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Assessing public perception of flood risk and flood control measure in urban areas

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Abstract

Questions regarding public acceptance of BMPs as well as public perception of the urban environment and of flood risk are addressed in this paper on the base of survey outcomes of a research project carried out in Belo Horizonte, the capital of Minas Gerais State, in Brazil. Public perception of these aspects was assessed employing structured questionnaires. Surveys were carried out in two urban catchments where detention basins are employed mainly for flood control purposes: the Santa Lucia and the Vilarinho detention basins. The two areas show significant differences in socio-economic terms as well as in the type of storage structure, allowing a rich discussion about people acceptance of this kind of stormwater alternative in the urban context.

Keywords: perception of risk, detention basin acceptability, decision-making

1 Introduction

Public participation on decision-making plays now a significant role on policy formulation at local spheres in different Brazilian cities. An example is the participatory budgeting, an innovative instrument of decision-making concerning investments on sanitation, housing, road system, creek restoration and stormwater management, involving intense citizen participation at local scale, currently adopted by some municipalities in Brazil. In Belo Horizonte, the capital of Minas Gerais State, other than the participatory budgeting, institutional arrangements promote public participation by means of representative processes in collegiate councils such as the Municipal Sanitation Council (COMUSA), the Municipal Council of Urban Policy and others (Costa & Costa, 2007; Dias et al, 2007).

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Decision-making at the municipal sphere frequently involves evaluating different urban drainage alternatives aiming to flood control and diffuse pollution abatement. In these processes, the confrontation of conventional to non-conventional drainage solutions is common (e.g. end of pipe versus source control, channelling versus river restoration, etc). It is well known that the so called “best management practices” (BMPs) in urban drainage offer an ample potential for integrating urban drainage purposes with the development of local amenities, resulting in multi-functional uses of the urban space. In Brazilian cities, with the exception of detention basins, BMPs are still rarely employed and, therefore, relatively unknown by citizens. Public acceptance of this kind of alternatives depends, therefore, on a wide range of aspects involving knowledge about how they work, the alternatives they may offer for an adequate integration with the local environment and information on risks that may be associated to them, e.g.: nuisances and failures due to lack of maintenance, health risks, drowning risks, etc. In this decisional context, public perception of the urban environment can therefore play a significant role.

When the focus is on flood control alternatives, particularly in the case of non-structural measures, public perception of flood risk may be, in the same way, very relevant. Actually, non-structural measures usually require public acceptance of living with floods and resistance in accepting this kind of solutions may emerge particularly when structural alternatives leading to a reduction on the probability of flooding are also under evaluation. An excess of confidence on the structural alternative performance in reducing flood frequency may bias the decision-making process and eventually lead to an inadequate occupation of flood prone areas, increasing flooding potential impacts in case of structural failures. These outcomes point out the need of public involvement from the beginning of the decision-making process rather than as only a way of validating choices already made by experts. It is also relevant to keep in mind that gaps usually exist between expert knowledge and lay understanding of flood risks. Therefore, the assessment of public perception of flood risk can certainly play a positive role in narrowing these gaps.

Flood warning is a current alternative of flood management, which is only effective when coupled with flood mitigation, flood fighting and flood recovery actions, essential components of local flood emergency plans that require permanent public involvement. Furthermore, in the flood emergency planning and implementation process, it is also important to take into account existing public experience on living with floods and on how local organizations usually operate during floods. Actually, flood emergency plans must be complementary rather than substitutive to existing experiences on flood management (e.g.: Alexander, 2002).

Regulatory measures, another example non-structural approaches, may involve land use restrictions based on flood risk zoning, or the adoption of long-term policies leading to a progressive change on land use in flood prone areas. In both cases, land use regulation may cause important impacts in social as well as in economic terms (e.g. impacts on the real state market, social link disruptions caused by moving people from risky areas). Their adoption and permanence in the long-term require measures to reduce social disruption, public acceptance as well as a permanent and sound political support.

Questions regarding public acceptance of BMPs as well as public perception of the urban environment and of flood risk are addressed in this paper on the base of outcomes of a research project carried out in Belo Horizonte. Public perception of these three aspects was assessed employing structured questionnaires. Surveys were carried out in two urban catchments where detention basins are employed for flood control: the Santa Lucia and the Vilarinho detention basins. These two areas show significant differences in socio-economic terms as well as in the type of storage structure, allowing a rich discussion about people acceptance of this kind of stormwater alternative in the urban context.

