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## Housing vulnerability, agricultural production, and goods lost estimated to floods in Rio Nuevo a rural community in Colombia

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### Abstract

Floods affect households, crops, and assets, especially in rural areas in Colombia; due to the lack of risk management plans, settlements without core services and land use planning, atypical natural phenomena, and climate change. The floods recorded since 1964, in the rural community of Rio Nuevo in the department of Córdoba, but there is a lack of estimates of the economic losses and housing vulnerability. The research aim was to determine the degree of physical vulnerability and estimated economic losses in crops and goods due to flooding in the local community of Río Nuevo, Valencia Town. The methodological guide for the elaboration of departmental plans for risk management (known in Spanish as PDGR), and the methodology for the economic valuation of potential direct tangible damages, was selected the variables (age, construction, regulations, soil, walls, floors, goods, and crops), questions, surveys to population, available data, proceed to process the information, elaborate maps and analyze. The results reveal physical vulnerability high in Rio Nuevo, with a value of 0.63 on a scale of 0 to 1. The rural community houses built located

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at a distance of fewer than 30 meters, mainly with wood, the soil of alluvial deposits, faced floods, humidity damages, hardening resistance, and non-quality life. The economic losses estimated between goods and crops were US\$174200.22. A poverty condition, poor infrastructure, and unfavorable places, hamper improve the quality of the people. Colombian government need to execute a proper infrastructure investment to reduce persistence vulnerability and relocated this riverside area, according to its culture and traditions, and protect the economy around crops.

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## 1. Introduction

The last 20 years of floods recorded, evidence as the most common disaster by more than 40% around the world, with combined economic losses of US\$82 billion in 2021 and affected to 1.6 billion persons worldwide (Human Cost of Natural Disasters, 2021). The Intergovernmental Panel on Climate Change (IPCC) predicted an increased risk of flooding in rural and urban areas worldwide (Connor and Hiroki, 2005; Field *et al.*, 2014). People concentration is not only evident in densely populated urban areas but also in rural areas with non-proper management policies and non-economy, which provides favorable conditions for impacts of climate change to be felt more (IPCC, 2014).

The differently predisposed to the harm of floods and vulnerability to nature is well established in research and practice. The local situation before a flooding disaster as poverty, chronic illness, and appropriate places to live make some social groups more likely to suffer losses. The damage to properties, goods, and crops is directly related to the zone recovery (Gallego, 2018). In addition to the social, demographic, and economic aspects, some communities should face a high risk of natural hazards due to their location, floodplains, or riverside cities. This scenario made especially vulnerable to the rainy season and flooding, and these hazards could be exacerbated by the “La Niña” phenomenon and Climate Change (Chang, 2015).

Although flood risk managers must engage with the extant science to inform decisions, the scholarship on how differences in socio-demographic characteristics influence perceived vulnerability and risk of floods is inconsistent. The ample literature presents that cognitive, affective, social, and cultural factors interact in complex ways to reflect on a household’s perception of risk or how vulnerable they think there are to flooding (Van der Linden, 2017). The risk perception allows knowing from the dwelling



knowledge, beliefs, judgments, reactions, and willingness to act, issues which are essential for decision-making, both institutional and in the daily inhabitants' lives of vulnerable territories (Peretti-Watel, 2003). The data collected indicates flooding behavior, mobility difficulties in the towns, and difficulties in accessing core services and products, but, the field of vulnerability perception correlates with people's crops and goods (IDEAM, 2018).

Between 2010 and 2011, Colombia suffered one of the worst rainy seasons in its history, by 8% of the Colombian population was affected by the flooding, with US\$3500 million destined on recovered and reactivated the economy. Some towns were more affected than others, and some received more resources from the central government, which created a source of variation in terms of the affected people and distribution of resources (Gallego, 2018).

Floods have become a global and national problem that leaves millions of people with irreparable damage to their homes every year, causing losses in goods and crops. One of the local communities in rural Colombia is Río Nuevo located in the Córdoba department, the municipality of Valencia, where the last 20 years it has presented flooding problems, as expressed by the risk management plan of the Valencia Mayor office in 2018. The poor territorial planning township, since the location of the houses, is at a critical point in the upper basin of the Sinú River. According to the national statistics department DANE (2018), Río Nuevo has presented population growth in the recent 20 years, a rise in households, and the pursuit of goods and crop production. The Sinú River, at this local community point, evidenced erosion related to deforestation on the riverbank and a vulnerability increase to flooding. This research aim is to analyze the housing vulnerability, crops, and goods due to flooding in Río Nuevo, municipality of Valencia-Córdoba.

