

ANALYSIS OF RISK MANAGEMENT IN TERRITORIAL PLANNING IN AREAS SUSCEPTIBLE TO SLOW FLOODING. CASE STUDY RURAL SETTLEMENT “EL PLAYÓN” BAJO SINÚ (CÓRDOBA, COLOMBIA).

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Abstract

As a result of this research, it is proposed the incorporation of risk management as an environmental determinant in flood areas of the lower Sinú River basin for territorial planning. This was carried out through the analysis of the total flood risk, determining the threat and vulnerability of the target community, likewise, the risk drivers were identified under approaches of the integral analysis of holistic and systemic risk using a PAR model through which it is established the underlying reason, the dynamic relationship of the environment, the unsafe conditions of geography, and the socio-economic characterization of the community. In this way, it was not only obtained the analysis of the areas affected by the floods by identifying the causes and establishing a level of risk tolerance, but also the risk factors with their effects in the study area. This highlighted the importance of developing immediate and priority activities in the study area.

Keywords: Territorial planning; Slow floods; Total risk analysis; Risk drivers; Environmental Determinants

Introduction

In Colombia, floods are increasing, and at the same time the socio-economic, environmental, institutional and physic-structural impacts.

This type of socio-natural disaster can affect the development of a community causing social, economic and even environmental consequences, which is currently a subject of research and entails to its subsequent analysis.

River flooding is one of the most important natural risks, affecting millions of people and causing severe economic and social impacts around the world. Research on river flooding includes flooding risk assessment [1], resilience assessment by *L.E. González et al.* [2], formulation of emergency strategies [1], and nature based solutions Bush et al [3] *I. Tumini et al.* [4].

Some studies on flooding risk and its relationship with planning processes are discussed at what follows. *L. García Barrón et al.* [5] determined severity of flooding of Guadalquivir River in southwest of the Iberian Peninsula during XIII to XIX centuries, by using social and

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historical analysis. *M. Zhao et al.* [6] assessed the effectiveness of projects of dams for controlling sudden floodings, water supply and irrigation at Wangmo basin in China, using HEC-HMS, HEC and FLO-2D models. *J. Hounkpè et al.* [7] assessed the observed and predicted vulnerability to flooding at Ouémé Río Cuenca in Benin (West Africa) under climatic change, using statistical approaches based on multiple models. *S. Santoro et al.* [8] addressed solution planning based on policies, for the reduction of flooding impact on the communities of Brindis (Puglia region).

Other studies address the effect of climatic change on flooding, what is important in risk management planning. *N.W. Arnell and S.N. Gosling* [9] assessed the environmental impacts caused by climatic change and its effect on flooding at global level, using a hydrological model and 21 climatic models. *G. Blöschl et al.* [10] assessed the effect of climatic change on flooding of European rivers. *B. Arheimer and G. Lindström* [11] assessed the effect of climate on flooding in Sweden, focusing on stream flows in the 1911-2100 period, using dynamic models in order to provide the prediction for the succeeding 100 years.

In our country, territorial planning is a subjectively new process that advances in conditions of normative development and very heterogeneous political-administrative decentralization.

The province of Córdoba has 28% of its territory in high-risk areas, most of it caused by periodic floods aggravated by “La Niña” weather event, totaling more than 295,731 hectares flooded, mainly in the Sinú and San Jorge basins. On average, the province faces conditions of medium-high vulnerability, with a value of 58.3% that reflects the degree of vulnerability to floods. Despite this, there are no detailed studies of threat, vulnerability and risk in the province that allow adequate risk management in territorial planning and know the territorial reality, by *C. Euscatogui and G. Hurtado* [12].

With the above, the purpose of the project is to propose the Incorporation of risk management as an environmental determinant in flood areas of the lower basin of the Sinú River for territorial planning, for this reason, the case study of the rural settlement “El Playón”, Bajo Sinú (Córdoba, Colombia) was used, consequently the development of this project will aim to analyze the threat of flooding and vulnerability in much more detail, to obtain the total risk, analyze the risk drivers that affect the generation of new dynamics in the construction of the risk in the rural settlement “El Playón” and establish the guidelines for the implementation of risk management as an environmental determinant in the rural settlement “El Playón”.

