillo (2009); Kaldellis et al. (2013); Stigka et al. (2014); Tsoutsos et al. (2007); Siciliano et al. (2015)
Environmental	
Control of water supply in rivers	Arabatzis and Myronidis (2011); Kaldellis et al. (2013); Evans et al. (2009)
Deforestation of vegetation	MME (2013); Tsoutsos et al. (2007); Pang et al. (2015)
Waste generation	Arabatzis and Myronidis (2011); Tsoutsos et al. (2007)
Noise generation	Stigka et al. (2014)
Impacts on fauna and flora	Abbasi & Abbasi (2011); MME (2013); Stigka et al. (2014); Tsoutsos et al. (2007); Siciliano et al. (2015)
Carbon free / use renewable sources	Kaldellis et al. (2013); Steinmetz and Sundqvist (2014); Stigka et al. (2014); Siciliano et al. (2015)
Aesthetic changes in the local landscape	Abbasi & Abbasi (2011); Kaldellis et al. (2013); Stigka et al. (2014); Tsoutsos et al. (2007)
Air Pollution / Emissions	Arabatzis and Myronidis (2011); Evans et al. (2009); Stigka et al. (2014); Tsoutsos et al. (2007)
Volume of the flooded areas	Arabatzis and Myronidis (2011); MME (2013); Tsoutsos et al. (2007); Evans et al. (2009)

Fig. 1. Potential impacts of renewable energy projects.

institutional stakeholders/actors, while Arabatzis and Myronidis (2011) focus on the role that SHPs play in regional development. By contrast, the present study investigates the perspectives of local stakeholders regarding the social, environmental and economic impacts (positive and negative) of SHPs.

4. Method

Q methodology was adopted because it offers a mixed method of research in which qualitative data on the perceptions and beliefs are analyzed through factor analysis and interpretive traditions (Brown, 1996; Ramlo and Newman, 2011). Setiawan and Cuppen (2013) emphasize that Q methodology is particularly suitable for the study of social phenomena in which there is considerable debate, conflict and contestation, such as environmental and energy policies, in which analysis of the conflicting issues can help identify the most effective policy solution.

Cuppen et al. (2010) present the key elements that make up Q methodology:

– The Qualitative phase: composed of two steps - Concourse and Q-set.
– The Quantitative phase: composed of three steps - P-Set, Q-Sort and Analysis.

This research was carried out at two SHPs, namely the Da Ilha SHP and Jararaca SHP, both located in the State of Rio Grande do Sul (RS). Data from ANEEL (2014) reveal there are 49 operational SHPs in the state, which together generate 558,293 kW. Another 15 SHPs are currently under construction or awaiting the start of construction. Table 1 presents technical information regarding the investigated SHPs, such as generating capacity and electricity produced. Regarding the resettlement, four families were resettlement at the Da Ilha SHP and nobody had to be relocated due to the construction of the Jararaca SHP.

The local stakeholders are made up of residents and government authorities in the region. It is important to understand these actors because of the power they have to influence decision-making during the licensing phase of the project. Local government authorities are directly impacted because they must be involved throughout the construction of the SHP and in managing taxes. The City Hall is responsible for providing a certificate stating the SHP project is in compliance with the legislation relating to land use and occupation, and identifying the existence of any restrictions. The certificate is a determining condition for the construction of the SHP. The residents are impacted, initially, because of the need for resettlement. The participation (and acceptance) of the residents in public hearings is fundamental. Local stakeholders can prevent project implementation if they refuse to accept the impacts and the compensation offered.

4.1. *The qualitative phase – concourse and Q-set*

A semi-structured interview script was prepared based on the social, environmental and economic impacts identified in the literature (Fig. 1). At least one representative from each stakeholder group involved with the SHPs was sought for the interviews (Fig. 2). Potential interviewees were identified from articles in newspapers and magazines and personal contacts, while the snowball technique was used to expand the sample based on suggestions from the interviewees themselves. According to Vogt (1999), snowball sampling can be defined as "a technique for finding respondents, where a respondent provides the researcher with the name of another respondent, who will provide the

Table 1
Characteristics of the investigated SHPs.
Source: HT Hidrotérmica (2017)