Colombia is characterized as a hydrological country because it has considerable tributaries that allow water demand. Becoming, according to the Ministry of the Environment (2018) the 15th country with water availability in the world, it brings agricultural diversity, fauna and flora, however, these tributaries also cause floods throughout the country. According to IDEAM (2018), 17% of the Colombian population suffers a flood, indicating housing vulnerability, goods, and crop loss. One of the studies on the conditions of housings vulnerability developed by Duran, C (2017) highlights that the problems are generally aimed at socioeconomic and environmental contexts, however, it is necessary to approach other scenarios such as territorial fragilities, an established methodology in indeed, which highlights the selection of factors (drainage, population density, seismology, geological faults, roads), which describe physical vulnerability, followed by an exploratory analysis of spatial data, at which stage the description



and visualization of the same, through the construction of vulnerability indices, being represented by color indicators and maps that demonstrate the results obtained, where it is interpreted that the departments with the highest vulnerability index physical are Antioquia, Santander and Meta, while the department of Córdoba and the municipality of Valencia presented a medium vulnerability, highlighting that for the analyses, there are causes that must contemplate a vulnerability evaluation, since these are divided directly and indirectly and, in turn, others are annexed, such as mining extraction, drug trafficking, climate change, and the labor market pointed out that the areas with greatest influence on physical vulnerability are the peripheral area of Colombia.

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## **2. Methodology**

Through the methodological guide for the preparation of departmental plans for risk management (2012); framed in law 1523 of the national risk management system, and the methodology for the economic valuation of potential direct tangible damages due to flooding (Baró, Díaz & Calderon, 2012). Heuristic method to evaluate a problem locally and correctly. Information acquisition data were obtained in the field. The data were collected, processed, and finally analyzed.

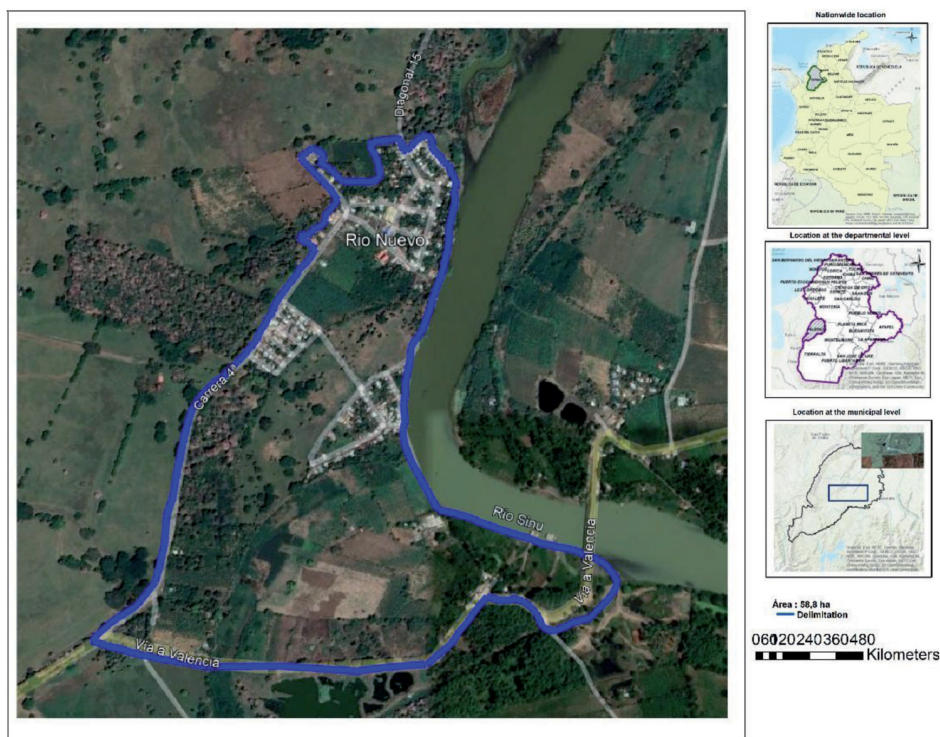
### *2.1. Study site description*

Río Nuevo, a rural community, Located at 8°15'03" N and 76°03'44" W in the municipality of Valencia-Córdoba, limited to the north by the Villanueva



rural community, to the south by the Manzanares rural community, to the east by the Sinú River, and the west by the Bijagual rural community and the municipal seat (Alcaldía De Valencia & Costa Atlántica Ltda., 2001, p. 40). This region is placed in an upper basin of the Sinú River, has a surface area of 58.8 hectares, and has crops and houses, with a population of 1,297 inhabitants in 187 dwellings. Figure 1 details the location of the district of Río Nuevo, located through the Google Earth program.