Experimental part

Materials and Methods

“El Playón” is a rural settlement of Lórica, in the province of Córdoba, located to the north at 9°11'28.34" and to the west to 75°49'09.43", on the left bank of the Sinú River. It is located within the Caribbean hydrographic zone, Sinú zone and subzone under Sinú, IDEAM [13]. It has an approximate extension of 8.26 hectares and can host 143 families for a total of 488 people.

Sample Calculation

Sample size: For a population size of 488 inhabitants, spread over 143 families, with a confidence level of 95%

A margin of error of 7% was obtained. From a sample size of 80 families surveyed.

Analysis of natural hazards by flooding

Following the guidelines and references of the Hydrological and Hydraulic Modeling Protocol, IDEAM [14] and the Methodological Guide for the Elaboration of Flood Maps, IDEAM [15], the following stages were adopted and carried out for the analysis of the threat of the rural settlement “El Playón” of the Municipality of Lórica:

(i) Obtaining graphic information, i.e. analysis of satellite images and collection of field information

ii) Obtaining a Digital Terrain Model.

iii) Hydrological modeling for the determination of flows for each return period

(iv) Hydrological modeling and mapping.

For the definition of the hydrological contribution area and the calculation of hydrological variables (average gradient of the channel, concentration time), a Digital Elevation Model (MDE) was used and the generation of an Ortho-photo. In these stage four flights were executed with a Phantom 4 Pro UAV Unmanned Aerial Vehicle in the area of influence of the flood, the photographs were taken with an overlap of 0.80, in order to create an overlapping among the images; the flights were made at 100m high with a resolution of 3.8cm per pixel. *M. Tiepolo et al.* [16] generated and analyzed orthophotos and concluded that the used method can be applied to different cases, serving as support for decision making in territorial planning.

This helped to determine in detail the problems associated with the real threat of flooding along with an interpolation of points and the transverse lines defined by Urrá for “La Palma” section, where the capacity points were taken, which generated a bathymetric profile, in addition they were interpolated with control points. The bathymetry was fundamental to develop the bottoms (axes, legs and crowns of the river). After this, the execution of the information was prepared.

Likewise, questionnaires were applied to identify population variables that specified the social determinants of the community.

Therefore, multiple return times were calculated for the hazard assessment, including the most crucial period (100 years). These return times were used to validate the current hydraulic capacity of the existing channel in the area (study section). Finally, based on these results, satellite photos of the site in rainy seasons will be taken into account to compare and check water spots and verify sites prone to flooding that may harm the research area.

Landsat 4-5 and Landsat 8 satellite images were analyzed with a spatial resolution of 30 meters and satellite images of the Rapid Eye constellation, obtained from the Planet platform with a spatial resolution of 3 meters. For a better interpretation of the water spots, the combinations of bands 5-4-2 and 6-4-3 were used, which represent the RGB combination that shows a more significant differentiation between water and soil, since they have two bands which are located in the infrared region, under these combinations, water, regardless of the number of sediments present, is displayed in dark colors. However, the altimetry in “El Playón” can vary from 2 to 10 meters above sea level. In this sense, the susceptibility to flooding in rainy seasons is high. Taking into account that the Sinú River has an average flow of 450m³/s and the proximity of the municipality to it, a possible risk scenario is presented.

For the threat analysis, the document generated by the National Disaster Risk Management Unit, UNGRD [17], was used, which includes the procedures for the construction of dangerous event scenarios, and it was adapted as a methodological guide. For dangerous events, a study of frequency, intensity and impacted territory was carried out, using the manual of the National Unit for Disaster Risk Management (UNGRD) [17], which provides the following criteria:

Threat rating: In the case of the rural settlement “El Playón”, threat levels will be used for the return periods of 2 and 100 years, taken as the scenarios of higher and lesser probability, respectively.

Frequency of the event:

An event that occurs more than once in a year or at least once in a period of 1 to 3 years: III (HIGH).

