FLOOD VULNERABILITY ASSESSMENT: A MULTISCALE, MULTITEMPORAL AND MULTIDISCIPLINARY APPROACH. COLOMBIAN CASE

E.M. Rodríguez [a b], V. Botero [a]

[a] Facultad de Arquitectura e Ingeniería, Institución Universitaria Colegio Mayor de Antioquia, Carrera 78 # 65-46, Medellín, Colombia - edna.rodriguez@colmayor.edu.co
[b] Escuela de Geociencias y Medio Ambiente, Universidad Nacional de Colombia, Carrera 80 No 65-223, Medellín, Colombia – vbotero@unal.edu.co

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ABSTRACT:

Recent catastrophic events related to floods in Colombia, reveal again the situation of disaster as a development issue not solved in the country. It is necessary to analyze in more detail the areas under threat and their respective vulnerability to the different mechanisms that can generate flooding events, and make adjustments in the assessment of disaster risks for the appropriate decision-making at the organization and local, regional and national. This article presents a research project in its first phase, whose main objective is to develop a methodology for vulnerability assessment from a multi-scale, multi-temporal and multi-disciplinary perspective, combining the use of indicators and a spatial information system to analyze exposure and vulnerability at regional and local level in specific areas. Moreover, this methodological tool will enable local and regional authorities to identify strategies to reduce vulnerability and adaptation options most appropriate, and make better decisions in assessing disaster risk. The information generated in this study will contribute to public policy action structured to correct short-and medium-term situations of actual or potential vulnerability, also for use in other activities of territorial and environmental planning, developing technology transfer activities and training associated with the research project in the service of the authorities and communities. Results obtained of the vulnerability analysis for a Colombian study area will relate to the hazards obtained in a parallel project, to identify the best risk management strategies through development of GIS-based scenarios for different options risk and vulnerability reduction.

1. INTRODUCTION

In Colombia, floods are the most frequent natural events. They are known as "socio-natural" threats that have generated great damages in the country's recent history by their high frequency, large territorial extensions involved and the high amount of population affected.

Since the second semester of 2010, Colombia is going through a winter emergency caused by rains reaching "catastrophic" levels. According to OCHA's figures consolidate, there are in the country 2´796.449 victims, 69 missing, 463 injured y 362 dead, besides hundreds of thousands of families have lost their goods, households, crops and other life means. This winter emergency has also affected severely multiple public infrastructures like schools, hospitals and communication ways.

Floods are increasing and with them the socio-economic, ecological and environmental impacts, this is due to the progressive deterioration of the basins, riverbeds and

streams, the clogging of natural drainages limiting the marshes, the increase of erosive processes by deforestation and the burning of forests, the occupancy of margins of rivers, etc.

The tragedy can be avoided or dramatically reduced through pre-, during, and post-disaster investments in preparedness activities and associated infrastructure, flood plain policy development, effective watershed land use planning, flood forecasting and warning systems, and response mechanisms.

The development agendas of the country are urged of conscience projects in disaster risk management, from public, private and mixed initiatives, whose principal objectives are strengthening the decision making capacity, planning and execution of tasks to prevent, mitigate or reduce disaster risks, as well as increase the quality of life of population under human sustainable premises.

Colombia is a country who has a lot of knowledge to develop and strengthen especially at a regional and local level of:

- Local realities and risk zones.
- Causing agents of risk situations.
- Evaluating and locating the minimum necessary resources to face any eventuality.
- Community inclusion and participation in the diagnosis, analysis and decision making processes.

This is why the most important subject that convokes to work today in this research is the vulnerability for risk mitigation and reduction.
It's a complex problem that requires studying all the social and natural systems that are intervening in a disaster modified environment, with different multi-temporal, multi-scalar, multi-disciplinary perspectives.

2. STUDY AREA

The study area is located between the departments of Bolivar, Sucre and Magdalena, on the coordinates 75.24° and 73.64° west and 9.64° and 8.38° north. (Figure 1.)

Is part of a large region called La Mojana, with an exceptional natural, environmental and cultural richness, due to the confluence of the Magdalena and Cauca rivers (two of the main rivers in Colombia) and the low slopes, presents a great deal of swamps or water bodies usually located in floodplains. This complex system of wetlands promotes natural control of the flooding cycles and creates a vital habitat for wildlife, flora and for communities which occupy the region.