*Figure 1 - Location of the rural community of Río Nuevo, Cordoba*



Source: Authors.

## 2.2. Study design and sampling

These were a population-based cross-sectional study carried out in 2018, embedded in the National Administrative Department of Statistics - DANE (for its acronym in Spanish). Based on demarcated Río Nuevo, rural



community 2018 census data collection, the sampling frame involved 187 households in location 1 and 178 households. Thus, 144 households reflected a response rate of approximately 99% and 5% correction. A household was considered on the arrangements made by persons, individually or in groups, living together in the same dwelling unit. The questionnaires were filled by one member whose informed consent forms. It was taken into account, that the probability assumed at the time of occurrence of a flood is 50% both for it to occur and for it not to occur. The location of each survey was given randomly, which indicates that each dwelling handles the same degree of importance, regardless of its location.

### *2.3. Execution of the experimental*

The executed experimental with surveys and field visits were made were o the corregimiento of Río Nuevo. The survey covered issues of construction materials, floods, distance from the houses concerning the Sinú River, sheets of water, duration, losses in goods and crops, restoration costs, and antiquity, among others, this source of primary information was supported by the Colombian geological service and the study of geology, geomorphology, fluvial dynamics and soils for the design of Valencia bridge foundations by Geosoluciones LTDA (2010-2011), thus allowing the obtaining of the type of soil that is registered in the study area, to this are added the secondary sources, among which are the IDEAM, DANE, municipal mayor's office, periodical sources, and scientific articles.

#### *2.3.1. Housing vulnerability*

For the analysis of the physical vulnerability of the rural community of Río Nuevo, the variables proposed by the 2012 Methodology Guide of the risk management plan were taken into account, likewise, variables that are considered essential were annexed, for the determination of the degree of vulnerability. As presented the Table 1.



*Table 1 - Variables and indicators of physical vulnerability*

Questionnaires				
Variables	Question	Indicator		Vulnerability
Building materials	What is the predominant material in the exterior walls of the house?	Concrete block or brick (good technique)		2
		Concrete block		74
		Wood		261
		Bahareque		3
		Metal Print		0
		Guadua		15
		Vegetable material		15
		Zinc, fabric, cardboard, cans, waste, plastic		21
	What is the predominant material of the floors of the house?	Soil, Sand		291
		cement, gravel		94
		Rough wood, board, plank, other vegetable		52
		polished wood		98
		Tile, brick, vinyl, other synthetic materials		129
		Marble		0
Seniority (Number of Years)	How old is your home since it was built?	Less than 5 years		36
		Between 6-20 years		68
		Older than 20 years		90
Compliance with Current Regulations	Was your home built by?	It complies with the regulations of the laws (NSR-10)	Professional (civil engineer)	1
		It moderately complies with the regulations of the laws (NSR-10)	Technician (builder)	8
		Does not comply with the laws (NSR-10)	Without academic training (empirical)	114
		Does not comply with the laws (NSR-10)	By your own	303
Location	How many meters is your House from the Sinú River?	Far away	>100 m	37
		Medium close	30-100 m	72
		Very close	<30 m	213
Flood	Does your house have flooding in rainy seasons?	Presents flood		423
		There is no flood		3
Sheet of Water	How much is your home flooded? (cm)			38 cm

Source: Authors.



### 2.3.2. Agricultural production and goods lost estimated

Recognition of study areas (Topography, Geology, Hydrology). - Number of dwellings and number of crops. - Types of goods and crops. Table 2 correlated the number of people per house. Most of the houses in the township are occupied by three people, highlighting that the inhabitants who live in vulnerable areas with respect to this number of people per house represent 25% of the total, comparing this With the different groups of families, there are other households where the number of people who live in a house is 12, 13 and even 15, and when studying from this perspective it can be considered that depending on the number of people who live in a house, There will be cases where there is a greater impact on the needs, expenses and goods to cover, since many people live in a house, a degree of responsibility is presented to support themselves, so that when interpreting this as an evaluation method, it will serve to define in which dwellings greater damage or economic loss.

