DAM-FORCED DISPLACEMENT AND SOCIAL-ECOLOGICAL RESILIENCE: THE BARRA GRANDE HYDROPOWER PLANT IN SOUTHERN BRAZIL[1]

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Introduction

Hidropower plants are prevalent in Brazil, where 75% of the energy mix is based on hydroelectricity sources (BRASIL, 2015). According to the World Commission On Dams (WCD, 2000), Brazil is one of the world's largest generators of hydroelectric power. In the next years, the Brazilian federal government expects to construct dozens of large dams in the Amazon region (FEARNSIDE, 2015, 2016; TUNDISI et al., 2014), considered Brazil's current "hydroelectric frontier" (LITTLE, 2014; MORETTO et al., 2012). The expectation is that Brazil's energy production expansion will continue to be driven by hydroelectricity, despite the costs of such choice (ALVES; UTURBEY, 2010; ANSAR et al., 2014) and the Brazilian potential to explore other sources of energy (ANDRADE GUERRA et al., 2015).

The negative impacts of large dams' construction are well known. These projects are frequently associated to severe political struggles (MCCULLY, 2001) particularly concerning indigenous people (MORAN, 2016), high levels of biodiversity loss (WINEMILLER et al., 2016), loss of habitats and the disappearance of fauna and flora (GOLDSMITH & HILDYARD, 1986), significant emission of greenhouse gases (FEARNSIDE; PUEYO, 2012; ROSENBERG et al., 1997; ROSENBERG; BODALY;

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USHER, 1995) and the blockade of the migration of aquatic organisms, specially fishes (ANDERSON; FREEMAN; PRINGLE, 2006). Large dams also cause harmful effects on downstream water systems as well on communities who depend on them (LESSARD et al., 2013; OKUKU et al., 2016; RICHTER et al., 2010; THOMAS; ADAMS, 1999; WCD, 2000) and may negatively affect human health (JACKSON; SLEIGH, 2000; LERER; SCUDDER, 1999).

Among the wide range of impacts caused by large dams, the displacement of people due to reservoirs creation is one of the most significant and remarkable effects (ÉGRÉ & SENÉCAL, 2003). According to WCD (2000), by 2000 dams have caused the displacement of as least 40 million people worldwide. In Brazil, the number of people displaced exceeds a million (ZHOURI; OLIVEIRA, 2007). Dam-induced displacement triggers several secondary effects, such as social disruption of communities (ROSENBERG; BODALY; USHER, 1995; TILT; GERKEY, 2016) and deep transformations of rural communities' livelihoods (SAYATHAM; SUHARDIMAN, 2015).

Displacement often puts farmers under completely new social, economical, political, technological and/or ecological conditions, thus changing their relation to their environment and its resource base (TILT; BRAUN; HE, 2009), disrupting their livelihoods, their sense of place and their social network (VANCLAY et al., 2015). There is growing evidence that such changes in livelihood are accompanied by ecological transformations, since social and ecological systems are mutually linked by feedback loops that produce co-dependent dynamics (OSTROM, 2009; WALKER et al., 2004; WALKER; SALT, 2006).

With this research, we analyze (in a prospective way, as explained in the method section) how dam-induced displacement may change the local social-ecological systems organization, affecting their resilience. This study intent to reveal hidden effects of dam-induced resettlement and contribute to the debate about the long-term effects of the "best-practice" of resettlement.

Our hypothesis is that the several consequences caused by dam-induced displacement may reduce the resilience of the entire social-ecological system. To investigate this issue, we chose Barra Grande hydropower plant case, located in Southern Brazil, since Barra Grande provides desirable conditions to develop this research. First, the Uruguai basin – in which Barra Grande is inserted – is an important area of hydroelectric expansion in Brazil and it has received little attention in comparison to the Amazon basin (BRACK et al., 2011). Second, Barra Grande itself is one of the major dams that recently started to operate in Brazil. Third, southern Brazil offers an interesting social and ecological context to develop the research, since agriculture and cattle raising are practiced in various forms in the region, influencing people's lives, traditional knowledge, culture and social organization (RUPPENTHAL, 2013), as detailed below. Finally, we took into account the availability of data and the access and involvement with local stakeholders.