	Installed power	Assured Energy (average)	Capacity Factor	Stage	Reservoir capacity	Reservoir dimension	Land used for construction
Da Ilha SHP	26.00 MW	19.03 MW	73.19%	In commercial operation	16×106 m^3	1.57 km2	284.4 ha
Jararaca SHP	28.00 MW	19.90 MW	71.07%	In commercial operation	93.3×106 m^3	0.72 km2	132.7 ha

name of a third, and so on." The interviews, which were recorded and transcribed, took place between June and October 2015, and lasted approximately 1 h on average. The data were analyzed using the technique proposed by Bardin (2010), the aim being to validate and/or identify new statements regarding the impacts caused by the SHPs. Of the techniques proposed by Bardin (2010), coding and categorization of the registration units have been adopted herein. Coding consists of transforming the raw data from texts into a representation of the contents. Subsequently, this representation is categorized. Categorization consists of classifying the elements according to their similarities and differences, with later regrouping being carried out according to common characteristics. In this research, the previously defined codes are the social, environmental and economic impacts caused by the SHPs in operation.

Following the categorization, the resulting concourse consisted of 47 statements related to the impacts. The concourse aggregates the ideas and opinions on the subject originating from the analysis of the literature and from the interviews with stakeholders (Webler et al., 2009). Those statements were analyzed again and those most found to be relevant defined as the 'Q-set'. Those that portrayed the impacts in the region and were easily perceived by local stakeholders were maintained, while statements that presented overlap, repetition or were especially complex and difficult for the respondents to understand were eliminated. The final Q-set was composed of 26 statements about the social, environmental and economic impacts of SHPs.

The final instrument was validated by two expert researchers on the subject. In addition, the resident who took part in the interviews in the qualitative step validated the understanding of the list of statements. Four other respondents with little knowledge about SHPs (non-specialists) were asked to respond to a test version of the online collection instrument to check if the way in which the statements were presented was comprehensible, as well as the functionality and ease of use the instrument.

4.2. Quantitative phase - P-Set, Q-Sort and analysis

The 'P-Set', which is the set of respondents to the questionnaire, was composed of 29 residents and representatives from the local authorities of the municipalities of Antônio Prado (AP), Nova Roma do Sul (NRS) and Veranópolis (VR). These three towns were selected because they are home to two small hydroelectric plants (SHP da Ilha and SHP Jararaca), which entered operation in April 2008. The SHPs were selected based on the 'operating time' criterion (at least 12 months), to ensure that the impacts caused by the projects have been perceived by the local stakeholders involved.

Each respondent should sort the statements into columns along a continuum (McKeown and Thomas, 1988). One principle of the distribution technique consists in the fact that the items should be compared with each other. The distribution of the statements made by the respondents was collected in person or using an online instrument.

Initially, the participant was asked to read the 26 statements about impacts caused by SHPs and separate them into three groups: a) the statements with which he 'agrees', b) the statements with which he 'disagrees' and c) the statements he considers neutral, ambivalent or of little importance. Subsequently, each respondent should classify the statements from the three groups considering his/her degree of agreement on a scale of -3 to $+3$, according to Fig. 3.

After distributing all the statements, the participants were asked to review the classification and make any changes they deemed necessary to define a distribution that was closer to their point of view. Finally, the interviewees were asked whether they had any additional comments about their perceptions of the social, environmental and economic impacts of SHPs.

The classification obtained from the Q-sort was analyzed using SPSS® software, version 17. The Factor Analysis technique was used with the Main Component Analysis extraction method and Varimax rotation, in which the classifications of the respondents who shared similar perceptions were grouped in a specific factor. First, the reliability of the instrument and the adequacy of the data were calculated. After the factors were defined, the Cronbach's Alpha of each factor was calculated. Once the factor numbers and Q distributions that make up each of these factors were defined, Pearson's correlation test was conducted between the coefficients of the resulting factors (Raadgever et al., 2008). The stronger the correlation between two factors, the greater the similarity between them (Cuppen et al., 2010). Afterwards, the final factorial scores were calculated for each statement, which indicates the average weight attributed by the respondents to each factor (Raadgever et al., 2008). Based on the weighted averages it was possible to distinguish the distinctive and the consensus statements.

