FLOODS AND SOCIAL VULNERABILITY: STUDY ON THE XINGU RIVER IN ALTAMIRA / PA

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Introduction

One of the undeniable consequences of the changes that Brazil has been experiencing in the last decades, concerns the diversification of the forms of population movements and human settlements, as well as the consolidation of a pattern of urban expansion characterized by the social, demographic, economic and environmental segmentation and differentiation (CHATEL; SPOSITO, 2015; CUNHA, 2006).

This pattern is also distinguished by the low quality of urban life and territorial spread, in which phenomena such as conurbation, demographic deconcentration, peripheralization and the consequent excessive accumulation of deprived areas of urban infrastructure and social facilities (CARDOSO; VENTURA NETO, 2013) are facts increasingly present in the large agglomerations of many Brazilian cities and municipalities, especially in locations with large projects such as hydroelectric plants.

Altamira is one of these municipalities located in the State of Pará, because despite having an area of 159,695,938 km^2, the largest municipality in the world, it has presented a considerable increase in its total population. According to the IBGE, until July 2014, Altamira had an estimated population of 106,768 inhabitants, while in the 2010 Census the population was 99,075 and in 2000 Census was 77,439 inhabitants.

The considerable increase from 2010 to 2014 is due to the displacement of a large number of people to the municipality (one of the largest migratory exodus in recent years) due to the implantation of the Belo Monte Hydroelectric Plant on the Xingu River, in which the largest dam is located in Altamira.

Among the main discussions on the negative impacts linked to the dam is the peak of population increase in Altamira, since not only those people who will work directly on the project, but also others looking for jobs and opportunities, thus generating externalities to local government (SOUZA JÚNIOR; REID, 2010), such as problems in health,

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education, prostitution, crime, housing construction in risk areas, whose consequences are associated with social vulnerability.

Social vulnerability is the estimated degree of loss or material damage resulting from a risk scenario associated with a particular threat or process with destructive potential to occur with a given severity and permanence, in which social factors influence the susceptibility of the various groups and also govern their responsiveness (CUTTER, 2003). In the analysis of this concept, it is common to be based on three categories: the assets, the set of opportunities from the social scope and the strategies. The absence of these three elements characterizes the situation of social vulnerability.

According to Kaztman (2001), situations of social vulnerability must be analysed from the existence or not, by individuals or families, of assets available and capable of facing certain risk situations.

Therefore, the vulnerability of an individual, family or social groups refers to the greater or lesser capacity to control the forces that affect their well-being, that is, the possession or control of assets that constitute the resources required to take advantage of the opportunities provided by the state, market or society.

Assets are made up of the material or socio-cultural resources that allow individuals to develop, since they encompass the fundamental inputs such as work, leisure, culture and education (GOMES; PEREIRA, 2005). The opportunities structures are provided by the market, state and society (PAIVA, WAJMAN, 2005).

Through these strategies, resources can be used more efficiently, thus promoting new assets and recovering the depleted ones; the strategies can be understood as the way in which the actors use the assets, in order to face the structural changes of a given social context (GALLEGUES et al., 2010).

Altamira lives an economic and social change since the beginning of the implantation of the Belo Monte hydroelectric plant, which indicates the need to investigate its classification of social vulnerability before this change and thus make prospects for a future of Belo Monte post-construction. Therefore, the objective of this research was to classify the social vulnerability of the municipality of Altamira, considering the occurrence of seasonal floods and the future scenario of stabilization of the water level in the flood quota.

Impacts relared to the implementation of the Belo Monte da complex

The Belo Monte Hydroelectric Plant, located on the "Volta Grande" area of the Xingu River, affluent on the right side of the Amazon river, has been the subject of controversy for more than 25 years. The original plan for the Xingu river comprised a total of six dams (Jarina, Kokraimoro, Ipixuna, Iriri, Babaquara and Belo Monte), the largest being the Babaquara or Altamira hydroelectric dam with 6140 km^2 that is twice larger than Balbina or Tucuruí (FEARNSIDE, 2006). From 1999 onwards, the project was renamed for the second time, being called CHBM - Belo Monte Hydroelectric Complex, only with the works of a plant in the Volta Grande (SEVÁ FILHO, 2005).

The building works of Belo Monte began in 2011 and consist of a main dam, a reservoir (partially covering the channel of the Xingu river and part of the lands of the left bank of this watercourse, near the section called Volta Grande with an area of approximately 386 km^2) and two powerhouses, the main one in the locality of Belo Monte and a complementary powerhouse to be positioned in the main dam (ELETROBRAS, 2009).