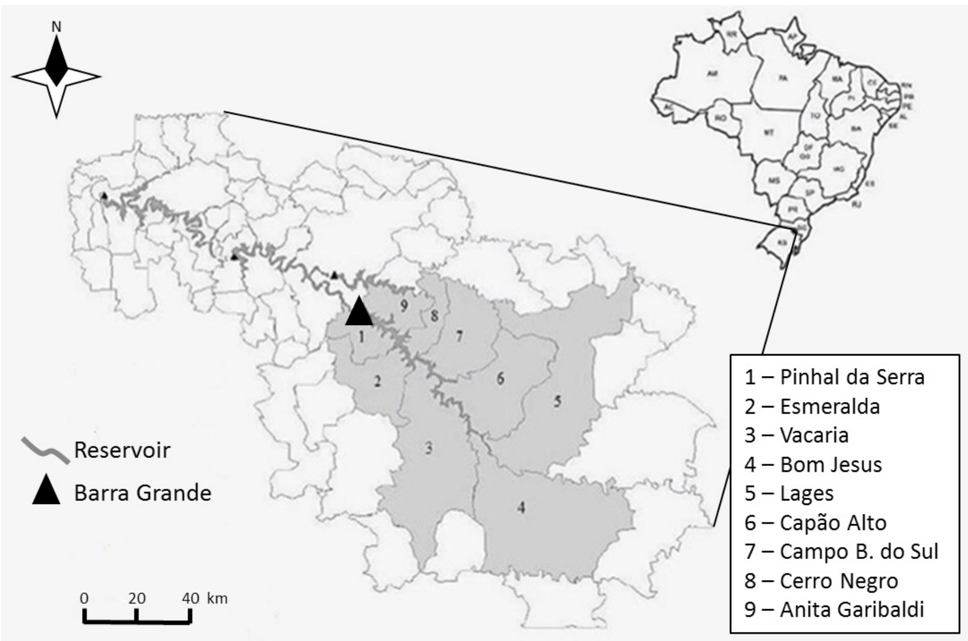
Barra Grande dam and its location

Barra Grande is a hydroelectric plant with an installed potential of 700 megawatts; it is filled by the Pelotas River's water in southern Brazil. The group responsible for this dam is the Barra Grande PLC Energy Corporation (or BAESA), whose shareholders include a number of construction and mining companies, such as Alcoa Alumínio PLC, Camargo Corrêa, Companhia Brasileira de Alumínio [Brazilian Aluminum Company] and DME Energética Ltda (PROCHNOW, 2005). The Barra Grande plant's Preliminary License was issued in December 1999. Construction started in June 2001 and the plant started its operation in 2005.

The Pelotas River is a deeply set river that separates the Brazilian states of Santa Catarina and Rio Grande do Sul. Its steep slopes facilitate the damming process. In this region, ecosystems consist of forests and fields, currently divided into a patchwork natural vegetation separated by areas of agricultural production. The predominant vegetation is composed of mixed rainforest areas known as araucaria forests (due to the high density of araucaria trees - *Araucaria angustifolia*). In this region, also known as *pampas* or southern fields, there is a preponderance of grass and shrub plain vegetation, making the area ideal for agriculture and cattle raising.

The plant's reservoir covers between eight and ten thousand hectares, flooding lands of nine Brazilian municipalities: Anita Garibaldi, Cerro Negro, Campo Belo do Sul, Capão Alto and Lages, in the state of Santa Catarina (SC), and Pinhal da Serra, Esmeralda, Vacaria and Bom Jesus, in the state of Rio Grande do Sul (RS), as Figure 1 shows.

Figure 1. Location of Barra Grande and municipalities containing flooded areas.



On average, population of regional municipalities is under 15000 inhabitants and are largely associated to agricultural activities and local commerce. Essentially, these municipalities consist of a little urban center surrounded by vast areas of cultivation. The urban centers typically have only a few streets where commercial and residential activities predominate. Most of these municipalities have small-scale and not very diverse economic activities. Public administration structures are also limited, both in terms of their physical presence and in terms of institutional arrangements.

Cattle raising was largely practiced in the region around twenty years ago, but herds have been giving way to cultivation since the 1990s, a process driven by the price of export commodities. Since then, agriculture became the most important economic activity, influencing people's daily routines and overall social organization (RUPPENTHAL, 2013). Two main cultivation models exist in the region. The most predominant occurs in the plains, where farmers grow mostly corn, employing tractors and mechanical plows along with artisanal irrigation systems, generally in properties of between 20 and 40 hectares. Pesticides, soil conditioners and fertilizers are also used.

The other form of cultivation is mainly found on the steep slopes of the Pelotas River, which are fertile due to the dynamic forest ecosystem near the watercourse. Overall, this form of cultivation makes use of the existing environmental conditions instead of employing technologies to control them. It is based on slash and burn techniques, traditional pest management and the use of locally produced seeds. Simple tools such as hoes and manual plows are preferred (steep slopes make it impossible to use tractors and trucks). Small holders are organized in family units that subsist from their agricultural production and sale of surplus produce in local markets. Properties' area usually do not exceeds 20 hectares.