2 Brief descriptions of the case studies

2.1 Belo Horizonte city

Belo Horizonte (BH) is the capital of the State of Minas Gerais, in Brazil. The city lies at 20° South latitude and 44° West longitude and has an altitude of 750 to 1,300 metres. It is located in a mountainous region of tropical soils that originated from the decomposition of metamorphic rock. Tropical highland weather predominates in this area, with an average yearly rainfall of 1,500 mm and an average yearly temperature of 21°C. The rainy season lasts from October to March, when on average 90% of the total yearly rainfall occurs. The highest monthly average rainfall (315mm) takes place in December. Typical rainfall intensities are also relatively high (e.g.: 200 mm/h in the case of a 10-year return period event with 5 minutes duration; 70 mm/h for the 50-year return period and 1h duration event). Mean relative humidity reaches 50% during winter and 75% in summer.

2.2 The Leitão creek catchment and the Santa Lucia Detention Basin

At the beginning of the 70's, the Santa Lucia detention basin (SLDB) was installed in the Leitão creek catchment with the main purpose of reducing flood risks along the Leitão creek, then already lined as a culvert concrete structure. The Leitão creek catchment area upstream to the SLDB is of 370 ha and the detention basin initial storage capacity was 300,000 m³. Despite the irregular topography and the low soil cohesion, this area became urbanised as of 1974 leading to an intense loss of soil and landslide occurrences. The SLDB became then a receptacle for sediments, domestic sewerage and garbage leading to a significant loss of storage capacity and to the development of an intensely polluted area.

From 1988 to 1995 the BH Municipality developed a recovery project for this area, which included the restoration of SLDB as an offline wet detention basin and the set up of a park, the Santa Lucia Park, equipped with different amenities: gardens and green areas, bikeways, soccer fields and kiosks (Figure 1.a). After dredging works, the detention basin storage capacity was recovered up to 70,000 m³. In spite of this storage capacity reduction, hydrologic simulations of the drainage system suggests that the SLDB is still capable of avoiding floods downstream up to the 10-year return period.

The Santa Lucia Park and detention basin are located in an area inhabited by two contrasting communities in welfare terms: an upper-middle class population usually living in detached houses and a low-income population living in a favela (shantytown).

2.3 The Vilarinho creek catchment and the Vilarinho Detention Basin

The Vilarinho is an offline dry detention basin (VDB) retrofitted in a urban area frequently flooded even in recent times. It was built by the end of the 90s, with a storage capacity of 80,000 m³ to control flows originated at the upstream area of the Vilarinho creek catchment, a densely occupied neighbourhood. As in the case of the Leitão creek, the Vilarinho creek is lined by a concrete culvert channel all along the Vilarinho avenue, a main road and commercial area. The VDB receives part of the Vilarinho creek flow during high waters as well as online contributions of two tributaries, the Lagoinha and Brejo do Quaresma creeks, both draining catchments of at about 1.0 km². The Brejo do Quaresma creek catchment is equipped with sewer systems but main interceptors are lacking and, as a consequence, all the collected sewerage is dumped into the creek, which is then heavily polluted by organic matters as well as by solid wastes dumped into the area (Figure 1.b).



(a)

(b)

Figure 1: (a) Santa Lucia detention basin; (b) Vilarinho detention basin outlet

The VDB is poorly integrated to the local urban environment¹ and the access of people to the area is forbidden, although not well controlled. Complains regarding nuisances as odour and mosquitoes are commonly stated by people living in the neighbourhoods.

3 Methodological aspects

There is a wide range of methods usually employed in the assessment of perception of natural risks and of environmental quality aspects. Some methods, based on psychological approaches, focus on probabilistic judgments and choices in face of risk or on cognitive processes associated to risk acceptance (e.g.: Slovic et al, 1974; Slovic et al, 1976). Cultural response to disaster, social construction of risk perception, the identification of cultural and social practices in face of natural and technological risk are currently assessed by sociological and anthropological approaches (e.g.: Oliver-Smith, 1999; Sefton & Sharp, 2007; Oliver-Smith and Hoffman, 2002; Peretti-Watel, 2003).

In the present research, the method employed consisted of interviewing people living in the detention basin neighbourhoods employing structured questionnaires. The questionnaire main focuses were on the acquired perception of local risks (risks associated to the detention ponds, flood risk) and on the local environment. The questionnaire was divided into five sections: (i) dwelling location in respect to the detention basin; (ii) socio-economic information; (iii) perception about the local environment; (iv) perception of risks associated to the detention pond and (v) perception of flood risk.