5. Data presentation and analysis

The factor analysis of the Q distributions indicates an organization of the respondents' different perceptions. The analysis of the interviews conducted during the qualitative phase and the additional comments collected in the questionnaires were essential for the interpretation of the results of the factor analysis in the studied context.

In the factor analysis, five factors were extracted that explain 59.3% of the total variance of the 26 classifications of the statements. The Cronbach's Alpha of the instrument was 0.79, suggesting its reliability (Hair et al., 2005). The Q distribution in the five factors can be seen in Table 2, in which the higher loads $+0.4$ are presented. It is noteworthy

Stakeholder group	Quantity	Entity/location
Government	2	E1: Representative from the State Secretariat of Mines and Energy of RS E2: Representative from the Electrical Energy Marketing Chamber
Investors and producers of renewable energy	2	E3: *Avir Engenharia* E4: *Toniolo Busnello*
Associations	3	E5: Representative from the Brazilian Association of Clean Energy Generation E6: Representative from the Association to Promote Small Hydroelectric Power Plants of RS E7: Representative from the Energy Group within the Federation of Industries of RS
Local residents and local authorities	2	E8: Mayor of Antônio Prado E9: Resident from the municipality with the SHP

Fig. 2. Interviewees by stakeholder group.

Strongly Disagree	Disagree too much	Partially Disagree	Neutral	Partially Agree	Agree too much	Strongly Agree
2 afirmações	3 afirmações	5 afirmações	6 afirmações	5 afirmações	3 afirmações	2 afirmações
-3	-2	-1	0	1	2	3

Fig. 3. - Distribution of the classification of the 26 affirmations – 'Q-Sort'.

Table 2
Q factor loadings of each respondent.

Respondents	F1	F2	F3	F4	F5
NRS8	0747				
AP6	0.599				
VR3	0.571				
NRS 3	0.569				
NRS 5	0.457				
VR 4	0.454				
NRS 6	0.428				
NRS 1		0.826			
Local Government 1		0.792			
Local Government 2		0.646			
NRS 7		0.634			
AP 1		0.615			
AP 2		0.537			
Local Government 4			0.824		
Local Government 3			0.791		
AP 3			0.762		
VR 5			0.539		
NRS 2			0.482		
NRS 9			−0.400		
NRS 4				0.688	
AP 4				0.675	
VR 2				0.629	
AP 7				0.556	
VR 7					0.739
VR 6					0.683
AP 5					0.604
VR 8					0.561
VR 1					0.437
Cronbach' Alpha	**0.683**	**0.796**	**0.625**	**0.768**	**0.71**

Note. Extraction Method: Principal Component Analysis | Rotation Method: Varimax with Kaiser Normalization | Rotation converged in 23 iterations.

that values above +0.3 are considered acceptable (MacDonald et al., 2015) and that each factor must have at least two representatives (Brown et al., 2007).

The distribution of the respondents in most of the factors was very heterogeneous, with representatives from all the towns included in the study. Factors 2 and 3 include local government representatives. This heterogeneity of the respondents from different towns may indicate the perceptions regarding the social, environmental and social impacts of SHPs in the region are shared, regardless of the locality in which the respondent resides.

Based on the mean scores of the divergent and consensus statements in each factor extracted in the factor analysis, it was possible to understand the meaning of each factor. A factor is considered divergent when, for example, a factorial score is negative for one factor and positive for the other factors for a given statement (MacDonald et al., 2015). Table 3 shows the results of the calculation of the final factorial scores for each statement.

6. Results

The five factors identified represent the different perspectives identified among the local stakeholders. Below, Fig. 4 was elaborated based on the final factorial scores of each statement (Table 2) and the classifications of the categories of the social, environmental and economic dimensions (Fig. 1). Positive (+) or negative (-) signs in each dimension indicate whether the statement was evaluated positively or negatively by the respondents.

The '**I am critical**' perspective is related to the group of respondents who focus their concerns on the negative environmental impacts caused by SHPs in the region, and find no positive impact. This group perceives a decrease in the quantity of fish in the region, believes the analyzed SHPs have caused many negative environmental impacts and that the local flora has not been completely replanted by the investors. A highly critical position is perceived in relation to the SHPs, not only in highlighting the negative environmental aspects but also in the suggestion of more effective alternative options from their point of view.