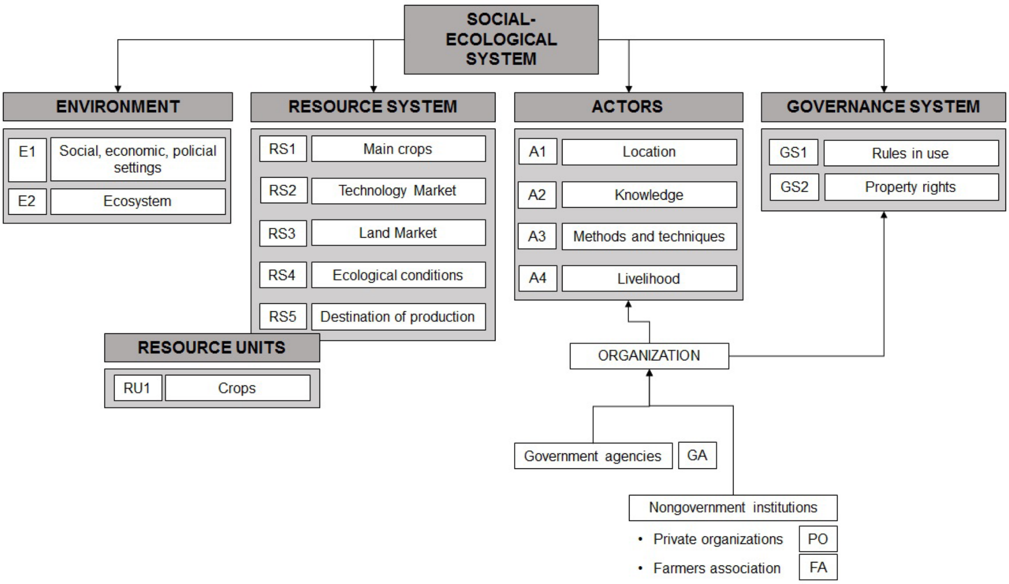
In both models, it is possible to observe the *arrendo* (or leasing) system, in which large property owners lease part of their land to small producers, in exchange for a monthly amount of produce.

Analytical framework and methods

In order to analyze how the dam-induced displacement may change the organization of the local social-ecological system, we adopted the social-ecological systems (SES) framework, which is strongly influenced by Ostrom (2009) and McGinnis & Ostrom (2014). According to Ostrom (2009), the SES framework aims to analyze how interactions in social-ecological systems produce outcomes and promote sustainability. Among several approaches to analyze changes in coupled human and environmental systems, social-ecological systems framework is useful for select variables, describe systems' dynamics and adjust the scale of analysis according to different research goals (BINDER et al., 2013). Although the SES framework was developed and applied mainly in the area of management, its use has been recently diversified (BOTS; SCHLÜTER; SENDZIMIR, 2015).

In the SES framework, social-ecological systems are systems integrated by ecosystems and human societies in reciprocal feedback and interdependence loops (FOLKE et al., 2010). Such framework divides the system in four first-level core subsystems: (i) resource systems, (ii) resource units, (iii) governance systems and (iv) actors. Each one of these is composed by multiple second-level variables, which are constituted by deeper--level variables (OSTROM, 2009). Ostrom's framework was criticized and improved by Hinkel, Bots, & Schlüter (2014) and Bots, Schlüter, & Sendzimir (2015), whose contributions are considered in the design of our analytical framework. The description of each subsystem, their attributes and second-level variables considered in this study (as well as methodological procedures to investigate them) are presented in Table 1. Variables were selected based on the literature about displacement (OLIVER-SMITH, 2002; SCUDDER, 2009; WCD, 2000), social-ecological systems (QUINLAN et al., 2015; SCHLÜTER et al., 2014; WALKER et al., 2012) and the rural context of southern Brazil (BRACK et al., 2011; RUPPENTHAL, 2013). Details about variables and methodological procedures are described below. The designed social-ecological system is represented in Figure 2. Dark and light grey boxes represent concepts, while white boxes represent system's attributes. Each white box is accompanied by an abbreviation. Downward arrows denote attribution relationships and upward arrows denote subsumption relationships.

Figure 2. Representation of the social-ecological system, its subsystems, concepts, atributes and relationships.



Social-ecological systems are complex adaptive systems, which means that the interaction between variables, subsystems and larger-scale phenomena produces dynamics that move the system away from determinist, predictable, mechanic and linear types of behavior (FOLKE, 2006; GUNDERSON; HOLLING, 2002). Such complex dynamics are determined mainly by feedback mechanisms that interlink systems' elements (SCHEFFER, 2009). Resilience is an outcome of this interaction (FOLKE et al., 2010; OSTROM, 2009; WALKER et al., 2004; WALKER; SALT, 2006). According to Walker

& Salt (2006), resilience is the ability of a system to receive disturbances and maintain its functions, structures and feedback loops.

In light of this framework, we considered the process of dam-induced displacement as a set of disturbances that the social-ecological system must cope with. These disturbances change the organization and interaction between subsystem and variables, influencing resilience. Measuring resilience, however, is a challenge surrounded by limitations, trade-offs and a risk to oversimplify phenomena of complex nature (QUINLAN et al., 2015). Thus, we are not seeking to determine in which measure the process of displacement weakened or strengthened the resilience of the system through changes in agricultural practices. Instead, we seek to verify if disturbances drove the system towards more or less resilient pathways.

Were analyzed the municipalities that have received massive numbers of resettled households: Pinhal da Serra, Anita Garibaldi, Esmeralda and Cerro Negro. Data gathering was based on two procedures: collecting secondary data and interviews with key informants. Secondary data was sought from Brazilian governmental agencies, as described in Table 1. The Barra Grande resettlement plan and the Barra Grande environmental impact report were also analyzed as secondary data.

Table 1. Description of subsystem, their variables and attributes, as well as data source used.