In this context, a relevant issue is the Xingu river level variation in the city of Altamira (expected with the implementation of the dam), where through the granted concession by the National Water Agency (ANA) there is a recommendation for the regularization of the maximum level in floods quota (ANA Resolution 48, February 28, 2011). The adverse effects of seasonal flooding on riverside communities are the main social consequences caused by the alteration of the hydrological regime (reduced flow in one area and increase of the quota in another) that can be associated with the effect of dams.

The river flow historical series of the Xingu river in the Altamira-PA station presents well-highlighted peaks, as presented in Santos et al. 2016, for the period from 1985 to 2013, in which it observed a interannual variation with Qmax in 2004 (27639 m^3/s) and Qmin in 1998 (9817 m^3/s). In the monthly average, for the same period, the Qmax occurs in April with a value greater than 19000 m^3/s and the Qmin in September (1153 m^3/s).

Molina (2009) reported that in the 100 km range between the site of the dam (Pimental) and Belo Monte, the water levels of the Xingu River will decrease as a consequence of the reduction of river flows. This is why it is called Reduced Flow Stretch (TVR). The decrease of the river levels will also occur in the final stretch of several tributaries including the Bacajá river, the main tributary of the Xingu in the TVR, even if this river does not suffer any flow reduction.

In order to mitigate the impacts of the river flow reduction, an ecological hydrogram was proposed by the Environmental Impact Study – EIA (RIMA, 2009) so that the alluvial plains can be wetted or, at least, the roots of the plants of the alluvial forests suffer the effects of moisture.

Two hydrograms were defined (HE I with a maximum flow rate of 4000 m^3/s and HE II with a maximum flow of 8000 m^3/s) to be applied alternately. The idea was that the TVR ecosystem could withstand one year with HE I and recover in the next year with HE II, and that in the dry period, minimum flow values will be guaranteed in order to allow navigation (MOLINA, 2009). However, the EIA did not include an analysis of the decrease of Xingu river water levels and its seasonal fluctuation as a consequence of the reduction of the river flow and that the proposed Ecological Hydrograph is based on economic criteria (energy generation).

According to Fearnside (2009), the water level in Babaquara (recently named Altamira) is expected to vary by 23 m in each year, thus repeatedly exposing an area of about 3580 km^2 (the depletion zone - when the operational minimum level in normal conditions is reached).

In the low Xingu, the river quota follows the Amazon regime that is close, and this phenomenon occurs in its main tributaries, forming the drowned valleys - type of estuary in which the sea invaded the lowlands and mouths of rivers (CASTRO; HUBER, 2012), where the sudden release of a larger amount of water coinciding with the high tide period in the board area would certainly have consequences, although this is unlikely between October and December, when the Xingu flow is reduced (SANTOS, 2009).

The Resolution 48 published in February 28, 2011 establishes in its Article 2 that the water availability for energy generation corresponds to the natural affluent flows (based on a series from 1931 to 2007, 76 years), subtracted from the average flows destined to the service of other upstream consumptive uses and of the flows destined to the maintenance of a flow hydrogram in the reduced flow segment ranging from maximums of 1800 to 4000 m^3/s (March-April-May) to a minimum of 700 m^3/s (October), in terms of monthly average.

Besides the effects that can be associated to the variation of water level, other elements can be identified that directly or indirectly are due to the implantation of the infrastructure of the reservoir as well the consequences of the enterprise for the region.

Among the factors associated with the impacts on the physical-biotic environment with the reservoir's implantation are: the formation of a reservoir increases the hydrostatic pressure on the nascent areas along the river and on the rivers that are dammed, which can lead to changes in natural feed and aquifer drainage (ELETROBRAS, 2009); the deforestation and increased erosion along riverbanks and streams; the elimination of the flood pulse; the changes in the river flow and changes in the hydrological cycle in the Grande Volta region; the loss of habitat and biodiversity; the loss of connectivity and migration routes; and changes in water quality (SANTOS, 2009).

The hydroelectric dams have large emissions in the early years from tree death, with the underwater decomposition of soil carbon and leaves from the original forest, and the explosion of macrophytes in the early years due to higher water fertility (FÉLIX FILHO, 2013).

The elements of a social nature related to the hydroelectric plant are diverse and come from historical discussions of more than 20 years (FEARNSIDE, 2006). Even with the reduction in the number of dams, the project was rejected by a broad social movement that brought together the indigenous peoples of the Xingu River, environmental activists, opposition politicians to the Brazilian government and people of international visibility (BERMANN, 2012).

One of main discussions about the negative impacts linked to the dam complex is the significant increase in population of Altamira, since not only those people who will work directly on the project will be displaced, but also those ones that are looking for jobs, as according the projections for the 2020, 2025 and 2030, in which the municipality will have a considerable increase of residents (Table 1); causing social and economic problems to the government (SOUZA JÚNIOR; REID, 2010). It is worth noting that from 2000 to 2009, while the State of Pará had an average annual population growth of 1.95%, the Xingu region presented 2.75% for the same period.

