

*FLOODS AND SOCIOENVIRONMENTAL  
VULNERABILITY IN THE MUNICIPALITY OF  
ATIBAIA, SP - BRAZIL*

ENCHENTES E VULNERABILIDADE SOCIOAMBIENTAL NO MUNICÍPIO DE  
ATIBAIA, SP – BRASIL

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**ABSTRACT**

The occurrence of floods is increasingly common in urbanized areas and creates a multitude of hazards and socioenvironmental vulnerabilities. The municipality of Atibaia in the state of São Paulo (Brazil), which was flooded in the years of 2002, 2009, 2010, and 2011, had some of its socioenvironmental vulnerabilities analyzed. Thus, this paper aims to analyze the occurrence of floods in Atibaia from 2000 to 2012. The methodological approach involved a review of the scientific literature, as well as the collection of secondary data from various governmental and non-governmental organizations working in this region.

**Key-Words:** Floods. Vulnerability. Urban Areas. Atibaia.

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**RESUMO**

A ocorrência de enchentes e inundações é cada vez mais frequente, sobretudo em áreas urbanizadas, criando uma infinidade de perigos e vulnerabilidades socioambientais. Algumas dessas vulnerabilidades foram examinadas com o exemplo de Atibaia, município do estado de São Paulo (Brasil), que foi submetido a inundações repetidas entre 2002, 2009, 2010 e 2011. Desta forma, o objetivo deste artigo é analisar a ocorrência de enchentes em Atibaia, no período de 2000 a 2012. A metodologia envolveu revisão da literatura científica, bem como a coleta de dados secundários de várias organizações governamentais e não-governamentais atuantes na região.

**Palavras-chave:** Inundações. Vulnerabilidade. Áreas urbanas. Atibaia.

**INTRODUCTION**

Technological advances have significantly changed social dynamics. While improving some aspects of life, e.g. facilitating access to services and consumer goods, such advances lead to a more comfortable and healthier life. They also promote changes in social and cultural habits. Due to the population growth, these changes are a driving force for the urbanization of cities. As a result, it increased the production levels demand and the level of energy that led to increased levels of waste. Along with other factors, these changes affect the quality and availability of natural resources (HOGAN; MARANDOLA, 200), that generate social tensions and increase companies' exposure to multiple risks and vulnerabilities.

The constant and progressive pressure on water resources, due to the growth of cities, sometimes fail to respect the individual geological conditions and the natural course of rivers is important in this context. For instance, roads construction on river banks lead to natural problems, such as floods, which are later "solved" by channeling rivers (AMARAL; RAJA, 2012; TOMINAGA; SANTORO; AMARAL, 2012).

The urbanization does not only alter the superficial landscape of an area, but also the hydrological dynamics of river basins, including changes to the watercourses.

As cities are urbanized surfaces they are sealed and there are high peak flows, which increase the flow capacity through pipelines and canals. Unprotected river surfaces lead to a higher production of sediments and these elevated levels of solid waste can be partially responsible for floods (TUCCI, 2008). Along with the vegetation, the soil

should in theory, facilitate the flow of water through suction, but in fact, it hinders the ability of water to infiltrate the ground in some areas, and making it virtually impossible in others. This ultimately favors the runoff, interferes with the watercourses and modifies the behavior of the surface area (AMARAL; RIBEIRO, 2012; TAVARES; SILVA, 2008; PINHEIRO, 2014; THOMAZIELLO, 2007).

Floods occurrence is increasingly common in urbanized areas and create a multitude of hazards and socioenvironmental vulnerabilities in many parts of the world. As demonstrated in the study by Galloway (2008), which presents the impacts of the Great Mississippi River Flood, occurred in 1993 and of the Hurricane Katrina in 2005, both in the United States, in which thousands of people lost their lives and flood damages were estimated at more than \$ 120 billion (U.S.).