Subsystem	Description	Variables and attributes	Data source
Resource system	Agriculture practiced in the region affected by the resettlement process	Main crops (RS1)	Instituto de Pesquisas Econômicas (IPEA)
		Technology market (RS2)	EMATER** and EPAGRI***; Interviews
		Land market (RS3)	EMATER and EPAGRI; Interviews
		Ecological conditions (RS4)	Interviews
		Destination of production (RS5)	Interviews
Resource units	Units that constitute the resource system	Cultivated crops (RU1)	Instituto de Pesquisas Econômicas (IPEA)
Governance System	Institutions of the agricultural practice	Rules in use (GS1)	Interviews
		Property rights (GS2)	Interviews
Organizations*	Organizations that participate of the governance system and influence users	Government agencies (GA)	BAESA reports; Interviews
		Private companies (PO)	Interviews
		Farmers association (FA)	Interviews
Actors	Farmers	Location (A1)	BAESA reports
		Knowledge (A2)	Interviews
		Methods and techniques (A3)	Interviews
		Livelihood (A4)	BAESA reports; Interviews

* Organizations were not considered a subsystem (see Hinkel *et al.*,2014), ** Empresa de Assistência Técnica e Extensão Rural do Rio Grande do Sul; *** Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina.

Twenty key informants were interviewed in the four analyzed municipalities during the first half of September 2012. Three were representatives of farmers associations or unions, seven were representatives of local municipal government departments and technical assistance organizations that were involved in the dam's construction process and ten were resettled farmers. These interviewees were selected based on their knowledge about the changes that occurred in the municipalities during the period comprised in this study. Further interviewees – specially resettled farmers – were reached by snowball sampling. To be considered in the study, farmers should (i) originally (i.e. prior to resettlement process) live in one of the studied municipalities, (ii) be one of those who were resettled due to the construction of the Barra Grande dam and (iii) live in one of BAESA's collective resettlement projects. First farmers were contacted through representatives of local municipal government departments and technical assistance organizations and further farmers were contacted through the first ones. Few farmers were available and/or agreed to participate of the research, therefore restricting the sample of interviewed farmers and thus imposing a preliminary/prospective nature to the study.

Semi structured interviews were based on a guide formulated reagrding literature produced about the local consequences of large dams and specific literature about the Barra Grande dam, as well as the data gathered.

Qualitative data was transcribed and analyzed in light of recent advances in resilience theory. Quantitative data was analyzed chronologically and was confronted with qualitative data in order to find evidences of systemic changes that affected resilience.

Results and discussion

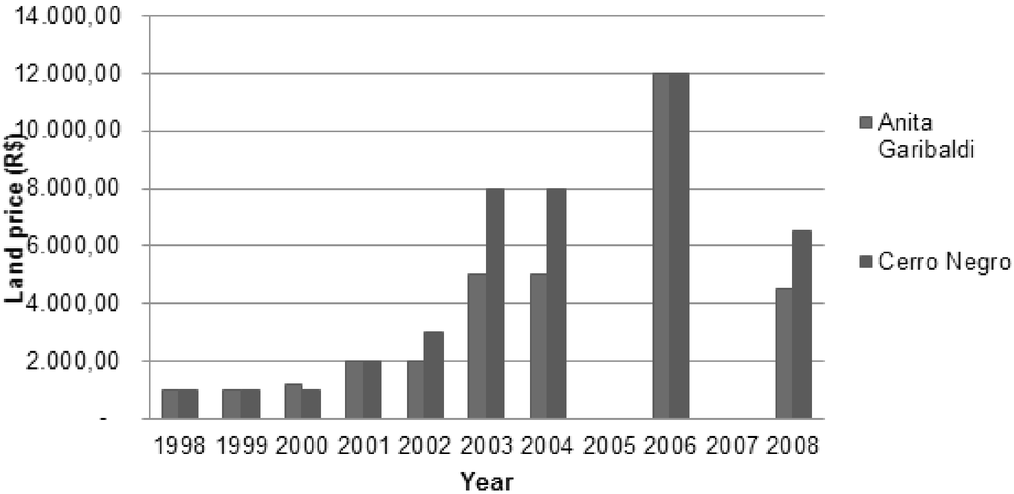
The resettlement process of the population bordering the reservoir meant that hundreds of families who lived in the region had to be moved. According to data provided by BAESA, 430 families were moved, 43.75% from Anita Garibaldi, 30% from Pinhal da Serra, 12.90% from Cerro Negro and the remainder (13.35%) from other municipalities. Data about the cultivation model practiced by the resettled families was not available from public records (or reports). Field interviews indicate that the majority of displaced farmers used to live in the slopes of the Pelotas River, where they used to raise beans and corn.

Through the resettlement process, households could choose between a property in collective rural settlements or a compensation in the form of "letters of credit" with which would allow them to buy properties of their choice. BAESA reports inform that 191 families were relocated to collective rural settlements located in the municipalities directly affected by the dam, whereas 239 chose to receive letters of credit. Most families from this latter group (55%) settled in the municipalities of Anita Garibaldi and Pinhal da Serra.

The process of displacement – or the change of farmers' location (A1) – boosted the agricultural land market (RS3). Evidence of the rise of the land price is presented in Figure 3 (the only data available was from Anita Garibaldi and Cerro Negro).