The sampling design for each catchment was based on census socio-economic data about the study population comprised by inhabitants as well as owners or employees of commercial and service shops in the study area. The detention basin border area and the flood prone area compose the study area. The detention basin border area was defined as all the area surrounding the detention basin physical borders, distant no further than 1,000 m of these borders. The flood prone areas were materialised with the help of hydraulic modelling and historical information about floods. Stratified random sampling was then adopted to compose the designed sample (see Table 1 on paragraph 4).

Potential respondents were first contacted by letter, explaining the research objectives and procedures, and after by telephone, in order to negotiate their participation to the interviews. It was assured to respondents the right to withdraw during the interview as well as the anonymity and confidentiality of the process.

¹ The VDB is part one of the SWITCH demo projects in Belo Horizonte. This demo project focus on improving pollution abatement and on an adequate integration of the detention basin in the Vilarinho urban area.

4 Results

4.1 The sample

Table 1 contains the main figures about the number of dwellings and establishments (commercial and service shops) located at the survey areas, here designated as sample population (pop), the designed sample (S_d) and the obtained sample (S_o).

Table 1: Sample characteristics

Sectors	Santa Lucia area			Vilarinho area		
	pop.	S_d	S_o	pop.	S_d	S_o
Detention basin borders, residential high income	376	46	24	-	-	
Detention basin borders, residential low income	638	61	36	268	29	14
Flood prone area, residential	959	54	18	910	56	27
Flood prone area, commerce and service	266	22	30	50	12	5
TOTAL	2239	183	108	1228	97	46

S_o corresponds to the number of people actually interviewed. Difficulties in obtaining the agreement to participate to the interviewing process explain, for the most, the reduced number of interviews attained in respect to the designed ones. This issue may ascribe higher uncertainties and risk of bias on the research results, a research weakness taken into account here during data evaluation and discussion.

4.2 Socio-economic data

Socio-economic data obtained by the survey are summarised in Table 2, where figures are percentages of respondents classified according to income classes and education. The income reference parameter is the local minimum wage², usually adopted in Brazil for classifying income rates.

Table 2: Socio-economic data

Area	Income (%)				Education (%)		
	< 1 mw	1 < mw < 5	5 < mw < 10	> 10 mw	Illiterate Primary	Secondary High school	Graduate
St. Lucia	24	46	6	24	30	39	31
Vilarinho	60	32	8	-	46	50	4

Contrast between low-income and high-income inhabitants is clear in the case of the Santa Lucia area, where the percentage of reach people equals that one of very poor people, an issue which is coherent with the wealthy and favela neighbourhoods in this area. Vilarinho, compared to Santa Lucia, is more homogeneous as a low-income area. Comparing Vilarinho and Santa Lucia in terms of education issues makes again emerge disparities, with a lower percentage of graduated people in the former one.

4.3 Perception of the local environment and the acceptability of the detention basins

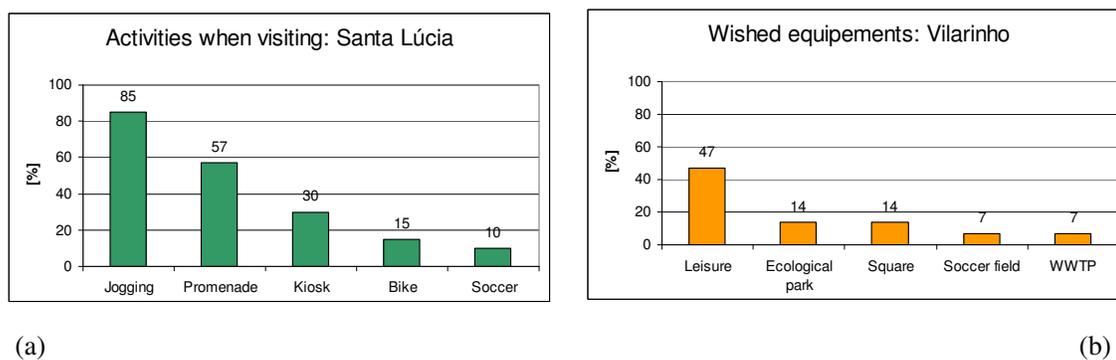
Perception of the environment surrounding the detention basins and the acceptability of these structures by the respondents were assessed mainly by the following questions:

² The current minimum wage in the Brazilian Southeast region is R\$ 380.00. R\$ is the Brazilian currency "real"; 1 real = 2.50 euros in current exchange rates.