According to the emergency database (EM-DAT), an international database on disasters, 98 flood and inundation-related emergencies were registered worldwide in 2013. Since many countries do not keep an up-to-date database for these events, the actual numbers must be even higher. Globally, these events caused 8,355 victims, where Asia is the most affected continent (EM-DAT, 2012). Floods and inundations, as 118 floodings registered, which were recorded there between 1900 and 2013 also heavily affected Brazil. These disasters caused 7,668 fatalities and affected more than 19 million people (EM-DAT, 2008). Floodings occur and have been studied in several regions of Brazil. For example, Rio Claro, in the state of São Paulo, received more than 6 billion liters of water within a few hours in January 29, 2005, which resulted in an inundation of great magnitude and a subsequent urban chaos (TAVARES; SILVA, 2008). Nationwide, the highest numbers of flood and inundation related casualties were recorded for the metropolitan area of São Paulo (TOMINAGA; SANTORO; AMARAL, 2012). Another interesting example is the municipality of Jaragua do Sul in the state of Santa Catarina. In 2008, severe floodings and inundations caused 13 fatalities, leaving 147 people injured and 40 homeless families (SILVA; PINTO, 2013).

Similar events were also recorded for Atibaia (São Paulo). From 2009 to 2011, several floods affected 6.835 people in 28 districts of the municipality (SEDEC, 2010; SEDEC, 2011). The problems arising from these events were intensified by a conflict regarding the reactivation of the small Atibaia hydroelectric power station (Pequena

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Central Hidrelétrica Atibaia - PCH Atibaia), which is located in a rural district of the municipality. A group, mainly consisting of members of an association of flood-affected residents (Associação dos Moradores dos Bairros Atingidos pelas Enchentes - AMBAE), is against the reactivation of PCH Atibaia because they believe it causes the floods.

Based on this situation, the objectives of this article are: 1) to survey the occurrence of floods in Atibaia from 2000 to 2012 by using data from the federal emergency management agency (Secretaria Nacional de Proteção e Defesa Civil). 2) To review the scientific literature on the concepts of socioenvironmental risks and vulnerabilities. 3) To identify relevant social organizations and their position in relation to the reactivation of the PCH Atibaia. The methodological approach involved a review of the scientific literature, as well as the collection of secondary data from various governmental and non-governmental organizations working in this region.

## **SOCIOENVIRONMENTAL RISKS AND VULNERABILITIES CAUSED BY FLOODS**

The discussion about social and environmental risks seems to be intensified recently, presumably because of the increasing occurrence of a variety of natural disasters. In addition, potential risks seem to be generated at a steadily increasing pace, due to the highly accelerated process of modernization (BECK, 1992; MATTEN, 2004). These risks have emerged as one of the major causes of the capitalist system and even raise capital in the insurance industry as well as use the production of objects for the prevention of risks (BECK, 1992).

Several scientific research areas focus on risk as the object of their studies and approach the concept from different angles (e.g. environmental, social, economic, political or medical), thus adding high levels of complexity when studying it. The risks may be related to the climate change, human interventions in the environment and subsequent global environmental degradation, as well as to situations involving

personal relationships, family and sexuality (GIDDENS, 2000). These situations generally contribute to the induction of stress and tensions within the population. Regarding environmental changes, different social groups will be affected by different types of risks and as well as different levels of risk exposure. Depending on living conditions, access to basic sanitation and medical services, and the particular socioenvironmental situation such groups will have their lives affected in various levels. The latter will determine the level of vulnerability for any given social group. The close relationship between risk and vulnerability is an extremely important issue, since the level of vulnerability of a particular element (i.e. an area, a society, a natural resource, etc.) is a determining factor for the social and environmental consequences or impact of a particular risk. An assessment of risks is essential to identify all the factors, which potentially affects a particular element (PEREIRA; SOUZA, 2006). Vulnerability is the result of complex interactions between environmental, social and economic systems. The vulnerability increases according to the level of exposure to the risk. This means that an analysis of vulnerability determines potential solution strategies for the risk (REBOTIER, 2012; KRISHNAMURTHY; LEWIS; CHOULARTON, 2014). Risk is consequently related to the probability of occurrence and exposure to a stressful situation (BAAN; KLIJIN, 2004), whereas vulnerability is related to the level of sensitivity towards the exposure to this stressful situation.