A respondent from Anita Garibaldi mentioned that an *alqueire* (2.72ha) of land was being sold for R$1,000 before the construction began, whereas it could be sold for R$50,000 in 2012. A similar tendency was verified in the other municipalities. In Pinhal da Serra, interviewees stated that the price of land went from R$1,500 in 2004 to roughly R$14,000 in 2010. In addition to the increase in rural property prices, there was an increase in the price of *arrendo* [leasing], from an average of six sacks of produce/hectare to fifteen sacks/hectare, putting pressure on leasers to adopt more intensive means of production. The price of rural property remained at the new level after the construction were completed. When fieldwork was done, property prices could reach more than three times what they were in the pre-dam period.

Figure 3. Performance regarding average prices of best quality land for Santa Catarina municipalities.



Findings show that the construction of the Barra Grande dam has pushed farmers of the Pelotas Rivers slopes to the plain areas of the affected municipalities. Since the creation of the reservoir diminished the offer of productive land in the Pelotas slopes, farmers had to move to the plains, a displacement that forced producers to tackle new ecological conditions if they were to continue their way of life (A4). Factors such as declivity, soil acidity, fertility, humidity and microclimate are extremely different on the slopes from the open fields. According to interviewed households, farmers knew how to cope with the environmental conditions under which they used to live. However, they lack knowledge (A2) about the ecological dynamics of the plains and the technical means to deal with it (A3). Okuku et al. (2016) found similar evidences for resettled communities of the lower Tana, in Kenya. According to the authors, communities reported that the flood control imposed by the dam affected the environment and livelihoods downstream which depend on natural small floods. Similarly, Nguyen; Lobry De Bruyn; Koech (2016) found that the crops cultivated by Vietnamese communities resettled due to the Ta Trach reservoir project declined because resettled farmers had insufficient land or poorer land quality. Sayatham; Suhardiman (2015) found similar evidence while studding the case of Nam

Mang 3 project in Laos. Therefore, access to agricultural land (A1) plays a fundamental role in households' ability to sustain livelihoods.

BAESA considered farmers' knowledge on how to raise crops within slopes' ecological conditions an obstacle to the success of the resettlement process. To overcome it, BAESA has established a partnership with local technical assistance governmental agencies (GA), funding an increase in the number of their staff members during the process of resettlement, thus transforming the capacity of government institutions involved in the governance of the social-ecological system.

Technical assistance sought to enable farmers to use new production methods (A3) and to introduce new livelihoods (A4). According to those interviewed in the field, agriculture technicians sought to "provide settlers with alternative means of income generation", because the artisanal techniques used on the slopes would result in low yields. Thus, technicians advised farmers to use agrochemicals in their cultivations as a means of guarding against pests, and to use lime-based products to correct the acidity of the soil. Mechanization was also encouraged, such as mechanical plows and harvesting machines, as well as sprinklers for irrigation.

The promotion of control of ecological conditions (RS4) through the mobilization of the governance system may contribute to the depletion of the system's resilience. Factors such as imposed control of ecological dynamics (E2), the loss of knowledge (A2) about ecosystems may generate states in which the diversity of agricultural methods and techniques (A3) is decreased. In their study about rural communities resettled due to the Ta Trach reservoir project in Vietnam, Nguyen; Lobry De Bruyn; Koech (2016) found that the loss of economic diversity negatively affected households income. Overcontrol and lack of diversity are usually linked to loss of resilience (HOLLING & MEFFE, 1996).

Technical assistance supported other forms of crop/farming, promoting the introduction of products that were not farmed on the slopes, such as soybeans. According to the respondents, the displacement of slope farmers to the plains acted as an incentive for soybean cultivation, to the detriment of beans and corn.

Data regarding the cultivation of soybeans, corn and beans are shown in Figures 4, 5 and 6, respectively.

Findings show that corn farming was prevalent in the pre-dam period, whereas beans and soybeans crops were much smaller. Between 2002 and 2005 (period of the resettlement process), soybean crops doubled while bean cultivation dropped by almost half. Corn cultivation remained stable and grew after 2006. Such results suggest that the dam-induced displacement changed crops cultivated area (RU1), changing the pattern of main crops (RS1). According to field reports, the change of main crops is accompanied by changes in all variables considered in the resource system. The new crops demand high investment in technology to persist, heating technology market (RS2). Moreover, they are destined to foreign market, while beans and corn of the slopes were traded in neighbor municipalities (RS5). The tendency to move away from traditional agriculture towards intensified agriculture was also found by Galipeau; Ingman; Tilt (2013) in their study about resettled farmers of the Mekong Basin in China and by Arnall et al. (2013)such

Figure 4. Performance of soybean cultivation areas.