Table 1 - Population projection for municipalities in the Xingu basin area.

Municipalities	2009	2014	2020	2025	2030
Altamira	98.750	128.846	123.958	128.996	134.239
Anapu	20.421	25.753	25.194	26.218	27.284
Brasil Novo	19.754	24.519	24.177	25.159	26.182
Medicilândia	23.682	25.222	26.921	28.015	29.154
Pacajá	41.953	44.681	47.691	49.629	51.647
Placas	19.592	20.866	22.272	23.177	24.119
Porto de Moz	28.091	29.918	31.933	33.231	34.582
Senador José Porfírio	14.434	18.102	17.758	18.480	19.231
Uruará	59.881	63.775	68.071	70.838	73.717
Vitória Xingu	9.664	43.207	26.817	27.907	29.041
Total	336.222	424.889	414.791	431.650	449.195

Source: PARÁ (2010).

In economic terms, the implementation of the Belo Monte Hydroelectric Power Plant, the paving of the Transamazônica Highway and the construction of the Transmission Line Tucuruí - Belo Monte - Manaus will transform the regional economic structure, which implies the need to promote land regularization (90.8% of the territory are under federal jurisdiction), to reduce conflicts on ownership of land (PARÁ, 2010). The uncertainty of land ownership in the Amazon, even with several accessible and available technologies for mapping, monitoring, crossing and data analysis, has limitations for the implementation of sustainable production and conservation policies in the region. To give way to the construction sites in Belo Monte and, more recently, to the reservoirs, 1934 families were registered for removal in rural areas until January 2015. The compulsory displacement of the population is the most sensitive impact of dam construction in Brazil (BRITO; CARDOSO JR., 2015; FGV, 2016).

Such factors should foster activities in the region, such as the agricultural-extractive sector, fishing activity (which is a source of livelihood of great importance to indigenous and communities in general) and river navigation. The last two activities correspond the ways of using the Xingu River in 72.9% and 67.09%, respectively, of the total domestic groups (RIMA, 2009).

According to Fearnside (2006) the Belo Monte hydroelectric dam would represent the beginning of a chain of dams in the Xingu; which would include the Babaquara reservoir, with twice the flooded area of the Balbina dam. The uncertainty about the future and the large amount of information produced have led several social sectors to speculate about the diverse impacts that the region would suffer after Belo Monte project (HALL; BRANFORD, 2012; FÉLIX FILHO, 2013; STICKLER et al. 2013).

The region needs more consistent positions in order to formulate real scenarios, so that appropriate public policies can be implemented to manage the effects of the Belo

Monte project and thus to condition some future possibilities for a greater and better social insertion of this type of enterprise large in the region.

Material e methods

In the evaluation of the vulnerable areas to the seasonal floods of the Xingu River, it was used fluviometric quota data from 1969 to 2012 - 44 years, provided by the National Water Agency (ANA); and we delimited the level predicted for the maximum floods (100 m) and the floodplain range, based on the digital terrain model elaborated for the region.

For the investigation of social vulnerability, the methodology developed by Szlafsztein et al. (2010), based on the combination of different socioeconomic variables (total, old and children population, educational level and poverty level), was adopted for the production of a single numerical value - the Social Vulnerability Index (IVS). In the construction of this index, a group of variables that have a high contribution to the characterization of the population's vulnerability in the face of a disaster risk, are identified, defined and analysed together (Table 2).

The objective is to apply an indicator of social vulnerability, obtained from public databases and that represent the relationship between risk areas and society. The IVS identified in this study reflects the social characteristic for the classification of vulnerability in the flood periods in Altamira, on the municipal level. The procedure for obtaining IVS includes the following steps:

a) Collection of information from IBGE's aggregated database (SIDRA), corresponding to Census (survey conducted by IBGE every ten years) for the years 1991/1996, 2000 and 2010. Table 2 presents the five variables and its definitions and importance for the construction of the IVS. The information that subsidized the poverty level (GINI index) for the year 1996 refers to the survey carried out for 1991.

The GINI index assesses the degree of income concentration (GUIMARAES; FEICHAS, 2009). This index is based on the Lorenz curve (Moreira et al., 2009), and compares the observed distribution of a variable with its uniform distribution of equality, being represented by a diagonal line, thus, the index is a summary measure of deviation of the Lorenz curve in relation to the equality diagonal, varying from 0 to 1, where the value 0 represents the equality situation (all have the same income) and the value 1 the opposite extreme (wealth is concentrated in a few groups). This will be used in the analysis integrated with the variables that characterize the IVS.