> There are other ways to generate energy with lower environmental impacts, such as wind and solar power, producing no impact […] solar energy should be prioritized, there's a lack of investment and government interest (Resident VR3).

> Incentives for self-production are lacking, the cost of building the dam is much higher than encouraging self-production (Resident AP6).

Despite the predominating environmental concern, this group is also critical regarding the social impacts: "Many people were in a bad way financially after the construction finished, because the workers returned to their cities of origin" (Resident AP6); "My mother got depressed, there were many fights, assaults, prostitution during the construction. I am against the installation of new SHPs" (Resident NRS5). In addition, these respondents also disagreed that the Ilha and Jararaca SHPs contributed towards reducing the price of electricity tariffs in the region.

The second perspective, '**I see regional benefits**', brings together respondents with more developmentalist characteristics. For them, the installation of the Ilha and Jararaca SHPs has contributed to regional development, in terms of increasing socioeconomic development, generating new jobs for the population and increasing the number of cities with access to electricity. In contrast to the others, the respondents in this perspective believed new companies were attracted to the region. In this group, the respondents do not perceive negative impacts on the local landscape or an increased risk of flooding after the installation of the SHPs. The quote from the resident NRS1 exemplifies this view: "people are against it, because of the environment, but they do not look at the economic issue, but they have to do it within the law and the environmental parameters".

Apparently, this group and the "I am critical" group have opposing perceptions regarding the SHPs: while the former only perceives negative impacts, the latter predominantly perceives positive impacts.

Table 3
Q statements and the factor arrays (Q factor scores).

Statements	F1	F2	F3	F4	F5
1. The installation of the Ilha and Jararaca SHPs has contributed to the increase in tourism and hotel and food activities in the region	−1	1	0	0	0
2. The installation of the Ilha and Jararaca SHPs has led to the creation of new access roads in the region.	0	0	2	−1	1
3. The installation of the Ilha and Jararaca SHPs has contributed to reduce the number of electric power outages in the region.	0	0	2	−1	0
4. The installation of the Ilha and Jararaca SHPs has contributed to the raise socioeconomic development in the region.	0	3	1	2	1
5. The installation of the Ilha and Jararaca SHPs has contributed to the reduction in the price of electricity tariffs paid by the families in the region.	−2	−2	−1	0	−2
6. The installation of the Ilha and Jararaca SHPs has attracted new companies to the region.	−1	1	−1	0	0
7. The price of the land near the dams has increased with the installation of the Ilha and Jararaca SHPs,	0	0	−1	0	2
8. The taxes generated by the Ilha and Jararaca SHPs are invested in improving the well-being of the population of the municipalities.	1	1	0	2	1
9. Only the areas and people located near the dams are benefited by the presence of SHPs in the region.	0	−1	−1	1	1
10. The Ilha and Jararaca SHPs constantly generate new jobs for the population of the region.	−1	2	0	1	−1
11. The Ilha and Jararaca SHPs mainly employ people from the region in their operation and maintenance activities.	0	1	−1	1	−1
12. The people who work in the Ilha and Jararaca SHPs receive higher salaries than other workers in the region.	1	1	−1	0	1
13. The investors in the Ilha and Jararaca SHPs and/or local government offer training courses so that the people of the region can work in the activities related to SHPs.	0	0	−1	−1	−1
14. The people who had to be relocated so that the Ilha and Jararaca SHPs could be built received a fair amount of compensation for their lands.	1	0	1	3	2
15. There are leisure areas (e.g. camping sites, barbecue areas, parks, etc.) open to the public near the Ilha and Jararaca SHPs.	−1	0	−2	−2	0
16. There are incentives for the external public to visit the Ilha and Jararaca SHPs facilities to show them in operation.	−1	−2	0	−3	0
17. The increase in the quality of life of the residents of the region is related to the installation of the Ilha and Jararaca SHPs.	−1	1	1	−1	0
18. The number of towns and villages in the region with access to electricity increased due to the installation of the Ilha and Jararaca SHPs,	1	2	0	0	−1
19. In recent years there has been a significant improvement in the environmental preservation of the area surrounding the dams of the Ilha and Jararaca SHPs.	0	0	1	1	2
20. The vegetation impacted by the construction of the Ilha and Jararaca SHP dams was completely replanted by the SHP investors.	−1	0	0	2	1
21. The quality and supply of water in the region benefitted from the installation of the Ilha and Jararaca SHPs.	−1	0	−1	−1	−2
22. The risk of flooding in the region increased after the construction of the Ilha and Jararaca SHPs.	−1	−2	−2	−1	−1
23. The construction of the dams for the Ilha and Jararaca SHPs caused a decrease in the amount of fish in the region.	2	−1	1	−1	−1
24. The construction of the Ilha and Jararaca SHPs caused a decrease in the number of animal species that inhabit the region.	1	−1	1	0	−2
25. The construction of the Ilha and Jararaca SHPs damaged the local landscape.	1	−2	1	1	−1
26. The Ilha and Jararaca SHPs cause many negative impacts in the environment.	2	−1	1	−1	0