- Do you frequently visit the Santa Lucia Park?
- What activities do you usually do when visiting this area (Santa Lucia Park)?
- What kind of equipments would you like to see implanted in the Vilarinho area?
- Has the detention basin contributed to improve the local environment?
- Would this neighbourhood be better with/without the detention basin?
- What, in your opinion, are the main purposes of the detention basin?

Question (a) received positive answers from almost all the interviewed people, without significant differences between lower income and wealthy people, 90% and 88% of “yes”, respectively. Only people occupying the flood prone area were less numerous in replying “yes” (59%), possibly due to factors like the distance to the Park, for residents in the flood prone area, and lack of time, for respondents from the commerce and service sectors not living in the neighbourhoods. In the present research these hypotheses have no been tested, so far.

Jogging and promenade are the main activities done by people visiting the Santa Lucia Park (Figure 2.a). Playing soccer, biking and going to kiosks were also mentioned. In the case of the VDB, visiting the area is not possible. Therefore, interviewed people were stimulated to express their wishes for equipments that would improve the quality of life in this area. Non-specified leisure equipments (Figure 2.b) obtained the highest score, followed by an ecological park and a square. Although with a lower score, the option for a wastewater treatment plant reveals concerns with highly polluted creek waters.



(a) Figure 2: (a) Activities done by people visiting SLDB; (b) wished equipments in the VDB area

Improvements to the local environment due to the detention basins were clearly recognised by respondents (Figure 3). Nevertheless, nuisances due to water pollution and aesthetic aspects seem to have led to a less enthusiastic opinion regarding the VDB.

A relatively similar question focused on whether the detention basins would exist or not in the neighbourhood (Figure 4). Similarly to answers to the (d) question above, the positive reply, meaning, “this neighbourhood is better with the detention basin”, was selected by the majority of respondents in both areas. But, in the Vilarinho area, the score for “better without” is not negligible (16%).

Regarding the main functions of detention ponds, respondents from the SLDB area scored leisure as its main purpose (Figure 5), followed by flood control aims. Well scored was also landscape composition, while pollution control was selected by 39% of responds, which can be considered a relatively high score because this role of the detention pond is difficult to be perceived, since the Leitoa creek is lined in this area and the detention basin is an offline structure functioning only for less-frequent floods.

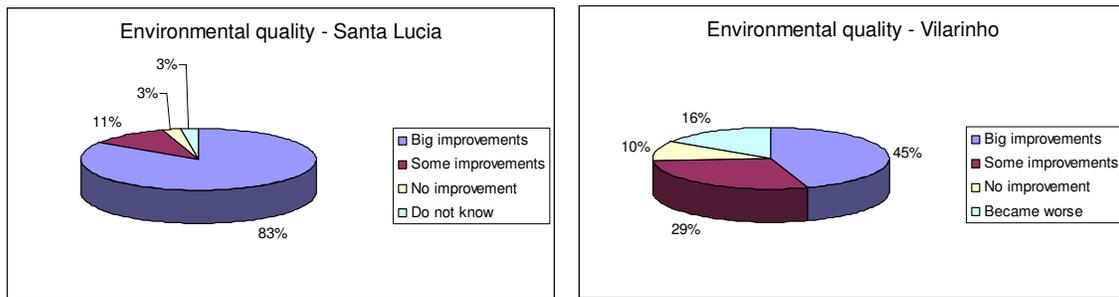


Figure 3: Environmental quality improvements due to the detention basins

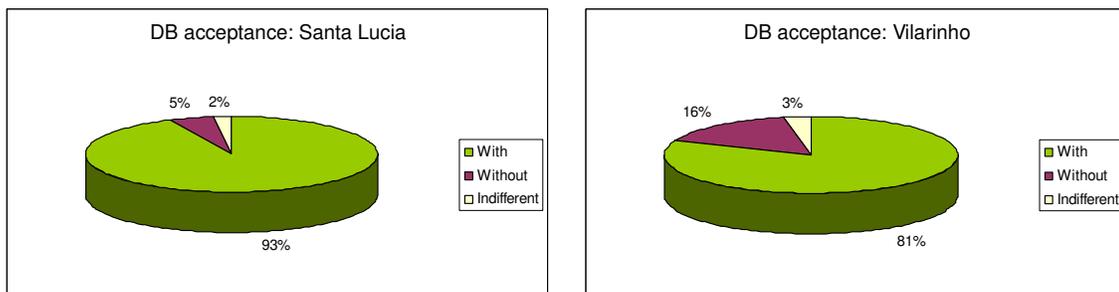


Figure 4: Acceptance of the detention basis

Flood control emerging as the major purpose of the VDB, with a score of 84% of respondents (Figure 5), suggests a good understanding of the sole function of this structure. Although landscape composition and pollution control also appear in this assessment, they are feeble scored.