In order to validate the selected indicators, we used:

- Analysis of Variance - ANOVA (F) is accepted that the y values may vary because they represent different levels of influence independent of a factor (LOUREIRO; GAMEIRO, 2011).
- Coefficient of determination (R^2) - is the square of Pearson's moment-product correlation coefficient. Triola (1999) explains that there is a correlation between two variables when one of them is related to the other in some way.

Table 2 - Variables and classification of the Social Vulnerability Index.

(a) Variables used for the construction of the Social Vulnerability Index.

Variables	Acronym	Definition	Importance
Total population	PT	Proportion (%) of the total population of the State that corresponds to the population of the municipality.	The decision to locate populations in areas susceptible to threats increases the vulnerability of society (KATAYAMA, 1993).
Children population	PIN	Proportion (%) of the total population corresponding to children between 0 and 4 years.	Children are usually among the first victims in periods of disaster because of their high dependency on the family. The effects of disasters range from physical (e.g. loss of life and injury) to psychological panic and the uncertainties associated with evacuation (UNDRO, 1992).
Old population	PID	Proportion (%) of the total population, corresponding to people over 60 years.	Older people suffer when their homes must be evacuated and present difficult to recover from the loss of their belongings and other economies (QUARENTELLI, 1994).
Level of Education	E	Proportion (%) of the total population, which has less than 4 years of study.	People who have not yet completed the first stage of elementary education in Brazil, the old primary course of four years, called the first cycle of elementary education and regulated by the Law of and bases of Education in 1996.
Level of Poverty	P	Proportion (%) of population, corresponding to heads of households with incomes less than two minimum salary.	Poverty is closely related to social marginalization and lack of access to resources, making this population group the main target of the impacts of disasters and climate change (SZLAFSZTEIN, 1995).

(b) Classification of vulnerability according to the grouping of social variables.

Vulnerability	Classification	Total population	Children population	Old population	Level of education	Level of poverty
Low	1	Until 10%	Until 10%	Until 10%	Until 30%	Until 30%
Moderate	2	10% to 20%	10% to 20%	10% to 20%	30% to 50%	30% to 50%
High	3	Greater than 20%	Greater than 20%	Greater than 20%	Greater than 50%	Greater than 50%

(c) Classification of vulnerability according to its degree of social vulnerability.

Classification Vulnerability	Calculated Value of IVS	Final IVS
Low	Between 1 e 1,7	1
Moderate	Between 1,8 e 2,3	2
High	Between 2,4 e 3	3

Source: Szlafstein et al. (2010).

• Test t - One of the most used methods for evaluating different statistics among data samples. Used to verify that the arithmetic means of different samples can be considered different from a given level of pre-established significance (BUSSAB; MORETTIN, 2004).

b) Identification of the vulnerability levels of the studied population, for each of the socioeconomic variables, according to what is presented in Table 2.

c) The construction of the Social Vulnerability Index (IVS) was based on the methodology developed by Szlafsztein et al. (2010) through the application of equation 1.

$$IVS = \frac{(PT+PIN+PID+E+P)}{5} \quad (1)$$

Where: PT- Total Population Index; PIN - Children Population Index; PID - Old Population Index; E - Education Level Index and P - Poverty Level Index.

d) Classification of social vulnerability relative to each degree according to Table 2.

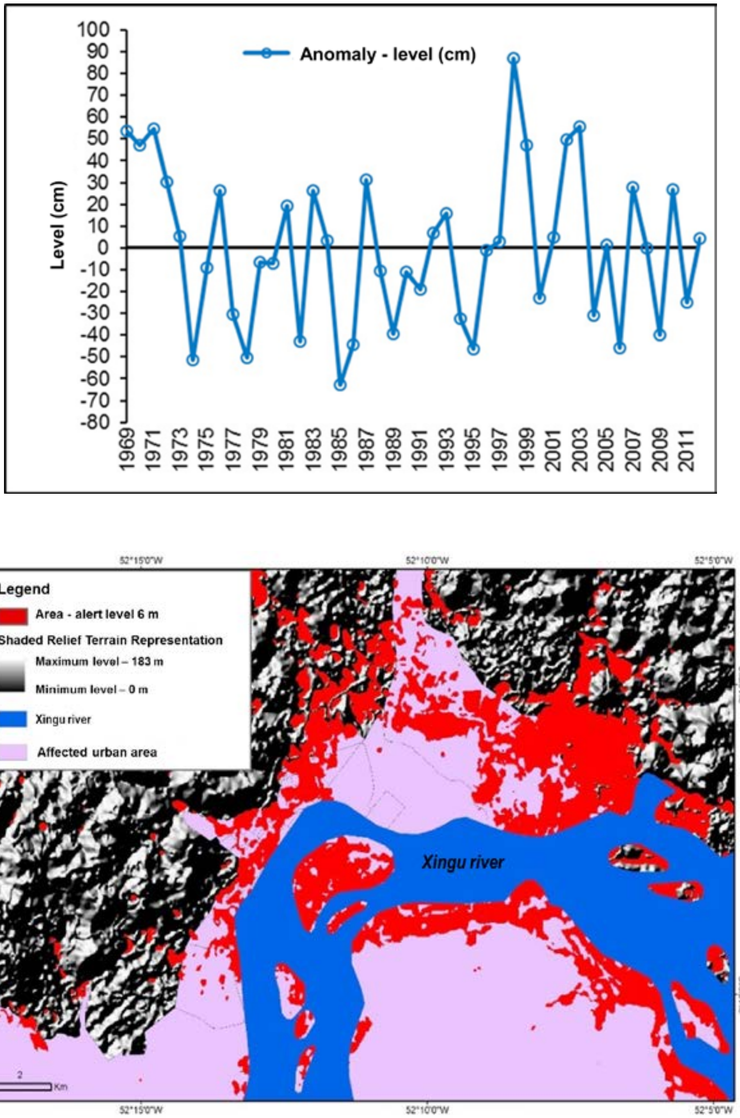
In order to delimit the predicted level for the maximum floods and the floodplain range, the digital terrain model was used to represent a mathematical model that reproduces a real surface from algorithms and a set of points (x, y, z) that describe the continuous altimetric variation of the surface (ASSAD; SANO, 1998). The 6 m height was used as reference; this was defined by the Municipal Civil Defense as a alert level for the riverine populations (1 m from the flood level) (APAC, 2104).