For Freitas and Cunha (2013), hazards such as floods and inundations can affect human beings directly or indirectly, individually or collectively. The level of vulnerability - regarding ecological or social conditions - is related to the response capacity towards the hazard. Adger (2006) on the other hand considers vulnerability as the state of susceptibility to damage from exposure to stress associated with environmental and social changes and a lack of adaptability. Given the characteristics of this research, we decided to use the concept of environmental vulnerability according Oni and Okanlawon (2013), for whom the term social (or environmental) vulnerability means that vulnerability is not only influenced by exposure to causes related to environmental stress, but also by social conditions. Within this context, vulnerability is the ability of a social group or individual to anticipate and recover from

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the impacts of disasters (WISNER; BLAIKIE; CANNON, 2013) and the increase of floods in urbanized areas is a good example of these impacts.

Several concepts for the terminology of floods or inundations can be found in the scientific literature on the subject. For Tucci (2008), two types of floods can occur in urban areas: 1) floods due to urbanization, i.e. by the use of dirt, which increases impervious areas, and by canal systems. 2) spontaneous floods in riverine areas, which mostly affecting illegal settlements in large riverbeds.

In riverine areas, floods are a natural phenomenon in river dynamics and statistically rivers are likely to overflow every two years in average. However, natural floods may be aggravated due to the obstruction of a river's flow through embankments and bridges, silting and poorly implemented drains (TUCCI, 2008). In this paper, the term "inundation" will be used for natural events, while the term "flood" will be used for events with anthropic causes. Inundations are considered natural phenomena, which periodically occur due to increased levels of precipitation. Riverine inundations may be amplified because of human actions. Floods, on the other hand, occur when parts of the precipitation in a hydrographic basin are unable to permeate the ground. Such precipitation is then retained by an interceptor element and flows until they reach a watercourse. Consequently, the flow of this watercourse gradually increases until it reaches a limit before decreasing again slowly. Increased discharges of water over a certain period are called "flooding" or "overflow" (OSTROWSKY; ZMIROWICZ, 1991). Onwuemele (2012) complements that floods can be described as the overflow of a large amount of water on an area of land, which is usually not submerged. This can result either from exceeding the local drainage capacity or from a combination of extreme hydrological and meteorological events with influence by anthropic factors. Floods cause a sudden and very intense barrier when it comes to space and time, and display very short periods between precipitation and the subsequent inundation of the river. Due to the rapid rise of water levels and the high speed by which sediments and debris are transported, floods represent an extreme threat to life, property and infrastructure. Vargas, Werneck and Ferreira (2008) point out that the principles of current employed drainage controls aim at draining precipitation as quickly as possible. This concept is

based on flow channeling, which is more expensive and causes major secondary flooding when channelings accumulate and have its peak further downstream. As previously mentioned, floods and inundations have been thoroughly studied and discussed in scientific literature. The possible relation between the occurrence of floods and inundations and the increase in rainfall due to natural climate changes caused by the greenhouse effect has significantly raised awareness for these issues (JOTHITYANGKOON et. al. 2013).

Floods in urban areas can occur due to:

- 1) Heavy rainfall over long periods of time and overflowing waterways caused by the hydrological cycle unbalance in regions upstream urban areas.
- 2) Excessive portions of land and the subsequent sealing of surfaces.
- 3) Illegal occupation of permanent sanctuary preservation areas (áreas de preservação permanente - APPs) such as floodplains, known inundation areas and wetlands.
- 4) Obstruction of pipes through debris and sediment.
- 5) Inadequate drainage facilities.
- 6) Urbanization itself when the increased flow is due to plumbing and waterproofing.

Considering urban drainage, sewage can become a major inducing flood and erosion factor, especially in hilly areas with human settlements (VARGAS; WERNECK; FERREIRA, 2008).

In order to obtain a more complete and thorough understanding of flood hazards, it is necessary to integrate human and natural systems, such as the interrelationship between human activities and natural phenomena (CREUTIN et. al., 2013). As previously mentioned floods can be caused by natural factors and be amplified by anthropic factors through the interaction between social and environmental systems (*vide supra*). For some authors, e.g. Ribeiro (2008), the most vulnerable flooding areas are those most vulnerable in socioeconomic terms, such as the part of the population with low or no income who cannot reside in safer locations.

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Nevertheless, not all population segments with low income or irregular occupations inhabit areas vulnerable to floods (FREITAS; CUNHA, 2013). Some affected neighborhoods accommodate predominantly residents from middle and high-income brackets as in Atibaia, which is the target area for this study.