An event that occurs at least once in a period of between 3 and 5 years: II (MEDIUM)

An event that occurs at least once in a period of between 5 and 20 years: I (LOW)

Intensity of the event:

Many dead, many people injured, large areas of the territory affected, serious damage to natural resources, suspension of essential public services, considerable economic activities, serious damage to local infrastructure and many houses destroyed: III (HIGH).

Few dead, several people with minor injuries, moderate damage to the territory, damage to public service networks, temporary suspension of public services, temporary suspension of economic activities, moderate damage to provincial infrastructures, few houses destroyed and several houses damaged: II (MEDIUM)

No dead, very few people with minor injuries, minimal damage to the territory, no damage to public service networks, no interruption of economic activities, no damage to provincial infrastructures, no destruction of houses, no damage to houses: I (LOW)

Affected territory

More than 80% of its territory is affected: III (HIGH)

Between 50% and 80% of the territory is affected: II (MEDIUM)

Less than 50% of the territory has some type of affectation: I (LOW)

Threat rating values

Interval: 1-3 = High

Interval 4-6 = Medium

Interval 7-9 = Low

Vulnerability assessment and categorization

Vulnerability refers to the sensitivity or fragility of society to threats to its well-being and its ability to recover from damages. Vulnerability is a social problem closely linked to the lack of development of a society.

Four dimensions that make up the vulnerability of the population were taken into account for the calculation of vulnerability: Social, Economical, Environmental, Institutional.

According to the fieldwork and a group of experts, the weights of the aforementioned dimensions were determined, and likewise the weights of the factors within each of the dimensions (exposure, fragility and resilience) were also calculated; the calculation of exposure is equal to the value of exposure by the weight of exposure, fragility is equal to the value of fragility by the weight of fragility, the weight of resilience is equal to the value of resilience by the weight of resilience, and the same for the other factors of the other dimensions.

Additionally, the dimensions of vulnerability were determined with the value of the final exposure plus fragility plus previously calculated resilience; among these factors will be the evaluation parameters whose information was collected through surveys of 50% of the homes in the community, meetings with focus groups and key participants; For each of the dimensions, factors and parameters, the values of importance will be determined using the method of hierarchical analytical processes through the matrices of, *T. Saaty* [18] and the weights of importance were determined by a panel of experts, in order to determine the vulnerability thresholds.

Once the allocation of weights was completed, the average of each of the values assigned by the experts was calculated, and these resulting weights were taken to an Excel spreadsheet for the development of the operations that allowed to establish the prioritization threshold and the level of vulnerability of the properties.

Risk Analysis: As part of the study and understanding of the phenomena in a specific region, it is necessary to clarify the theoretical situation, that is, to describe and characterize the scenario. *J. Gil and P. Steinbach* [19], *H.G. Winsemius et al.* [20], *P.J. Winsemius et al.* [21], *M. Arosio et al.* [22] assessed risk management based on its three parts: hazard, exposure and vulnerability. They stressed that using a detailed scale is crucial for a proper analysis. Part of this is to identify the word danger as a starting point and then move to a subdivision of natural danger, which gives characteristics to the settlement of the human being in the face of various natural or artificial disasters.

V. Meyer et al. [23] and H. Apele et al. [24] indican que las medidas de gestión del riesgo de inundación no solo tienen como objetivo controlar las aguas de inundaciones, sino que también tienen en cuenta las posibilidades de reducir la vulnerabilidad a las inundaciones por medio de la preparación de medidas eficaces de mitigación.

The naturalness of the language incorporates several disciplines, which gives rise to a permanent use. Consequently, B. Echemendía [25] thinks that the risk of the activity can have two components: the potential or probability of a fatal consequence and the size of that event. Consequently, when the probability and possible loss increase, the risk increases.

It is as if risk and probability act on the area, regardless of its physical qualities, and deciding that this danger is constituted by natural or anthropic processes, warning that most of them are involuntary.