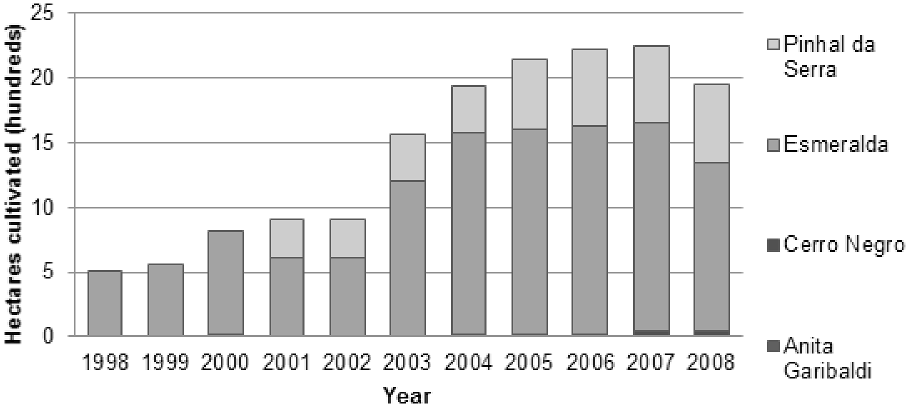


Figure 5. Performance of corn cultivation areas.

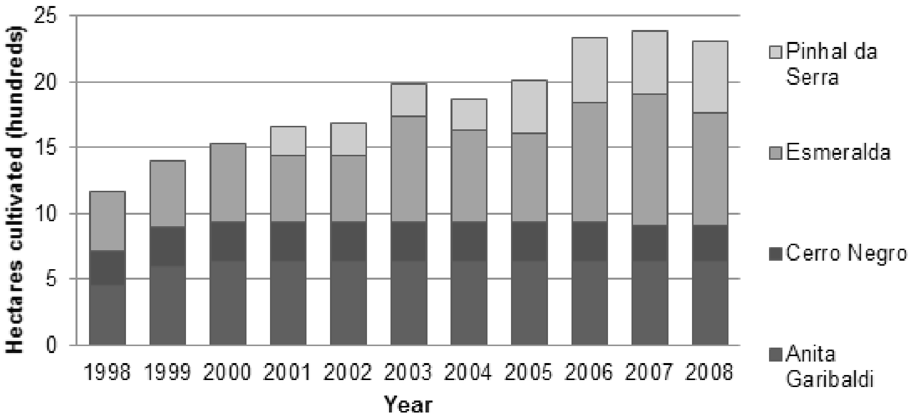
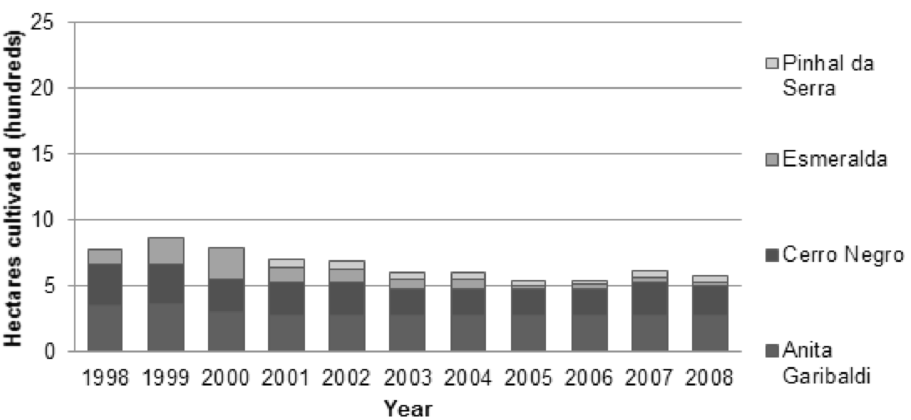


Figure 6. Performance of bean cultivation areas.



as resettlement, can have major impacts on communities. This paper examines how and why people's livelihoods change as a result of resettlement, and relocated people's views of such changes, in the context of natural disasters. It presents two historically-grounded, comparative case studies of post-flood resettlement in rural Mozambique. The studies demonstrate a movement away from rain-fed subsistence agriculture towards commercial agriculture and non-agricultural activities. The ability to secure a viable livelihood was a key determinant of whether resettlers remained in their new locations or returned to the river valleys despite the risks posed by floods. The findings suggest that more research is required to understand i in their study about rural households in Mozambique. Such market oriented, control-based, agrochemical-intensive agriculture tend to promote loss of resilience.

Technical assistance also encouraged farmers to undertake new economic activities, such as small sport fishing and tourism business. Field respondents affirmed that it happened in a less intense way when compared to the introduction of soybeans. According to the interviewed representatives of technical assistance agencies, data about sport fishing and tourism entrepreneurship in the studied municipalities is non-existent. Even so, the encouragement of these economic activities may drive some farmers away form the agricultural practice, which may represent changes in livelihood (A4) and may indicates a movement towards economic diversification, a factor usually linked to the promotion of resilience (GUNDERSON; HOLLING, 2002; WALKER; SALT, 2006).

Findings presented so far show a first set of disturbances in the social-ecological system. Attributes that undergone major changes are highlighted in the text. It is important to stress that such major changes happened in less than five years, a short period of time to restablish social chacarteristics that took generations to be built (BENNETT; MCDOWELL, 2012).

It was verified in the field that, in sought to cope with these changes, households adopted different strategies, similarly to what Sayatham; Suhardiman, (2015) found in their research on villagers affected by the Nam Mang 3 hydropower project. Taken together, these strategies engendered a new round of changes in the social-ecological system. Three main strategies were identified: migration, adaptation and innovation.