## **METHODS**

The objectives of our study are:

- 1) To survey the occurrence of floods in Atibaia from 2000 to 2012 by using data from the federal emergency management agency.
- 2) To review the scientific literature on the concepts of socioenvironmental risks and vulnerabilities.
- 3) To identify relevant social organizations and their position regarding the reactivation of PCH Atibaia.

Therefore, we conducted a review of the scientific literature on the interconnection among risks, vulnerability, floods and inundations. Besides, further data was collected from various governmental (e.g. Atibaia city hall, Atibaia municipality departments of the environment and civil defense, etc.), non-governmental agencies (e.g. the Associação dos Moradores dos Bairros Atingidos pelas Enchentes - AMBAE) and institutions representing civil society, (e.g. NEPAM/Campinas University) in the region. Damage analysis (ADAVAN) of flood events occurring in 2002, 2009, 2010 and 2010, 2011 were obtained from the state emergency management agency (Secretaria de Defesa Civil – SEDEC). As it comprises the characteristics of these events and the various types of damage (human, physical, environmental, economic and social) involved, they allow a comprehensive evaluation of the disaster intensity. In addition, we reviewed reports from the state department of sanitation and water resources (Secretaria de Saneamento e Recursos Hídricos – SSRH) and the state department of water and electricity (Departamento de Águas e Energia Elétrica) of the state of São Paulo in Brazil. These reports show



hydraulic studies, hydrological and flood zoning plans, and measures to cope with the floods of the rivers Jaguary and Atibaia.

## **CHARACTERISATION OF THE STUDY AREA**

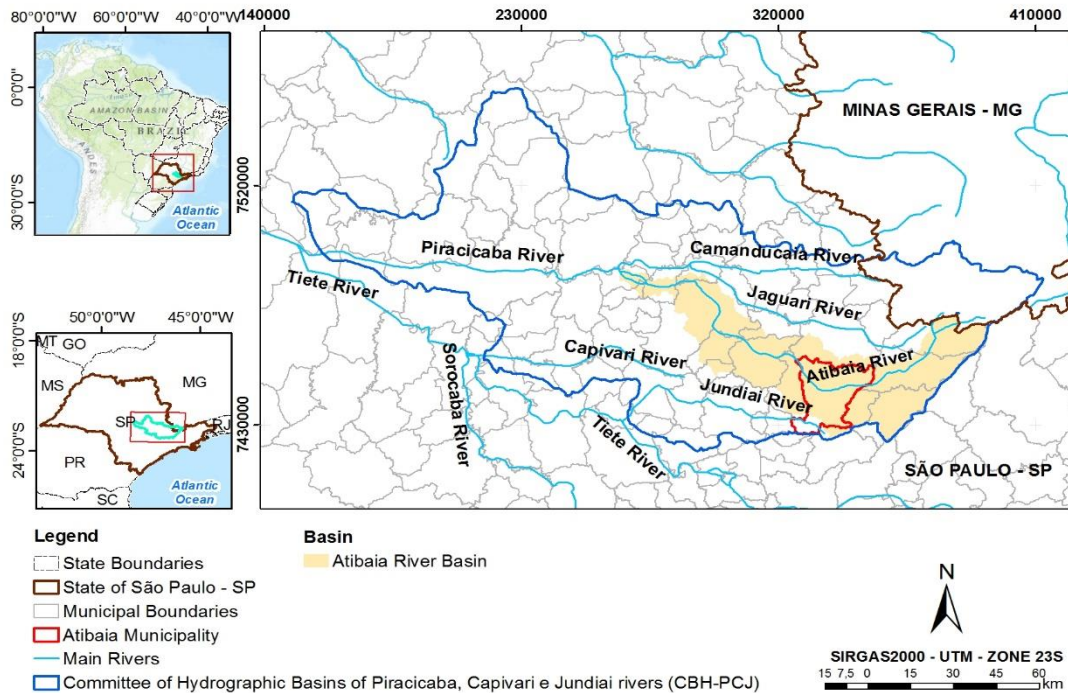
The city of Atibaia is located 65 km north of the city of São Paulo in the state of São Paulo (Brazil), encompasses an area of 478 km<sup>2</sup> and is home of 127,000 inhabitants (ATIBAIA, 2006; IBGE, 2010). Located on the southern foothills of the Serra da Mantiqueira, the municipality of Atibaia forms part of the Bragantina region. It is close to large urban centers (São Paulo, Campinas and São José dos Campos) and considered a tourist destination, which has led to various typical environmental changes in recent decades. Being a hot spot for tourists Atibaia has developed significant industrial services and led to the growth of real estate speculation as many people now use Atibaia as a commuter town for those who work in the outskirts of the city of São Paulo. Atibaia is connected to the Fernão Dias highway (linking São Paulo to the south of Minas Gerais and Belo Horizonte) and the Dom Pedro I highway (linking the country side of São Paulo and Campinas to the Presidente Dutra highway and the port of São Sebastião). These highways are part of the city's plan to establish itself as a major logistic hub (ATIBAIA, 2006). Simultaneously, a process of disorganised occupation can be observed. This highly dynamic process has intensified real estate speculations and it is favored by well-developed traffic routes (HOEFFEL *et. al.*, 2009; SEIXAS *et. al.*, 2012), as the easy access via the Dom Pedro I and Fernão Dias highways has amplified the impacts towards urbanisation and population growth within the city.