Results and discussion

Figure 1(a) shows the annual evolution of the Xingu River quota anomaly in Altamira during the analysed period (1969 to 2012, 44 years). A variation between -80 and 100 cm is observed with a greater amount of negative anomaly events, but the events with positive anomaly show values with greater significance, for example in the years 1969 to 1971 and 1999, 2001 and 2003, in which is noted a positive anomaly between 50 and 60 cm and in 1998 with approximately 90 cm, which shows significant flooding events in the floodplain area of the Xingu river in the municipality, already occupied by housing and productive activities (including main tributaries near the urban area), linked to the extraction of clay and sand.

Figure 1(b) illustrates the digital model of flooded area with boundary of the alert level in the city of Altamira, that is, the area with the greatest influence to the effects of Xingu river floods.

Figure 1 – (a) Annual evolution of the Xingu river quota anomaly (b) Flooded area model with boundary of the alert level (6 m) in the city of Altamira.



Source: Prepared by the author.

Note that not all of this area is seasonally flooded, but it can be classified as subject, since it is in the natural floodplain area, defined from the channel boundary (approximately 90 m elevation) until the 100 m elevation (ACSELRAD; MELLO, 2009). According to the weekly Hydroclimatic Monitoring Bulletin nº 1278/2014 (SUDAM, 2014), the quota of the Xingu River reached 8 m in April/2014, when the alert quota is 6 m.

In the region defined as the area of influence of the floods, according to the IBGE survey (2010), about 12900 households are registered, indicating the severity of the seasonal impact of floods in the region.

According to Ribeiro and Carneiro (2016), many places in the Brazilian Amazon experienced annually the flooding of rivers, whose event has diverse impacts on the living conditions of rural and urban populations, especially the issues related to health, education, basic sanitation, work, income and housing. The authors emphasize that this reality is more evident if viewed the daily life of the families that live on the Amazonian riverine zones.

Floods in urban areas occur due to uncontrolled growth, lack of infrastructure, poverty, and weak political structure. This combined with the occupation of spaces exposed to natural threats, can generate environments of intense social vulnerability and a weakening of the society's capacity to respond to emergencies (QUINTAIROS, 2012).

In the municipalities of the State of Pará, floods and floods are frequent during the rainy season (December to May), which is the summer/fall of the southern hemisphere. In this interval, municipalities such as Santarém, Marabá and Altamira face great difficulties due to disorderly occupation near riverside, resulting in homelessness, housing collapses, garbage accumulation and disease increase conditions. Souza and Almeida (2010) show that communities living near course of the Amazon River suffer serious socioeconomic and environmental impacts caused by floods, making the population susceptible and vulnerable.

In the socio-environmental vulnerability assessment, the data referring to IBGE censuses for the years 1991/1996, 2000 and 2010 were compared; and the analysis of variance (F), R^2 and t-Test indicated that there is a difference (independence) between the variables adopted (Table 3b).

Based on these proportions, the results of the vulnerability level of the studied population for the five variables are shown in Table 3.