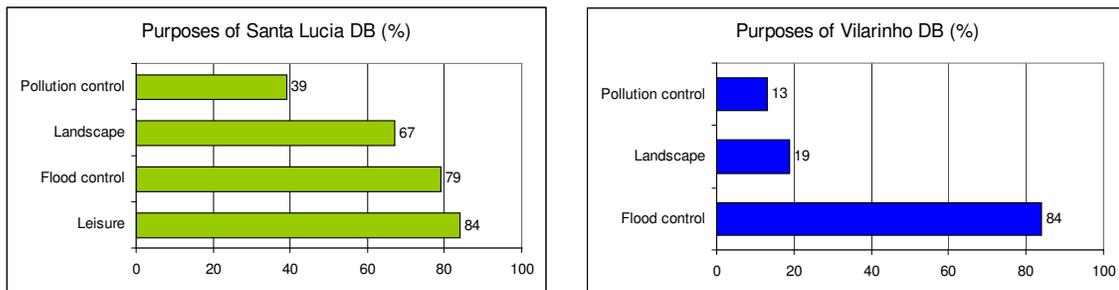


Figure 5: Main purposes of the detention basis (% of respondents)

4.4 Perception of risk

The perception of risk assessment focused on five different aspects: (i) risks associated to the detention basins; (ii) flood risk compared with other current risks in life; (iii) knowledge about flood characteristics in the area (concerning only the Santa Lucia area); (iv) choices among different flood control measures, and (v) acceptable risk of flood

Respondents identified robbery as the main risk associated to the detention basins in both areas, possibly meaning that these structures facilitate the actions of thieves (Figure 6). Health risks are also

of concern, particularly in the case of the VDB, possibly due to the environmental degradation perceived in this area. Drowning appears as more significant risk in the SLDB area than in the case of the VDB, an issue that is likely associated to the fact that SLDB is a wet detention basin.

Interviewed people were also invited to state a score for current risks in life (Figure 7) according to an interval from 1 (very feeble risk) to 10 (high risk). Again, in this case, for both areas robbery appears as a major risk. Floods are scored as a mean to feeble risk although for the VDB area this risk is perceived as higher than for the SLDB area, an issue probably due to the fact that the Vilarinho area has been flooded much more recently than the Leitao creek area. Since the recovery works in the SLDB (end of the 90s) the area located downstream has not faced flood problems. In both areas, risks typically associated to life in urban areas, car accidents and illness associated to pollution or food contamination by chemicals appear as also important.

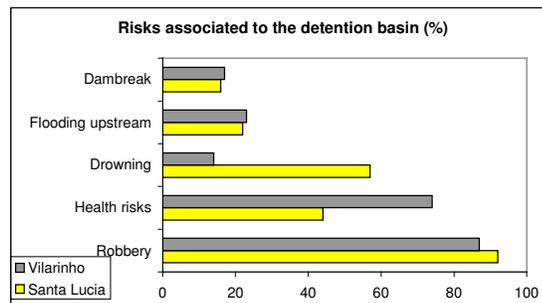


Figure 6: Risks associated to detention basins (% of respondents)

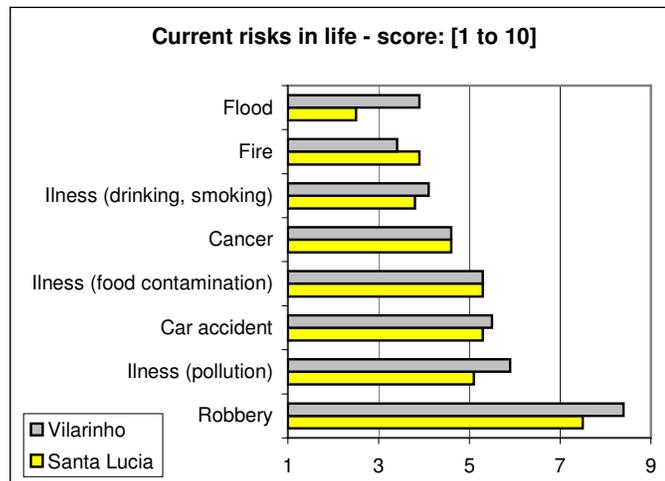


Figure 7: Current risks in life (% of respondents)

Interviewed people occupying the flood prone area in the Leitão catchment were invited to characterise local floods in terms of their frequency, typical duration and depth. Only 17% of respondents recognised living in a flood prone area, an issue that is possibly related to the non-occurrence of floods in this areas in the last 12 years. Those who believe they occupy a flood prone area demonstrated a good knowledge about the main characteristics of local floods: low depths, short duration, and high flow velocities.