Dimensions	I'm critical	I see regional benefits	I want more results	I want social well-being	I weigh all sides
Environmental (+)		Water supply (22) Landscape (25)	Water supply (22)	Flora and Fauna (20)	Licensing and Environmental Programs (19) Flora and Fauna (24)
Social (+)		Employment and income (10) Access to energy (18)	Local demands (2)		Employment and income (7)
Economic (+)		Economic Diversification (4 and 6)	Energy quality (3)	Taxes (8) Compensation (14) Economic diversification (4)	Compensation (14)
Environmental (-)	Flora and Fauna (10 and 23) Licensing and Environmental Programs (26)				Water supply (21)
Social (-)		Places to visit (16)	Places to visit (15) Employment and income (7 and 12)	Places to visit (15 and 16) Local demands (2)	Access to energy (18)
Economic (-)	Price of energy (5)	Price of energy (5)		Energy quality (3)	Price of energy (5)

Fig. 4. Schematic representation of the results by categories and factors.

The negative impacts identified by this group refer to the lack of incentives for tourism and energy prices.

The respondents included in the "**I want more results'** perspective perceive there has been development in the regional infrastructure, through the creation of new access roads and the reduction in the number of electrical power outages. However, while recognizing the benefits related to the local infrastructure, these respondents want more local development. In contrast to those that compose the other perspectives, respondents with this perspective have higher expectations regarding the direct impacts of SHPs. They disagreed with the statements related to the rising value of the land located near the dams, the payment of higher salaries to the workers from the Ilha and Jararaca SHPs and that there are leisure areas open to the public. The complementary quotes from the Perspective 3 respondents exemplify this observation: "there could be more leisure areas" (Resident NRS2) and "there aren't many spaces with guides and places to visit" (Resident AP3).

The '**I want social well-being'** perspective reflects a concern with economic aspects as long as they are associated with social benefits. The statements with the highest rates of agreement among the respondents in this group are related to the increase in socioeconomic development, the contribution of the taxes generated by the SHPs to the improvement of the population's well-being, to the fair financial compensation received by the people that had to be reallocated and the replanting of vegetation in the areas impacted by the construction of the dams. The respondents of this perspective expressed disagreement regarding the existence of leisure areas open to the public and the incentive of investors to promote visits to the SHP facilities. Resident NRS4 points out that "there are few access roads to the Ilha and Jararaca SHPs. There used to be rafting, but with the reduced flow, a 3-km stretch of the river had been lost because it is very shallow".

Finally, the respondents from the '**I weigh all sides**' perspective perceive both positive and negative impacts in all the analyzed, economic, social and environmental dimensions. It is the group that presents the best balance between negative and positive impacts. The positive impacts they identified were that the compensation paid to the people relocated was correct and that the value of land near the dam had risen. Furthermore, they perceive a significant improvement in the environmental preservation of the areas surrounding the SHP dams and disagree with the assertion that there was a decrease in the quantity of animal species that inhabit the region, due to the construction of the SHPs. Regarding the negative impacts, these respondents disagree that the SHPs contribute to the reduction in the price of tariffs, the increase in the number of towns with access to energy or even to the improvement in the quality and supply of water.