According to respondents, slope farmers continued to plant corn and beans on their new properties, but not all of the crops yielded successful results. A farmer stated that "at the beginning, many [resettled farmers] suffered. They did not know how to farm in these new lands. Despite technical assistance, many gave up and decided to do something else." Many farmers sought to return to their original municipalities, either because they did not adapt to the new methods of production, or perhaps for personal reasons, creating a movement of resettlement evasion. This movement happened in all studied municipalities, but was stronger in Anita Garibaldi and Cerro Negro. According to interviewees, 70% of the farmers from these municipalities who opted for individual resettlement have returned to their original municipalities. Resettlement project evasion was also verified by Arnall et al. (2013) and by Obour et al. (2016). Unable to purchase new properties because of the land price rise, they ended by providing basic services in the urban centers of these municipalities, changing their livelihhods (A4). Others, who were either not successful in adapting to mechanized forms of production, sold their new properties to return to the reminiscent Pelotas slopes.

Although some were unsuccessful, others have adapted to mechanized techniques, based on the use of agrochemicals, and prospered growing corn, soybeans and beans, as well as producing milk and making crafts and other simple manufactured goods. Producers established in resettlements – particularly the collective resettlements – who previously used artisanal agricultural practices started using more chemicals to increase production, moving away from artisanal agriculture to new ways of production (A3).

The establishment of resettled farmers led to the emergence of a new and important player in governance system: the cooperatives. They had a fundamental role in the fertilizer, pesticide, soil conditioner and modified seed trade (RS2). Together with technical assistance agencies, cooperatives reinforced the transition from slope cultivation to mechanized agriculture. According to respondents belonging to rural trade unions and the municipal departments of agriculture, technical solutions proposed by assistance agencies were (and still are) applied by the cooperatives that sold agricultural supplies and subsequently bought their clients' production.

Although these organizations call themselves "cooperatives", field reports reveal that they usually are commercial institutions, i.e., private bodies (PO) which are often based outside municipalities. Local family producers are not involved in their administration. According to the farmers interviewed, these organizations "determine the cost of agricultural supplies and the price of the products they buy". Reports have consistently showed the dependency of small producers on these institutions. According to respondents in Pinhal da Serra, Cerro Negro and Anita Garibaldi, small producers spend between 50% and 70% of their total income on agrochemicals, reducing their net profit, influencing livelihood economic viability (A4) and compromising their social resilience (ADGER, 2000).

Secondary migration and adaptation consolidated the systemic changes triggered by the dam-induced displacement. Changes in technology market (RS2), land market (RS3), unavailability of lands (influencing location, A1) and the rise of private organizations (PO) precluded resettled farmers to return to the slopes. The same changes enabled the change of livelihood of those who accepted to live in the fields, reinforcing the transition from a small-scale ecological knowledge based agriculture to a bigger-scale control-oriented mode of production. According to Berkes & Folke (2000) and Adger (2000), transitions alike tend to drive social-ecological systems in less resilient pathways.

Finally, there were those who innovated. Farmers who were resettled in collectives found themselves having to innovate to cope with the high costs imposed by the new models of production. They set up agricultural production associations (FA) in order to receive funding from BAESA, which denotes some level of self-administration (SINGER; HOANG; OCHIAI, 2015). According to one interviewee working in the agricultural sector in Esmeralda, the associations thus set up became a new element in the political scenario, previously marked by the presence of small holders (farmers possessing between 20 to 40 hectares) and large property owners, whose main source of income was the leasing of their land. Therefore, collective resettlement led to the emergence of a new player in the region.

Agricultural associations set up new ways of organizing agricultural production. According to Walker et al. (2004), this can be conceived as a feature of the adaptability. A resettled involved in the setup and management of a producers' association stressed the need to ensure benefits to members as a whole, committed to mutually helping each other. Such statement suggest a change in rules in use (GS1) and in property rights (GS2) and denotes an unprecedented predisposition of organization.

Findings revealed that the manner in which the resettlement process was conducted benefitted the uniformity of agricultural practices, by prompting producers to adopt mechanized solutions strongly based on the use of agrochemicals in order to control the ecological conditions of the system. In systemic terms, this phenomenon could represent a long-term reduction in the number of strategies for economic adaptation, a factor that could negatively affect the resilience of the social-ecological system as a whole. Furthermore, uniformity can lead to a loss of knowledge within the local social-ecological system of agriculture-related artisanal techniques. Accordingly, human consumption would be left at the mercy of agricultural suppliers and the commodities market (driven by the actions of "cooperatives").