Table 3(c) shows that in the 1991/96 census, the total population (PT) of the municipality represented 1.43% of the total population of the state, 11.8% of the children population (PIN), 4.23% of old population (PID), the percentage of people with less than four years of schooling - Level of Education (E) in Altamira was 37.7% and the level of Poverty (P) approximately 35%. In the census of the year 2000, there was a decrease in the PT variable to 1.21%, on the other hand, the other variables PIN, PID, E and P increased, especially the variable poverty level that doubled its value. The increase in the value of these variables (2000 census) may be related to the significant inundation event of the floodplain area in 1998 (Figure 1a), especially with the variable poverty level, since with flooding many families move to other areas, having to live in inferior conditions. In 2010, the values of the variables PT, PID and P increased, and PIN and E presented a considerable decrease, despite the significant increase in the variable poverty level (P).

Table 3 - Analytical variables adopted.

(a) Defined values for the indicators considered			
Variables	1991/1996 %	2000 %	2010 %
PT	1,43	1,21	1,30
PIN	11,81	12,00	9,30
PID	4,23	5,19	6,70
E	37,72	47,43	25,57
P	34,68	76,04	83,45
GINI	0,59	0,58	0,57

(b) Statistical tests applied, according to the group of indicators (i) per year				
Groups		$i_{91/96}$	i_{2000}	i_{2010}
R^2		0,96	0,98	0,98
Test-t		2,19	1,87	1,62
p (α = 0,05)		0,08	0,12	0,16
F (p< 0,0001)	14.61			

(c) Level of Vulnerability of the population of the municipality of Altamira according to five socioeconomic variables, and IVS calculated for the years considered.						
	1991/1996		2000		2010	
Variables	%	Vulnerability classification	%	Vulnerability classification	%	Vulnerability classification
PT	1,43	1	1,21	1	1,30	1
PIN	11,81	2	12,00	2	9,30	1
PID	4,23	1	5,19	1	6,70	1
E	37,72	2	47,43	2	25,57	1
P	34,68	2	76,04	3	83,45	3
IVS		1.6 (Low)		1.8 (Moderate)		1.4 (Low)

(d) Population variation of Altamira and its relation with the total population of the state of Pará							
Years	1991[1]	1996[1]	2000[1]	2007[2]	2010[1]	2014[2]	2020[2]
Relation (a/b) %	1,46	1,43	1,21	1,31	1,30	1,60	1,44
Population – Altamira(a)	72.408	78.782	77.439	92.105	99.075	128.846	123.958
Total population - Pará (b)	4.950.060	5.510.849	6.386.876	7.031.660	7.638.340	8.073.924	8.628.901

[1] Count from IBGE Census. [2] IBGE estimates.

The calculated IVS was moderate to low, where the population variables (total, children and old) were the ones that contributed the most to these values. The total population of Altamira had a significant increase from 2000 to 2010 (an increase of 21.84%), motivated by the intense migration generated by all processes around the Belo Monte plant's implementation. However, for IBGE, is estimated a reduction of this value until 2020 to around 4% of the total expected in 2014.

The population increase in areas subject to Large Investment Projects (GPIs) (BORTOLETO, 2001) can have several consequences. For Zhouri and Oliveira (2007), who dealt with communities affected by hydroelectric projects in the Jequitinhonha Valley (Minas Gerais), the populations living in GPI sites understand the territory as patrimony, which generate some conflicts with the conception of these projects, generally conceived in the framework of a development policy restricted to economic growth, thus generating social conflicts, which can cause tensions, disputes and extreme reactions on the part of social movements and local mobilizations.

In this discussion, Cruz e Silva (2010) complement that the negative effects in resident populations in these areas are many; and these do not occur only at the time of construction. They are felt in time and space and can sometimes cause problems that will remain for many years (FILIZOLA et al., 2006).

Siqueira Soares et al. (2014) concludes that the disorderly growth of cities linked to the lack of urban planning makes populations susceptible to natural disasters. The decrease in the percentage of the level of education in Altamira in 2010 may also be a reflection of the number of migrants to the region, which offers employment to a lower qualified workforce. Data from the National Employment System (SINE) recorded, from January to March 2010, 8266 registrations for Altamira that is equivalent to almost double of the 4218 registrations obtained in 2009.

According to the United Nations Development Program (PNUD), the municipality of Altamira presented IDHM Education (Municipal Human Development Index) of 0.322 in 2000 and 0.548 in 2010, an index considered low, despite the increase in 2010 (PNUD, 2013). The low level of education has been identified as one of the determinants of high poverty rates (the only factor that ranged from moderate to high), which in turn is also related to social vulnerability.