*Table 2 - Number of people living in a dwelling*

Quantity of people	4	13	36	26	25	18	4	11	2	2	1	1	1
Households	1	2	3	4	5	6	7	8	9	10	11	13	15

*Source:* Authors.

45% of the inhabitants surveyed have hectares, whose source of employment earns daily, although in Table 3. it can be seen that in the rural community of Río Nuevo there is a diversity of crops. The cultivated are corn, rice, plantain, cassava, and vegetables. On the other hand, 77 surveyed do not have crops due to habitants most lost investment previously floods.

Loss of property due to flooding in homes showed that 6% of household goods, 4% of other valuables, 10% of household appliances, 1% of vehicles, 47% of real estate occupying the first place, and 32% of animals taking the second, make up the losses and economic damages that generally affect the inhabitants of Rio Nuevo.



*Table 3 - Number of people with crop*

Quantity of household	1	2	6	8	14	16	25	29	77
Crop	Watermelon Collard Greens Sapote Cacao String bean Papoche	Tomato Bell pepper	Ñame	Papaya	Cassava	Plantain	Rice	Corn	Non Crop

*Source:* Authors.

## *2.4. Data processing*

The data processing through the following tools: data software, the weightings were made to determine the graphs of the variables of physical vulnerability and economic losses, thus allowing to know the economic valuation of the corregimiento when a flood occurs; After having the valuations and percentages of the variables, the properties of each survey in the Google Earth Pro software, then in the ArcGIS Pro software, the maps corresponding to the variables of the physical vulnerability and in goods and crops, it was done using the descriptive and observational statistical method.

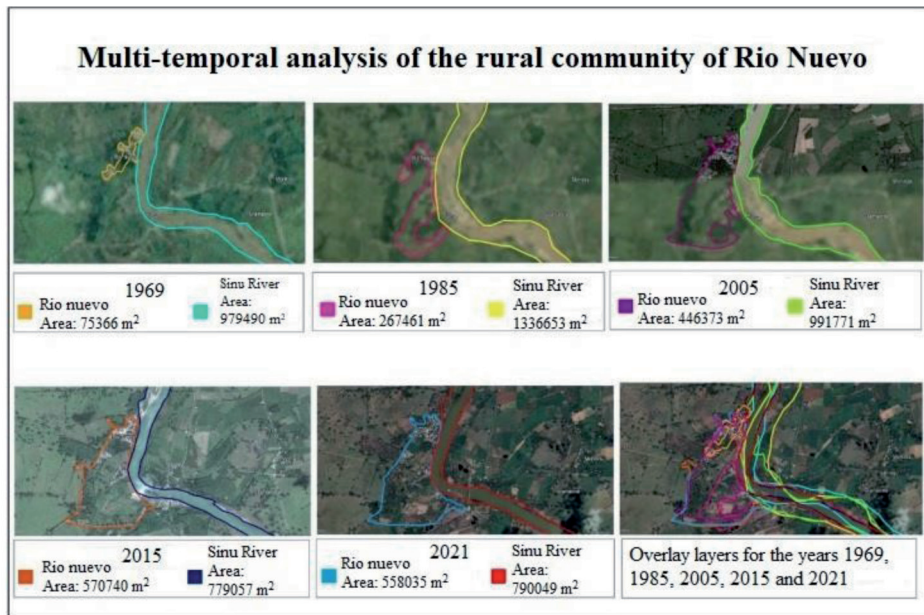
## **3. Results and discussion**

### *3.1. Multi-temporal analysis of the rural community of Rio Nuevo*

Over the years, vegetation cover largely extinguished of the banks of the Sinú River in the last 50 years. Due houses construction, as shown in Figure 2, where it is evident that from 1969 to 2021 the rural community has gone from 75,366 m<sup>2</sup> to 558.80 m<sup>2</sup> where the riverbank has been affected, in the same way, it can be seen that the dynamics of the Sinú River in recent years tend to go to the rural community, therefore when an overflow occurs it is more prone to flood.



Figure 2 - Multi-temporal analysis of the rural community of Rio Nuevo



Source: Authors.