According to the national water agency (ANA, 2008), the management of water resources in the state of São Paulo is regulated through the state water resources plan. The plan divides the State into 22 units of water resource management (UGRHIs) and aims to minimize conflicts of interest and to ensure the quality of water by an integrated plan and management. Atibaia is included in UGRHI

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5, which comprises the hydrographic basins of the rivers Piracicaba, Capivari, Jundiá and Atibaia.

**Figure 1 – Location of the hydrographic basin of the Atibaia River and of the Atibaia municipality (regional and national scale).**



Source: produced by the authors (2014).

The Atibaia river basin is the home of one of Brazil’s main industrial centers. Apart from also being densely populated and a major agricultural area, it is almost exclusively responsible for the water supply to the cities of Atibaia (90%) and Campinas (95%). As the Atibaia River is also one of the main rivers feeding the Piracicaba river basin, it is responsible for the water supply for almost 4.5 million people in 60 towns in the region. Despite its strategic importance for the region, the Atibaia River is heavily polluted. About 90% of the urban domestic sewage and 20% of the industrial waste generated in the region are disposed untreated into the river (COMITÊS PCJ, 2010). The core area of this study is the part of the hydrographic basin of the Atibaia River, which lies within the boundaries of the Atibaia municipality.

## **RESULTS AND DISCUSSION**

Floods are caused by various factors related to misuse and inappropriate land occupation of such as sealing, occupation of APPs and increased runoff from urbanized areas in combination with a significant increase in rainfall (TUCCI, 2008; VARGAS; WERNECK; FERREIRA, 2008). Several floods were registered in Atibaia in 2002, 2009, 2011 and 6,835 people were displaced (2002: 802 victims; 2009-2010: 2,668 victims; 2010-2011: 3,365 victims), evacuated or otherwise affected. There were damage and victims in over 28 districts in the municipality. In 2010, the Atibaia River overflowed because of the water levels rose 5 m over normal level. In 2011, water levels rose up to 3.76 m above normal level (SEDEC, 2010; SEDEC, 2011).

Between November 1 and December 31, 2009 there was a precipitation of 601.9 mm, according to data provided by the municipality, registered for the Atibaia river basin in the municipality of Atibaia. In comparison, the historical precipitation average between November 1 and December 31 for this area is 252.4 mm. This extreme and unusual increase in precipitation caused the waters of the Atibaia River to overflow to the riverbanks. The flood was aggravated by rainfall occurring further upstream in the water basins of the Cachoeira and Atibainha rivers, which feed the Atibaia river. In December, the river basins accumulated a total precipitation of 376 mm for the Cachoeira River (historical average for December: 214 mm), 352 mm for the Atibainha River in the municipality of Bom Jesus dos Perdões (historical average for December in Bom Jesus dos Perdões: 196 mm). Still, 327 mm for the Atibainha River in the municipality of Nazaré Paulista (historical average for December in Nazaré Paulista: 196 mm). According to the national federal emergency management agency, such events would have fallen if they opened the Cantareira River reservoir floodgates (SEDEC, 2010).