7. Discussion

The values and perceptions of stakeholders can only be understood if their views are mapped, by identifying the points-of-view that drive the debates and conflicts (Matinga et al., 2014). Among the negative impacts identified, two stand out due to their greater presence in all the perspectives, prompting us to discuss them in detail below.

7.1. The price of energy

The first concerns the price of energy not having decreased due to the proximity of the SHPs. This fact is related to the way energy is produced and distributed in Brazil, mainly through the National Interconnected System (NIS). Respondents E1 and E6 pointed out that centralized power generation through the NIS can be seen as a negative element, since people living close to the generation areas are not directly benefited by cheaper energy. Hence, the perception that SHPs do not contribute to the reduction of electricity prices: "the distributed generation would provide gains for the developer or a reduction in costs for those who are close to generation plant, but there is no such thing today" (E6). Still on the form of centralized generation, E1 states that "today we have a condominium system and everyone feels the benefit and harm of the system, everything is centralized." The arguments presented by the interviewees suggest the need to discuss whether having generation plants closer to the points of consumption should be rethought in Brazil: "Centralized generation generates losses, any cable that carries energy from point A to point B loses energy, so the closer it occurs to the point of consumption, the smaller the loss" (E6). Thus, there could be an incentive to install SHPs, because they reduce costs and energy loss.

The appeal to rethink government policies is reinforced in Ferreira et al. (2016) who argue that government policy towards the electricity sector should focus on ensuring the full potential of SHPs available in Brazil is reached. ANEEL's Normative Resolution No. 482/12, which deals with power distribution, opens the door for the development of public policies aimed at the population generating electricity. For some of the survey respondents (E1, E5, E9), distributed power generation could be one means of reducing the cost of energy for consumers (residential and commercial), since it provides for the own-production of energy, whereby the Brazilian consumer has the right to generate their own electricity (up to a maximum of 1 MW) from renewable sources (hydropower, solar, wind, biomass, etc.) (ANEEL, 2012).

7.2. Absence of leisure areas

The second negative impact concerns the absence of public recreation areas near the dams, incentives for visitation and the construction of access roads in the region (even those leading to the SHPs). In many cases, the relationship between the SHP and the community is mainly restricted to the commercial aspect of electricity supply.

> This [the areas open to the public], is another failure, few are organized for this kind of thing, no one denies, but sometimes there is not even the structure. […] there could be observation points, audiovisual rooms to show the construction, how it operates, what programs exist, show the benefits (E3).

> The SHPs do not generate any curiosity because there is no access to the dam, because it is not used by the local community. Public recreation is zero, there is no road that allows access to the SHPs (E8).

Despite the attempt to provide the community with a recreational area, these statements indicate a failure on the part of the SHP managers to encourage visits to local dams and facilities. It is emphasized that there is even specific legislation in Brazil, art. 4 of CONAMA (National Environment Council Resolution, 2002) no. 302/02, which provides for the possibility of using up to 10% of the total area surrounding an artificial reservoir for the implementation of tourist and leisure centers. Certainly, the fact that local legislation does not oblige the implementation of such leisure areas near SHPs contributes to the low investments in this area. Based on the analyzed data, it is believed that greater investment by the developers of SHPs in the creation of such public spaces could create the basis for a new form of relationship between the SHP and the community, contributing to greater transparency and access to information on the environmental preservation and compensation and maintenance programs carried out. Furthermore, encouraging the public to visit and creating leisure areas would facilitate the perception of these actions by the general public and broaden the acceptance of the existing SHPs and of future ventures.

The study into public infrastructure and construction carried out by Li et al. (2012) pointed out that the interviewees from the general public and pressure groups considered balancing land use between commercial, residential and leisure activities to be of great importance for improving the living conditions of the public and the quality of the built environment. Thus highlighting the opportunity to contribute towards social well-being by transforming areas close to dams into places of leisure and for encouraging the integration of local communities.

Finally, a third topic of discussion refers to the importance of local stakeholders in the decision-making process involving SHP projects.