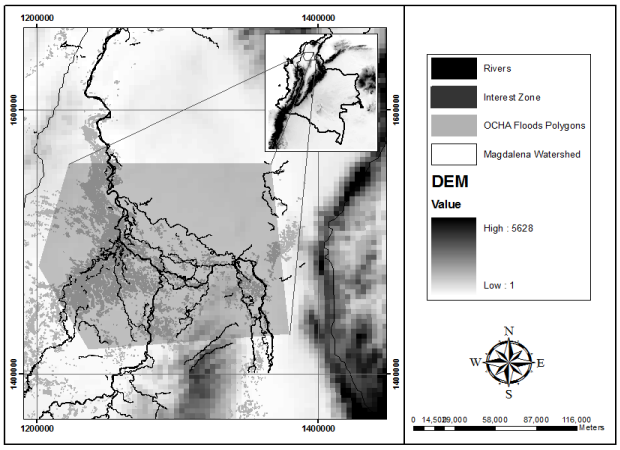

Figure 1. Study area

This zone is unsustainable in its current condition of development, due to impacts caused by the absence of planning, land use and inappropriate use of natural resources. Floods are increasingly affecting the conditions of social and economic development of its communities and the different mitigation measures implemented until now have been characterized as sectoral, disjointed and punctual. That's why we want to contribute in the creation of a participatory territorial development model, based on an appropriate flood risk assessment to promote an adequate management and thus a sustainable development in the region.

3. METODOLOGHY

The methodological proposal is located within a conceptual framework that defines the problem

of disasters as an unresolved problem of development, under the view that disasters are not a problem of nature but a problem of the relationship between the environment and the organization and structure of society, it's a real, viable cause-effect relationship to be overcome and that includes all society and the development processes.

Is necessary to see this problem from two perspectives; a systemic approach that brings together processes and activities aimed at achieving a specific objective: assessing the vulnerability for an appropriate disaster risk management, this approach should allow local authorities to identify processes that can trigger a disaster event within its territorial context and decide how it's going to be controlled or reduced. And a management approach which helps to build concepts and criteria to guide risk management. This approach must be oriented to a better environment in its territory. It will require the use of tools and means to know and evaluate the condition and dynamics of local-level vulnerability. Because of this, the vulnerability flood assessment is complex and there is great uncertainty when taking decisions. These decisions are influenced by other factors that add complexity or affect the work, as the absence or limitation of the quantity and reliability of data, environmental dynamic and risk conditions, the definition of the study period and the complexity of risk under changing development patterns in economic, social, environmental and territorial terms.

3.1. Study Area Restriction and Data Processing

There has been a collection of information related to floods in the area: information gathered from historical studies and reports, technical information obtained by Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia-IDEAM and mapping generated by Instituto Geográfico Agustín Codazzi -IGAC and Oficina para la Coordinación de Asuntos Humanitarios de las Naciones Unidas- OCHA Colombia.

We have identified the most affected populations, registers of water level stations located at or near their jurisdiction and made a selection of dates belonging to the maximum events for the area (which for practical purposes had to be divided in two Zones 1 and 2, since it is a large area). In Tables 1. through 4. stations and dates of events maximum for zones 1 and 2 respectively are shown. Also the obtained flood polygons are shown in Figure 2.

Code	Station
2502737	Santa Ana
2502745	Plato
2502768	Magangué-Esperanza
2502794	Tacamocho
2901701	Tenerife
2903702	Calamar
2904707	San Pedrito

Table 1. Stations located in Zone 1

Year	Month	Level obtained (cm)
1974	December	939
1984	November	979
1988	November	973
1999	November	853

Table 2. Selected years for Zone 1

Code	Station
2320705	La Nobleza
2321706	La Gloria
2502702	El Banco
2502715	Guaranda
2502729	Sitio Nuevo
2502732	San Roque
2502733	Peñoncito
2502736	Armenia
2502741	Regidor
2502749	Las Aguadas
2502753	Barbosa
2502764	Tres Cruces
2502793	Coyongal

Table 3. Stations located in Zone 2

Year	Month	Level obtained (cm)
1975	November	930
1999	November	979
2007	November	876

Table 4. Selected years for Zone 2

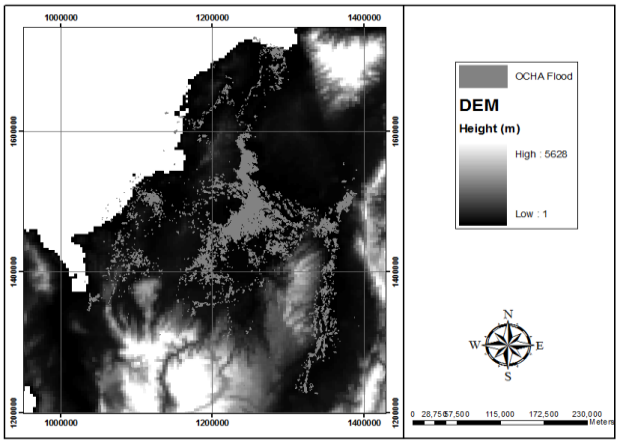

Figure 2. Flooding Polygons in the Study Area

3.2. Field level verification.

For field verification a travel route has been designed. It consists on going through two circuits, seeking to cover the major number of municipalities and populated centers, with two essential characteristics: a large population and historical flood occurrence (Figure 3).Circuits go as follows:

- Brazo de Loba and Brazo de Mompós on the Magdalena River.
- Brazo de la Mojana to El reposo, then Cauca River to the Brazo de Loba.