A summary of floods that caused damage and a conclusive analysis of its intensity in the period of 2002 is presented below:

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**Table 1: Summary of damage evaluation and disaster caused by floods in Atibaia in 2002.**

<b>Damage intensity</b>		<b>Negligible</b>	<b>Average</b>	<b>Important</b>	<b>Very Important</b>
	<i>Humans</i>	-	-	-	-
	<i>Construction material in buildings (infrastructural) USD 11,764.70</i>	X			
	<i>Environmental damages</i>	-	-	-	-
<b>Losses</b>	<i>Economic</i>	X			
	<i>Social</i>	X			
<b>Total</b>	<b>USD 11,764.70</b>				
<b>Aggravating criteria</b>	<i>Importance of secondary disasters</i>		X		
	<i>Lack of preparation with the local emergency management agency</i>	X			
	<i>Level of vulnerability of the floods scenario</i>				X
	<i>Level of vulnerability of the community</i>			X	

Exchange rate: 1 USD = 1.87 BRL (January 2010). Source: Banco Central do Brazil, 2014.  
Source: Own elaboration based on data provided from SEDEC, 2010.

The floods, which occurred in Atibaia in 2002, caused an estimated damage of USD 11,764.70 regarding the destruction of infrastructure. The evaluation considered the disaster's intensity, material, economic and social damages negligible. The aggravating factors such as the importance of secondary disasters were classified as average. However, the lack of preparation of the local emergency management agency was evaluated as negligible. The level of vulnerability regarding the scenario was evaluated as very important. The level of vulnerability of the community were evaluated as important (SEDEC, 2010).

A summary of the damages these floods caused and a conclusive analysis of their intensity in the period of 2009-2010 is presented below:

**Table 2: Summary of damage evaluation and disaster intensity of the floods in Atibaia in 2009-2010.**

		Negligible	Average		Important	Very Important
<b>Damage intensity</b>	Humans		X			
	Construction materials in buildings (Residential, industrial, commercial, works of art, infrastructural, etc.) USD 15,080,007.73				X	
	Environmental damages (sewage, mud, soil erosion, landslides, ground contamination) USD 1,200,127.95				X	
<b>Losses</b>	<b>Economic</b> Agriculture: (grains, corn, leguminous crops, fruits, flowers, etc.) USD 2,392,255.05 Industrial: (extraction and transformation of minerals) USD 1,066,780.40 Services: (commerce) USD 266,695.10	X				
	<b>Social</b> Transport (roads) USD 2,265,308.18 Sewers (collection network, sewage treatment plants) USD 10,667.80 Litter (collection) USD 3,200.34	X				
<b>Total</b>	<b>USD 22,285,042.56</b>					
<b>Aggravating criteria</b>	Importance of secondary disasters		X			
	Lack of preparation with the local					X

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	emergency management agency					
	Level of vulnerability of the floods scenario					X
	Level of vulnerability of the community					X

Exchange rate: 1 USD = 1.87 BRL (January 2010). Source: Banco Central do Brazil, 2014.

Source: Own elaboration based on data provided from SEDEC, 2010.

The floods, which occurred in Atibaia in 2009-2010, caused an estimated damage of USD 22,285,042.00 (including environmental, economic, social damages, destruction of buildings, etc.). For the evaluation of the disaster's intensity, human losses were, albeit deplorable, classified as average. Material and environmental damages were considered important, while economic and social damages were classified negligible. The need for external financial aid was considerable but funds were available, and aggravating factors such as the importance of secondary disasters were classified as average. However, the lack of preparation of the local emergency management agency staff as well as the levels of vulnerability regarding the scenario and the community were evaluated as very important. The evolutionary pattern of this disaster was described as sudden and predictable, with a tendency to increase, all of which resulted in an overall average level of intensity [10].

From December 28, 2010 to January 11, 2011, heavy rainfalls were recorded in the Atibaia municipality with a total precipitation volume of 649.2 mm. In only 7 hours of January 11, 2011, 160 mm of precipitation was recorded, which is equivalent to half of the average precipitation volume for the entire month of January.