7.3. Inclusive participation of local stakeholders in decision making

By providing the City Hall Certificate and holding public hearings, local stakeholders (i.e. local authorities and residents) play a significant role in the environmental licensing of SHP projects. Public hearings, which are required by Brazilian legislation, are held to present the main impacts and the counterparts provided. The National Environment Council Resolution no. 09 of December 3, 1987 (CONAMA, 1987) provides for Public Hearings to be held to inform the interested parties regarding the content of the product under analysis and of its referred Environmental Impact Report (RIMA – In Portuguese), to resolve any doubts and gather the criticisms and suggestions regarding them from those present. Participation in the decision-making process of building a SHP can help mitigate the environmental and social impacts known to the local community, so enhancing development in rural and urban areas.

Although formal mechanisms to present arguments about the SHPs exist, the interviewees in the qualitative phase of the present study emphasized the importance of dialogue and the dissemination of the results of the projects in commercial operation. In other words, our data indicated the need for participation not only in the public hearings considering project approval, but also during the operation of the SHP, ensuring transparency and showing whether the expected results (presented in public hearings) are being achieved. Here, it can be seen that, while there is a clear orientation for those responsible for renewable energy projects and the government to inform the population about all the results (developmental, economic, social and environmental) caused by SHPs, currently this is not happening. It remains to be seen if this situation is due to mere neglect or to political and economic interests: perhaps the promised results and compensations presented at the time of approval of the SHP project are not delivered. It must be recognized that this issue can only be addressed through greater transparency. In the same way that formal mechanisms regulate the existence of public hearings for the approval of the SHPs, forums should be formally established for the presentation of results after the SHP enters into operation.

8. Conclusion and policy implications

In terms of its theoretical contribution, this research proposes the existence of five distinct perspectives that group local stakeholders according to their perceptions regarding the impacts of a SHP, namely: 'I'm critical', 'I see regional benefits', 'I want more results', 'I want social benefits" and 'I weigh all sides'. The identification of five perspectives among local stakeholders reflects the different values and interests that need to be addressed in each group.

It is noteworthy that in the perspectives 'I see regional benefits' and 'I want more results' two representatives of the municipal governments are present in each one, suggesting a greater inclination towards the positive impacts among those respondents. One possible explanation may be the increased opportunities for tax collection that SHPs bring to the region. Siciliano et al. (2015) showed there is a considerable divergence in the prioritization of the perceived impacts between residents and governmental officials. This divergence over priorities refers to two distinct aspects: the scale, i.e. national and local priorities, and the type of the impacts, i.e. positive or negative impacts.

Future studies could explore the relationships between the different perspectives or more deeply analyze one impact dimension (social, environmental or economic) to identify the dependent and independent variables. According to Todt (2011), some participatory exercises show that some stakeholder groups may choose not to participate in the decision-making process, even when given the opportunity. Analyzing the dynamics of participatory exercises during the period of negotiating SHP projects and the responses provided in each perspective could also generate future studies.

Another suggestion for future research is the application of this same methodology to cover all the stakeholder groups identified in this study, with the objective of evaluating their different perceptions. The comparative analysis of the perception of local stakeholders on the impacts of different renewable energy sources, among them, mainly wind and solar, also opens another avenue for future research.

This study contributes towards practice by drawing the attention of managers and politicians to the need to increase transparency and communication regarding the actions carried out. In addition, it may guide the formation of public policy regarding energy management. The respondents in the groups 'I see regional benefits,' 'I want more results,' and 'I want social well-being,' did not perceive negative changes to the environment. This result leads us to believe that the existence of environmental compensatory measures supported by the legislation and environmental licensing itself can contribute to the positive perception of the respondents regarding the environmental impacts caused by the analyzed SHPs. This study also highlighted the difficulty of the energy sector in general in explaining to the population the reason for the different tariffs for power generation and the role that small hydroelectric power plants have in this regard. In summary, this paper provides results that may be of use in the analysis of future strategies and policies regarding hydropower development with special emphasis on SHPs.

According to the interviews held in the qualitative phase, the expansion of the positive impacts related to the social and economic aspects that can be produced by SHPs project depends the local stakeholders' capacity for mobilization, mainly during the phase that precedes environmental licensing. That mobilization should promote discussion and debate of all the demands within the region that will house the new project. Moreover, it should be able to differentiate between the different perspectives held by the people affected and relate to conditions before and after the construction of the dam. This could help to avoid or minimize the social and political costs of energy policies, thus obtaining reliable energy systems that we hope will remain in the long term.

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