When selecting a location to where communities will be placed after resettlement, decision-makers must obseve whether the plance provides the conditions to resettleds reproduce their means of life and livelihoods (VANCLAY et al., 2015). The evidence gathered in this work indicates that the choice of the location for the communities affected by the Barra Grande dam hampers the reproduction of farmers' livelihood, imposing a transition that may drive the system towards less resilient pathways. Such transition from artisanal to mechanized agriculture may be due to lack of consideration of cultural aspects in the resettlement process, as pointed out by Hanna et al. (2016), whose study about the impacts of the Lajeado Dam over the Xerente indigenous people (Northern Brazil) revealed a transition from traditional farming technics to mechanical agriculture. This, in turn, impacted negatively their cultural reproduction and food security. Since the conception of resettlement projects is often based on a western view of agricultural practice (BENNETT; MCDOWELL, 2012), decision-makers and technicians usually conceive management plans that foster gains in productivity and modernization of the means of production over social and cultural aspects that are determinant to the success of the project in the long-term. Therefore, the lack of consideration of social and cultural aspects in resettlement plans must be observed along with the environmental aspects that permit communities to reproduce sustainable livelihoods.

Conclusions

The process of resettlement induced by the construction of the Barra Grande Dam produced a multiplicity of unpredicted effects, such as a second round of farmers migration, the emergence of new agriculture related players and the strengthening of associativism. Although these effects were generated by several factors in systemic interaction, they are all related to the fact that those responsible for the resettlement process forced farmers to tackle new environmental conditions by placing them in a significant different habitat. Authorities' efforts to assist farmers in such transition partially worked. The resettlement as a whole acted as a process of selective pressure over displaced farmers. By the evidence gathered in this study, we conclude that the interaction between farmers and the environmental conditions they have to cope with played a central role in the way the process of resettlement of the Barra Grande dam developed so far. As presented in the discussion section, resembling trend was found for dams in Laos, Vietnam, China and Kenya, which may indicate that the study of environmental conditions should be part of the design of strategies of resettlement, as well as be considered in studies of sociology and anthropology of resettlement. In the Barra Grande case, the role of the environmental conditions and the systemic interaction between factors were not observed when strategies to manage the process of resettlement were proposed. Perhaps the most important outcome of this paper is the demonstration that current practices of management of dam-induced displacement may be shortsighted and over-focused on socioeconomic factors, given that they do not consider their second-order consequences and systemic interactions that might negatively affect resilience in the mid and long-term. It is recommended that guidelines and best-practice manuals on resettlement projects address this issue in order to help decision-makers in achieving more successful results when designing resettlement plans.

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DAM-FORCED DISPLACEMENT AND SOCIAL-ECOLOGICAL RESILIENCE: THE BARRA GRANDE HYDROPOWER PLANT IN SOUTHERN BRAZIL

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***Resumo*:** Um dos principais impactos causados pela implantação de grandes barragens é o deslocamento populacional, que está associado a uma série de efeitos secundários social e ecologicamente negativos. O objetivo deste estudo é analisar como o processo de reassentamento engendrado pela instalação da usina hidrelétrica de Barra Grande re-organizou o sistema socioecológico local, afetando sua resiliência. O estudo está baseado no modelo de análise de sistemas socioecológicos. Foram coletados dados quantitativos em fontes secundárias oficiais e realizadas entrevistas com atores locais. Os dados foram analisados a fim de encontrar evidências de como as perturbações conduziram o sistema em trajetórias mais ou menos resilientes. Os resultados encontrados revelam que o processo de reassentamento favoreceu a uniformidade das práticas agrícolas e encorajou ariculto-res a controlar as condições do sistema socioecológico local, afetando negativamente a resiliência do sistema em questão.

Palavras-chave: Barra Grande. Usina hidrelétrica. Reassentamento. Resiliência. Sistema socioecológico.

***Abstract*:** One of the major impacts caused by large dams is induced displacement, which is associated to several social and ecological negative secondary effects. This study's objective is to analyze how the resettlement process engendered by the Barra Grande hydropower plant reorganized the local social-ecological system, affecting its resilience. The study is based on the social-ecological systems framework. Quantitative data was collected in official sources and field interviews were conduced. Collected data was analyzed in order to verify if disturbances drove the system towards more or less resilient pathways. Findings reveal that the resettlement process has benefitted the uniformity of agricultural practices and has encouraged farmers to control the system ecological conditions, negatively affecting the resilience of the social-ecological system.

***Keywords*:** Barra Grande. Hydropower plant. Resettlement. Resilience. Social-ecological system.

Resumen: Un de los principales impactos ocasionados por la implantación de grandes presas es el desplazamiento, que se asocia con una serie de efectos secundarios socialmente y medioambientalmente negativos. El objetivo de este estudio es analizar cómo el proceso de reasentamiento engendrado por la instalación de la central hidroeléctrica de Barra Grande reorganizó el sistema socio-ecológico local, afectando su resiliencia. El estudio se basa en el modelo de análisis de sistemas sistema socio-ecológicos. Datos cuantitativos fueron obtenidos en fuentes secundarias oficiales y fueron realizadas entrevistas con actores locales. Los datos fueron analizados con el fin de encontrar evidencia de cómo las perturbaciones en el sistema o condujeron en el sentido de trayectorias más o menos resistentes. Los resultados mostraron que el proceso de reasentamiento favoreció la uniformidad de las prácticas agrícolas y alentó aricultores para el control de las condiciones medioambientales del sistema socio-ecológico, afectando negativamente a la resiliencia del sistema en cuestión.

***Palabras-clave*:** Barra Grande. Central hidroeléctrica. Reasentamiento. Resiliencia. Sistema socioecológico