Meteorological agencies, unfortunately, did not predicted this unusual strong, high concentrated and intense rainfall recorded over the Serra do Itapetinga. Subsequently, large volumes of water reached the valley where the municipality of Atibaia is located at the same time, thus damaging neighborhoods, which were unaffected in previous floods [11]. This situation is consistent with international data, which show that in 2010 and 2012 hydrological disasters were the most common variety of catastrophe worldwide. In 2010, they accounted for 56.1% of global disasters, while in 2012 they accounted for 49.4% [35, 36]. In 2012 Brazil reached the

10<sup>th</sup> place for the worldwide ranking of countries with high climatological and hydrological disaster damages having estimated damages of USD 1.6 billion [36].

A summary of flood damages in Atibaia between 2010 and 2011 and a conclusive analysis of their intensity is presented below:

**Table 3: Summary of damage evaluation and disaster intensity of the floods in Atibaia in 2010-2011.**

Damage intensity		Negligible	Average	Important	Very Important
		Humans		X	
	Construction materials in buildings (residential, industrial, commercial, works of art, infrastructural, etc.) USD 24,551,812.59			X	
	Environmental damages (sewage, mud, soil erosion, landslides, ground contamination) USD 8,724,752.68			X	
Losses	<b>Economic</b> Agriculture: (fruits, flowers, horticulture) USD 298,792.90 Service sector: (commerce) USD 358,551.48		X		
	<b>Social</b> Transport (roads) USD 2,987,929.00 Sewers (collection network, sewage treatment plants) USD 209,155.09 Litter (collection) USD 89,637.87 Water supply (distribution network; wastewater treatment plants - ETA) USD 179,275.74 Electric energy (distribution network; consumers without energy) USD 58,563.41		X		
<b>Total</b>	<b>USD 37,458,470.40</b>				
	Importance of secondary disasters		X		

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<b>Aggravating criteria</b>	Lack of preparation of the local emergency management agency staff		X		
	Level of vulnerability of the scenario				X
	Level of vulnerability of the community				X

Exchange rate: 1 USD = 1.67 BRL (January 2011). Source: [34].

Source: self-conclusion based on data provided by Sedec, 2011.

In 2010-2011, flood-related damages were calculated in USD 37,458,470.70, an increase of 40.5% compared to the previous year (Table 3). Human damage was considered average, while material and environmental damages were – as in 2009-2010 – classified as important. However, economic and social damages were upgraded to average. The need for external financial aid was also considerable and funds were available. The analysis of the aggravating criteria was slightly modified, as the importance of secondary disasters and the emergency management agency staff’s lack of preparation were classified as average. The level of vulnerability for the scenario and the community was considered very important. The evolutionary pattern of the disaster was classified as sudden and unpredictable, with a tendency to increase, resulting in a total level of high disaster intensity (SEDEC, 2011).

As initial response actions to minimize the impacts of the floods emergency assistance was provided. Later, a series of studies were initiated, which focused on identifying the causes of the floods, and developing measures to avoid them. Emergency measures included removing silt from the Atibaia River in four times. However, although these actions probably will be beneficial for human, the risks and vulnerabilities in the short term, isolated local actions, as in this case, are unlikely to solve the problem in the long term. According to Hardoy and Pandiella (2009), governments tend to focus on quick responses to emergencies and recovery, while the implementation of preventive disaster strategies are left for an uncertain future.

Intensifying the problems arising from these disaster events was a conflict regarding the reactivation of PCH Atibaia, which is located in a rural district in the county. Some residents argued that the dam of the PCH was supposedly restricting the natural flow of the river and should be responsible by flooding the urban area of



Atibaia. This hypothesis was supported by the report of an engineer, who was hired by a commission of affected residents (AMBAAE). Conversely, a preliminary study presented by the DAEE concluded that the PCH should not be held responsible for the floods. The minimal backwater, resulting from the dam could not account for the events of the observed magnitude (SSRH, 2012).

A civil lawsuit contributed to this conflict by accusing the current and former mayors of Atibaia of irregularities related to the issuance of permits for the operation and maintenance of the PCH. Important failures are alleged to have happened on the operation of the plant and other incidences of negligence, which resulted in siltation of the Atibaia River and irregular occupation of the floodplains and permanent protection facilities, thus contributing to the occurrence of floods (MPF, 2012).