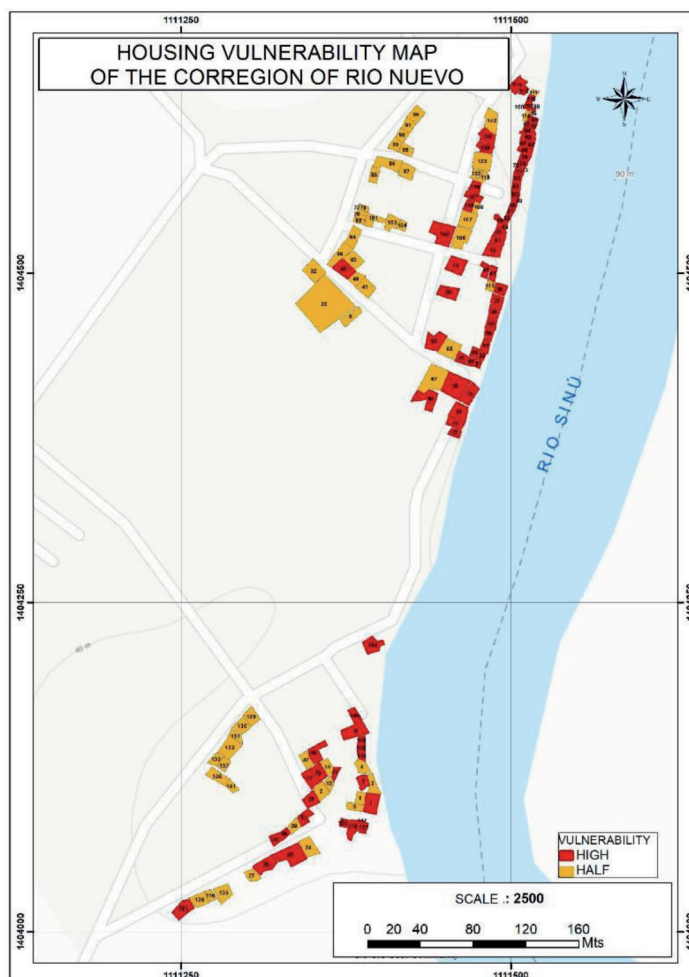
### 3.2. Housing vulnerability

The score of housing vulnerability presented by the rural community of Río Nuevo is high, 63.39; indicates that the township shows a probability of 0.63 on a scale of 0 to 1 of presenting physical damage when a flood occurs, as shown in Figure 3. The physical vulnerability that occurs in Río Nuevo is due to the fact that the material of the walls is 60% wood, which, when subjected to weathering processes caused by floods, loses the characteristics of texture, rigidity, resistance and ductility, among others, leading to the generation of instability in the structures. adds that 30% of the homes are more than 20 years old, which indicates that these materials have had interaction with the floods and therefore have low yields, in addition, the professional level variable is 96% corresponding to constructions carried out empirically and masons, who lack construction techniques that allow compliance with the NSR-10 standard, in the same way the houses that are n Less than 30 meters from the Sinú River with a percentage of 49%, they are in a high degree of exposure, indicating that they are more likely to suffer potential damage that leads to generating greater economic losses. On the other hand, according to the environmental regulations of decree 2811 of 1974 where it is specified in article 83 subsection D, the distance parallel to the line of the permanent



channel of rivers and lakes must be 30 meters, an evident situation that they do not comply with. Some houses in the corregimiento as they are built in public spaces destined for the intrinsic tree cover of the Sinú River.

*Figure 3 - Housing vulnerability map of Rio Nuevo, Colombia*



Source: Authors.