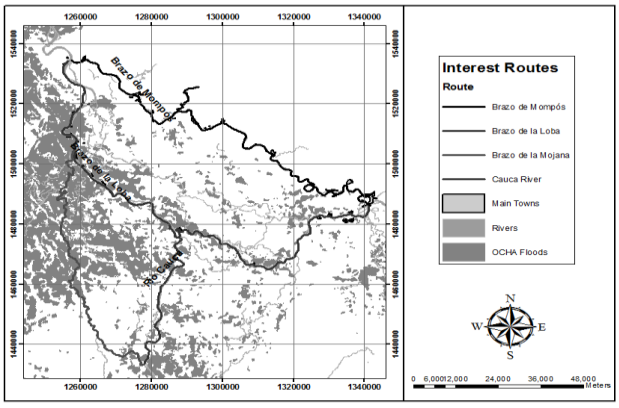

Figure 3. Selected circuits

In these circuits we gather geo-referenced information on maximum events, (levels attained, duration, cause and effect, and other elements to fully describe the process of flooding) of floods in the areas. It's also going to be taken the benchmarks of the stations for grid of points of accuracy that can be combined with data from satellite images, to create new flood polygons and associate them to flood return periods. Besides, with this information we can correct the existing digital terrain models.

Other relevant information is obtained from local authorities and communities living in the area, as well as from the documents found in historical records, especially regarding potentially vulnerable elements (all those in the flood plains) and direct and indirect impacts (assessment of loss or damage) caused by the floods.

Finally to generate the final mapping of threats, a classification of floods is done according to: its behavior, magnitude and impacts, using a qualitative classification proposed by Barriendos and Coeur (2004), ordinary flood, extraordinary flood and catastrophic flooding.

3.3. Vulnerability Assessment for mitigation

Risk management is part of shifting paradigm within the planning of sustainable development. It is essential to reduce vulnerabilities that have been increasing in recent years. The vulnerability assessment focuses the attention on floods, in the analysis and solution before and during of the causes and effects generated taking into account the reduction cycle premises of Figure 4 (Adapted from Bollin. In: Kari Keipi. 2005).

The main purpose of this research is to find the right methodology to support the threat and vulnerability at the same scale (local and regional) for different return periods. To accomplish this search:

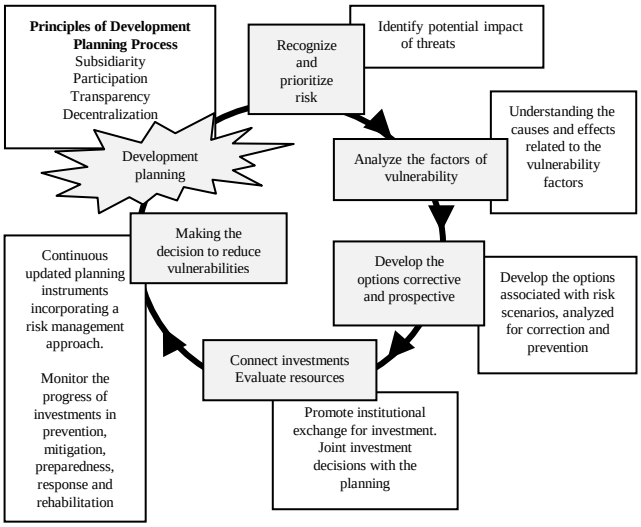

Figure 4. Cycle to reduce vulnerabilities factors

- Using quantitative and qualitative methods finding different alternatives to standardize assessment of economic, social and environmental communities' losses.
- Form multidisciplinary teams to perform technical engineering exercises and local development planning, to assess those factors or conditions determined by physical, social, economic, and environmental factors that increase the impact susceptibility of communities to flooding.
- Build different scenarios of impact-adaptation.
- Build an indicator system related to the socio-natural conditions, to the institutional capacity and citizen participation.

Besides, there has been a local strategic context established contemplating the relationship between the town, its organization and its environment. We compare the nature, condition and dynamics of floods with the condition and structure of the operational base and its capacity of how to respond to them. It includes the analysis of environmental, financial, political, institutional, social conditions, and the identification of the actors who can affect or be affected by their decisions and/or activities.

It is also provided an organizational context including regulatory, administrative and technical elements.

We consider necessary to do a systematic process which identifies the different components of vulnerability, trying to cover all aspects (Wilches Chaux, 1989):

1. Physical vulnerability
2. Economic vulnerability
3. Social vulnerability
4. Institutional vulnerability
5. Politic vulnerability
6. Technical vulnerability
7. Cultural vulnerability
8. Ideological vulnerability
9. Educational vulnerability
10. Ecological vulnerability

This identification must be done under consult mechanisms to ensure that all actors that have a large knowledge contribute from their different perspectives. All this information supports the indicator system construction; in addition with the information that could be gotten of the county from the data base Sistema de Identificación de Potenciales Beneficiarios de Programas Sociales-SISBEN, regional annual statistics, quality life poles, quality indicators, information from territorial outlines and plans on local environmental systems, reports of environmental authorities and other sources.

We have a challenge ahead; with the academic investigation we build a future of more resilient to risk communities and foment consciousness in the importance of risk reduction as an integral component in sustainable development.

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