It is reasonable to assume that the occurrence of floods is caused by several rather isolated factors. For the city of Atibaia, potentially the contributing factors are:

- An increasing level of urbanization in the municipality;
- An increase in impervious areas and channeling of water resources;
- Approval and regularization of the occupancy of APPs;
- Irregular and inappropriate occupation;
- The construction of dams in the Cantareira system, which decreased the flow of water into the Atibaia river and led to the occupation of areas previously subjected to floods;
- The construction of the PCH Atibaia dam, which may have caused a backflow of water and increased the water-covered area during floods;
- The refurbish for the reactivation of PCH Atibaia, as floodgates were closed during the floods;
- The management of the Cantareira system, as reservoirs were not emptied between late 2009 and early 2010;
- Failure of the meteorological systems used by the Cantareira system and the municipality;
- Increase levels of precipitation;

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The urban sprawl in Atibaia has created pressure mostly for APPs, which have created environmental impacts by increasing the level of vulnerability for the general population in the municipality. This increased vulnerability is reflected in the increased number of families affected by the floods. However, it should also be noted that most of the flood-stricken areas are, even though located in APPs, approved by the local government and populated by privileged social groups.

Jothityangkoon et. al. (2013) point out that an issue, which has been increasingly discussed is whether the hydroelectric dam remains safe considering all the environmental changes that have occurred in that area over the years, as well as the capacity of the spillways of dams are sufficient for the volume and frequency of current and future floods. The work of these authors demonstrates that the changes in climate and the use of land can cause significant changes in the magnitude of flooding and extreme inundations.

Disasters should be managed by emergency services in accordance with the urgency that the risk demands it. They must be performed in accordance with operating procedures defined earlier, as decisions need to consider and coordinate the various management policy organizations responsible for the disaster area.

The necessity to use environmental planning in order to minimize the impacts caused by unplanned urban expansion becomes even more obvious, as well as the necessary implementation of management programs, which consider actual local characteristics, vulnerability concepts and environmental risk assessments. Methodological approaches to manage environmental risks include the identification and analysis of risks, the definition and implementation of preventive measures for accidents and risk reduction, planning for contingency situations, public information and training as well as social mobilization for self-defense.

## **CONCLUSION**

Floodings and inundations cause multiple socioenvironmental impacts. They are driven by an intense urbanization process, which often occurs without adequate territorial planning. The occupation of APPs needs to be evaluated considering various aspects, which involve proper planning laws in order to set clear criteria for territorial management. An active surveillance service should be established, so that these occupations are effectively inhibited in the future. Unfortunately, improper approval of parcellations, which are often motivated by other interests and mostly legitimized by the local government, are hard to prevent. These areas, once regulated and approved by the land use and occupation laws, feature an infrastructure, which favors occupation by more privileged social groups. The illegal occupation subsequently leads to low building standards, but even these low-standard buildings hamper future removal. Illegal occupations in areas with elevated risk and vulnerability levels should be closed considering the restrictions imposed by environmental legislation, but often these issues are ignored due to real estate interests, which involve various social factors. The municipality has to monitor these areas, so as not to allow their occupation, and simultaneously provide alternative housing schemes for the communities. The mapping of risk areas and the implementation of appropriate management strategies would allow a significant decrease of disaster risks. Still, most municipalities do not have a program for flood prevention, or a contingency plan to act timely after flooding events, even though these may be recurring problems. Another problem to tackle is that prevention and flood control measures usually correspond to changes, improvements and structural and technical work, which often do not involve the communities affected. Involving communities to create and develop flood prevention and reaction schemes is important in order to ensure efficient and effective protection in the short and long term. The continuity of these processes is also very important, so that the population of these communities be better prepared to confront repeating floods and thus reduce damage. The difficulty in the creation and implementation of programs of flood control and prevention is the fact that these phenomena are not always

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predictable in Brazil. They are influenced and depend on a variety of intricately correlated factors, as the concentration of precipitation per time and area, level of urbanization, soil permeability, waste volumes on public roads and rivers and others.

Therefore, the formation of interdisciplinary teams, which can discuss and analyze the problems of flooding in a broad and integrated context, as well as the implementation of studies that allow improved understanding, techniques and procedures, is essential for the development of plans, programs and measures to prevent, combat and control flooding.

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