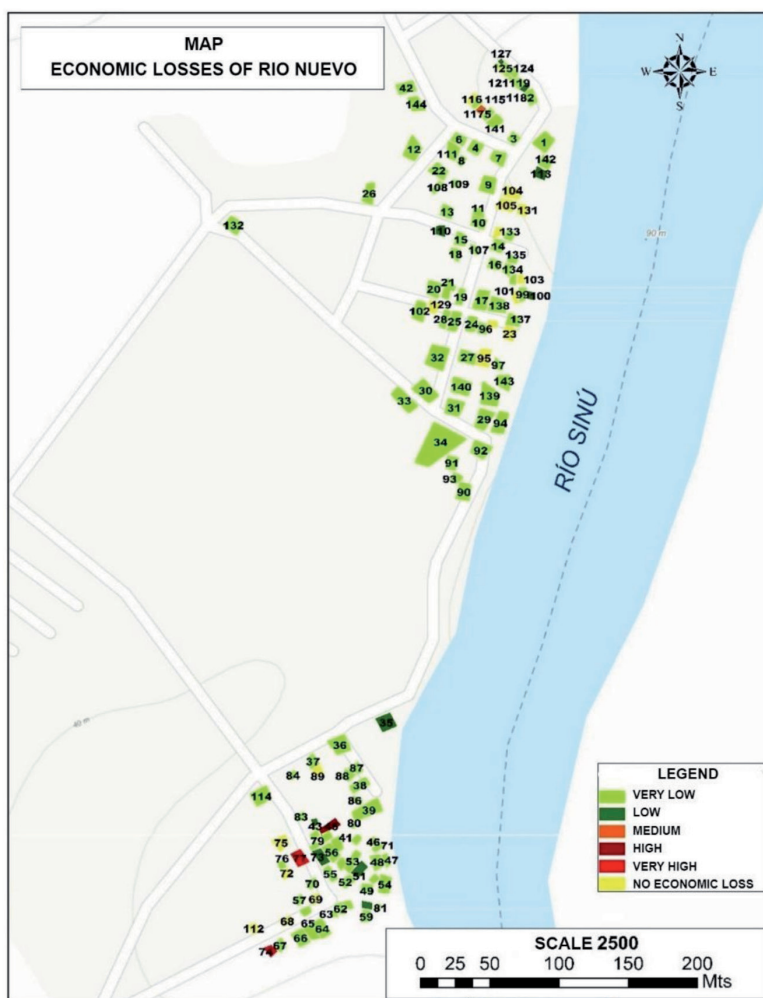
### *3.3. Agricultural production, and goods lost estimated to floods*

Due to the occurrence of disasters due to floods, the economic losses in goods corresponding to 59% yielded US\$103332,92 while in crop losses 41%



of the total lost US\$70867,30, taking into account that 45% of the respondents have hectares where they grow corn, vegetables, cocoa, cassava, avocado, yam, tomato, banana, sapote, cabbage, rice, beans, cucumber, watermelon, papaya, chili, eggplant and papoche, where the most frequent are corn, rice, plantain, cassava and vegetables, it was possible to analyze that 62% of the crops are exposed to these events whose damages present partial or total losses in the land, for which many of these people have had to stop cultivating due to the fact that the flood ruins the hectares that were suitable for these activities.

Figure 4 - Agricultural production, and goods lost estimated to floods



Source: Authors.



According to the methodology implemented for the economic valuation of direct tangible potential damages due to flooding (Baró, Díaz & Calderón, 2012), a range identify in which loss each of the inhabitants of the township was located and based on this, obtained: too low 53%, low 23%, medium 3%, high 6% and very high 15%. According to the above, related the nearest the house to the river more losses could occur.

The floods that have brought the most repercussions for the rural community were carried out in the years 1964, 2004 and 2010, the first being the longest lasting with a time of 1 month, since the construction of the Urra hydroelectric was not counted on, followed in early 2010, with a durations between 7 to 15 days and 3 to 5 days occurred, in which all events lost goods and crops, the most representative losses being goods with 59% and crops with 41%, thus achieving a total economic loss of US\$174200,22 located within the methodology with a valuation whose majority registered very low losses with 53%.

## **Conclusions**

The rural community of Río Nuevo presents a high degree of housing vulnerability, due the building materials used on houses, wood being the main material because it is acquired low cost in the area, however, the lacks a treatment that helps withstand exposure to floods, to this is added that the inhabitants do not invest in their homes due to fear of the occurrence of the disaster, thus causing the goods and crops that have been acquired to be lost.

On the other hand, the houses that are less than 30 meters do not fulfil with the regulation 2811 of 1974, which states that the distance of 30 meters perpendicular to the tributary is a public space, causing the houses to be exposed to floods and increase the problematic in the loss of goods and crops, when located in spaces destined to the vegetal covers of the rivers or some mitigation work, therefore, it is necessary to relocate them.

Sinú River had too low losses since they are in a high index of marginalization or poverty, which leads to the conditions in which they live presenting material goods of very high quality. Low cost to be in a site of threat susceptible to flooding, in the same way, these losses depend on the level of water and the exposure factor with respect to assets and crops.

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