Regarding flood control measures, improvement on maintenance was elected as a priority in both surveyed areas (Figure 8). A relatively surprising outcome is the fact that in both areas lining channels is still preferred to detention basin. In the VDB area, in spite of the relatively good acceptance of the detention basin, more of such structures for flood control was only elected by 7% of respondents.

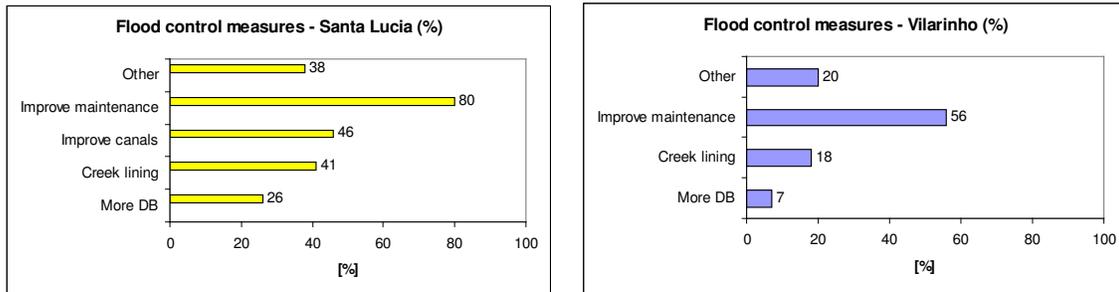


Figure 8: Flood control alternatives (% of respondents)

In order to assess people acceptance to be flooded respondents who agreed with the statement that zero risk in flood control is unattainable were invited to state how frequently they would accepted to be flooded. Figure 9 illustrates main issues obtained for this question in terms of return periods.

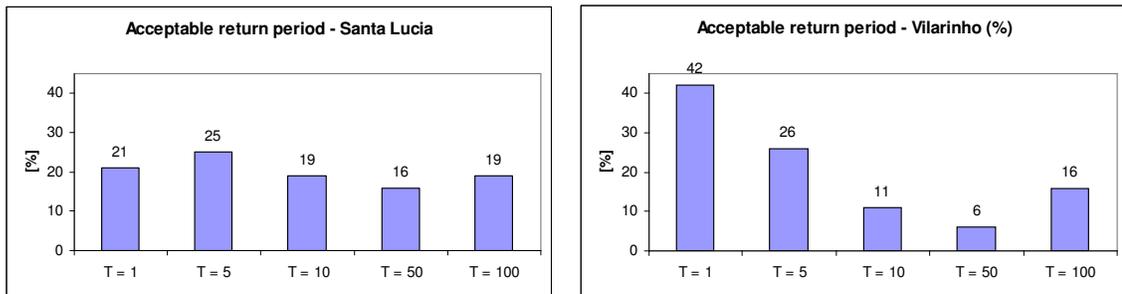


Figure 9: Acceptance to be flooded (% of respondents)

The outcomes illustrate the difficulties of lay people on dealing with natural random processes. The high level of acceptance of very frequent floods (1 to 5-y return periods) makes evident that respondents could not understand the issues of the question. This certainly point out a drawback of the questionnaire here employed and needs of deal with this point by different approaches.

5 Conclusion

Interviewed people demonstrated to have a good understanding about detention basin main roles for flood control, although not identifying in these solutions a possible contribution in terms of pollution abatement.

In spite of a good acceptance of storage facilities for flood control and the recognition of the possibility of combining these facilities with other urban equipments (e.g.: parks, squares, etc.), lining creeks is still perceived as a major flood control alternative.

Respondents living in flood prone areas revealed a good knowledge of typical flood parameters. Nevertheless, dealing with flood probabilistic concepts seems to be more difficult. In fact, issues of this survey point out a tendency on overestimating flood probability and significant difficulties in stating flood control objectives in terms of accepted flood frequency. This issue also point out the inadequacy of the approach here employed in assessing people acceptance to live with floods.

Further developments on this research project will focus on relationships among perception of flood risk and socio-economic and demographic aspects (gender, age, number of children, etc), risk aversion, and difficulties of dealing with the probabilistic aspects of floods.

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