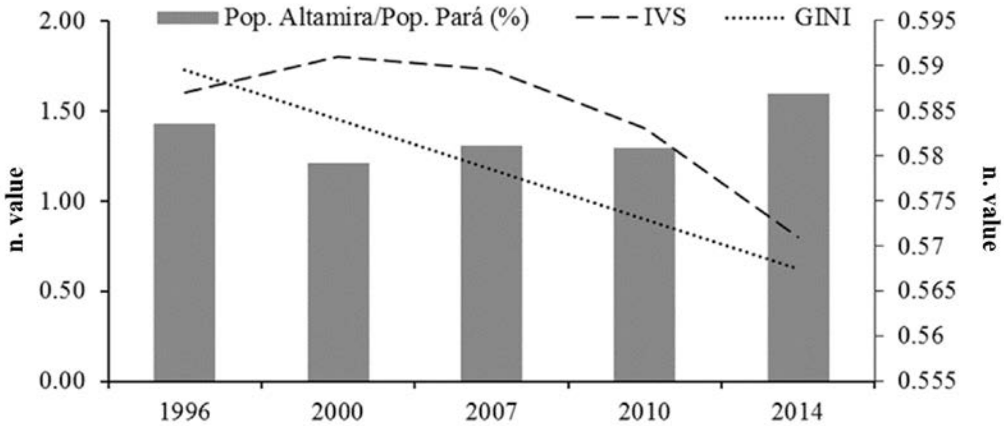
According to Szlafsztein (1995), poverty is closely related to social marginalization and lack of access to resources, which makes the poor population the main target of the impacts of natural disasters, since they are generally located over risk areas, notably in regions presenting high risk of seasonal flooding (the lowlands).

Poverty is a multidimensional phenomenon in which there is a lack of what is necessary for material well-being (CRESPO; GUROVITZ, 2002). This concept is associated with the lack of voice, power and independence of the poor that subjects them to exploitation; propensity to diseases; lack of basic infrastructure, lack of physical, human, social and environmental assets, and greater vulnerability and exposure to risk.

Figure 2 illustrates a period of time (1996-2014) with the great population migration resulting from the construction of the Belo Monte plant, and in turn the arrival of workers from the most diverse formations and regions; this situation directly influenced local socioeconomic indicators (SILVEIRA et al, 2017).

The results obtained from the profile that characterized the IVS (predominantly from moderate to low), and the use of a complementary form of the GINI index (Figure 2), demonstrate that apparently the picture shown as high susceptibility to flood occurrence would have its impact reduced by the fact that the population of Altamira has a profile capable of responding and setting the lowest number of liabilities, that is, a moderate to high resilience. Before regularization of the flood quota in the municipality, the population usually absorbed the seasonal fluctuations migrating during the flood periods and

Figure 2 - Integrated assessment considering the % of the Altamira population relative to the state of Pará, the IVS and the GINI index, period from 1996 to 2014*.



Source: Prepared by the author.
* The values for 2007 and 2014 were estimated for the IVS and GINI from trend curves.

returning to their homes when the situation backs to normal conditions. According to Saavedra and Budd (2009), resilience is man's ability to anticipate future changes and dynamics in order to adapt and be prepared to deal with them, with land-use planning being one of the tools to reduce losses and damages.

However, there are facts such as the recorded by the Official Diary of the State of Pará (DOE) in March 21, 2013 with the Decree No. 96/2013 in which was declared an emergency situation in the municipality, due to excessive rainfall in the areas of the basins of the Ambé, Altamira and Panelas streams and the Xingu river, which affected many families, among children, young, adults and the old people. The majority of the population affected is those inhabiting located in regions with quotas less than 100 m. This indicates a reality not counted by the numbers, since they translate a larger sample, which does not allow evidence the existing differentiations.

Bortoleto (2001), Carvalho (2008) and Franco and Feitosa (2013) argue that changes in the physical and biotic systems have their repercussions in the social, economic and cultural aspects of the regions subject to the effects of dam leases. Where the social-space impacts caused by large floods in urban perimeters (commercially productive) and rural properties located near the reservoirs (usually high natural fertility); which consequently maintains a status of permanent loss and the need for efficient public policies that act in the reduction or elimination of the generated liabilities.

Manyari and Carvalho (2007) studied the behaviour of fluviometric quota before and after the Tucurí-PA Hydroelectric Power Plant, and observed that the highest-level frequency was between 2 and 3 m, which was 20% before the dam and 35% after the dam. The level variation before and after the dam is recorded as similar for the heights between 6 m and 11 m, all with a variation of 5% of frequency. Although they constitute distinct reservoirs, it is observed that even when is a regulated, the level has a significant variation, which should be predicted and analysed with some criteria, since according to Figures 3 and 4 between 1969 and 2012 the highest frequency of quotas in the Xingu River was around 6 to 7 m, indicating the recurrent situation of threat to the local population.

Comparing the results of Manyari and Carvalho (2007) with other studies, we have:

Iwama et al. (2014) call attention to the risks associated with extreme climatic events that may reach everyone independent of socioeconomic status, so that the preventive actions and prospective planning as a basis for disaster risk reduction are increasingly urgent. Some municipalities in the state of Pará, (for example, Marabá) suffer every year with the seasonal floods, and many disorders can be avoided from preventive actions to the population.

Medeiros and Souza (2016) have identified some districts in Ceará that have greater risks of loss of well-being, generated by possible changes in economic, social, political and environmental plans.

Santos (2015) has shown that there is a close relationship between environmental fragility and social vulnerability and susceptibility to risks. And, Alves (2013) explains that socio-environmental vulnerability can be described as “the coexistence, cumulativeness or spatial overlapping of situations of poverty and social deprivation and situations of exposure to environmental risk”.

Final considerations

The municipality of Altamira presented moderate to low vulnerability in the analysed period (1996 to 2014). However, this result may not configure the existing effective situation. The construction of the Belo Monte Hydroelectric Plant showed a migration effect to the region, which was detected by the 2010 census. The before and after the construction of the plant should show a new regional framework that should cause changes in the values of the variables studied.

The wetland digital model illustrated a broad region subject to variations above the 6 m alert level, indicating that the population of the city of Altamira lives under the threat of the effect of the Xingu seasonal floods and that the planned works with the construction of the Belo Monte plant should be associated with an efficient territorial reordering project in order to minimize the impacts generated by the removal of the significant number of people residing in these areas.

The IVS considers a number of variables, which demonstrate a level of efficiency among them, but the applied database must have specific sample spaces; for example, the constant relation with the total population of the municipality did not emphasize the possible concentration of the old and children in the places where the overcoming of the 6m alert quota is more recurrent. The results of the integrated analysis demonstrate the need to develop an index with a more robust set of variables that allow the identification of internal differences within the municipality.

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Submitted on: 19/09/2016
Accepted on: 11/03/2018
http://dx.doi.org/10.1590/1809-4422asoc0157r3vu18L1AO
2018;21:e01573
Original Article

FLOODS AND SOCIAL VULNERABILITY: STUDY ON THE XINGU RIVER IN ALTAMIRA / PA

Abstract: The objective of this research was to classify the social vulnerability in Altamira--PA, considering the occurrence of seasonal floods and the future scenario of stabilization of the water level in the flood quota. The Social Vulnerability Index was determined by using fluviometric station data provided by ANA and socioeconomic variables from IBGE. The results indicate a moderate to low vulnerability that does not reflect the socio-spatial environment of the area, where the alert level of 6 m is recurrently exceeded during the floods of the Xingu river. The Belo Monte hydroelectric power plant will ensure the maintenance of the level of floods, which implies in the demand of urban planning that can reduce the liabilities generated by both the maintenance of wetlands, and for the extensive relocation of people, in addition by studies that assess the influence and consequence of extreme events in the region.

Keywords: Extreme events. Flood. Belo Monte.

Resumo: O objetivo desta pesquisa foi classificar a vulnerabilidade social em Altamira--PA, considerando a ocorrência das cheias sazonais e o cenário futuro de estabilização do nível d´água na cota de cheias. Para determinar o Índice de Vulnerabilidade Social foram utilizados dados de cota fornecidos pela ANA e variáveis socioeconômicas do IBGE. Os resultados indicam uma vulnerabilidade de moderada a baixa que não reflete o ambiente sócio espacial da área, onde é recorrente a superação do nível de alerta de 6 m durante as cheias do rio Xingu. A Usina Hidrelétrica de Belo Monte irá regularizar a manutenção do nível das cheias, o que implica na demanda de um planejamento urbano que reduza os passivos gerados tanto pela manutenção das áreas alagadas, quanto pelo amplo remanejamento de pessoas, além dos estudos que avaliem a influência e consequência dos eventos extremos na região.

Palavras-chave: Eventos extremos. Inundação. Belo Monte.

Resumen: El objetivo de esta investigación fue clasificar la vulnerabilidad social en Altamira--PA, considerando la ocurrencia de las inundaciones estacionales y el escenario futuro de estabilización del nivel de agua en la cuota de inundaciones. Para determinar el Índice de Vulnerabilidad Social se utilizaron datos de cuota proporcionados por ANA y variables socioeconómicas del IBGE. Los resultados indican una vulnerabilidad de moderada a baja, que no refleja el entorno socio - espacial de la zona, que se repite la superación de nivel de alerta 6 metros durante la inundación del río Xingu. La planta hidroeléctrica de Belo Monte regulará para mantener el nivel de las inundaciones, lo que implica la demanda de planificación urbana que reduce los pasivos generados por tanto el mantenimiento de las zonas húmedas, como la amplia reorganización de las personas, y por estudios de evaluación de la influencia y los efectos de eventos extremos en la región.

Palabras Clave: Eventos extremos. Inundación. Belo Monte.