For the case of the present study, the risk level assessment will use the technique applied in the report of the "Analysis of the type of infrastructure-based adaptation measures for selected important sites in the "Sinú, San Jorge, Canalete and Zona Costanera" river basins." Agreement 026 of 2016, UPB – CVS [26] where once the threats (A) have been identified which the populated center of the settlement of "El Playón" is exposed, and the vulnerability investigation (V) has been carried out, a joint evaluation was carried out to calculate the risk (R), that is, to estimate the possibility of expected losses and damages (people, material goods, economic resources) before a natural, socio-natural or anthropic phenomenon. For this purpose, the following matrix was used (Table 1):

Table 1. Matrix to determine the risk by threatening events (Source: CVS, UPB, 2016)

High Threat	Medium Risk	High Risk	High Risk
Medium Threat	Low Risk	Medium Risk	High Risk
Low Threat	Low Risk	Low Risk	Medium Risk
	Low Vulnerability	Medium Vulnerability	High Vulnerability

The expected amount of risk can be estimated by crossing the two numbers. If a high threat finds a high vulnerability event, and they overlap in the same zone, this technique is used based on the attributes of danger and vulnerability. The level of risk required can be calculated by crossing the two numbers.

Risk drivers: The strategy designed to obtain the information and meet this objective was based on the information collected with the focus groups, surveys and descriptive and evaluative research where the variables collected were known, delimited and analyzed regarding the flooding problem that has been evidenced for several years in the rural settlement of "El Playón". Belonging to the municipality of Santa Cruz de Lorica.

For the articulation of Risk Management in territorial planning plans, it is essential to identify and recognize those variables, antecedents and conditions that are generating risk in the territories, for this the underlying causes that generate limited access to resources must be evaluated, as well as the pressures and conditions that represent scenarios of unsafe and threat to the population.

The steps or stages for the methodological development are:

- Analysis of risk-driving conditions.

They are political, social and economical conditions that contribute to the social construction of risk. This concept is derived from two central ideas: (i) the understanding of risk as a process, that is, that it has specific antecedents and, therefore, is not an "ad hoc" or fortuitous situation, but a phenomenon that occurs when certain conditions of territorial sustainability are ignored during the development process; and (ii) that the processes that contribute to risk creation are known as risk drivers, UNDRR [27].

Within the same questionnaires applied to identify population variables related to vulnerability, questions were posed for the identification of these drivers.

- Pressure analysis and disaster release proposed by *P. Blaikie et al.* [28].

G. Blöschl [10] proposed the model of pressure and releasing by relating the conditions of risk from the complex relationship between threats and vulnerability, understanding the latter as the result of antecedent causes (ideological processes of an economic, demographic and political nature that influence power relations) that are manifested in dynamic pressures, *J.P. Sarmiento* [29].

It is important to highlight that this model has a dynamic nature and that the processes that interact with it are constantly changing. In this context, four basic risk management concepts are used for this study: threat, vulnerability, resilience and underlying disaster risk factors.

Environmental determinants in the rural settlement of “El Playón”: To identify the environmental determinants in the study area, a bibliographic review and an analysis of all the environmental regulations established by the Ministry of the Environment were carried out, and all the relevant information was summarized.

To ensure the inclusion of environmental factors and their impact in land use decisions, it was verified the inclusion of strategic areas and ecosystems defined in the Technical Guide for the Development of Watershed Planning and Management of the POMCA at the basin level, *Minambiente* [30] as well as the participation in the categories of territorial planning and the impact of this stage (determinant of the environment) in the Territorial plans.

Results and discussion

“El Playón” is a community characterized by a discontinuous urban tissue, which has approximately 143 homes, CVS [31] and is located a few meters from the Sinú River, on its lowest basin. In this sense, it is observed in the images, the muddy complex of Lorica that spreads in areas surrounding this community due to the low topography conditions, as represented in the MDE.

Most of the territory has an altimetry of less than 20 meters above sea level. However, the altimetry in “El Playón” can vary between 1.4 to 45 meters above sea level (masl). In this sense, the susceptibility to flooding during rainy seasons is high. Taking into account that the Sinú River has an average flow of $450\text{m}^3/\text{s}$ and the proximity of the population to it, a possible risk scenario is presented (Fig. 1).

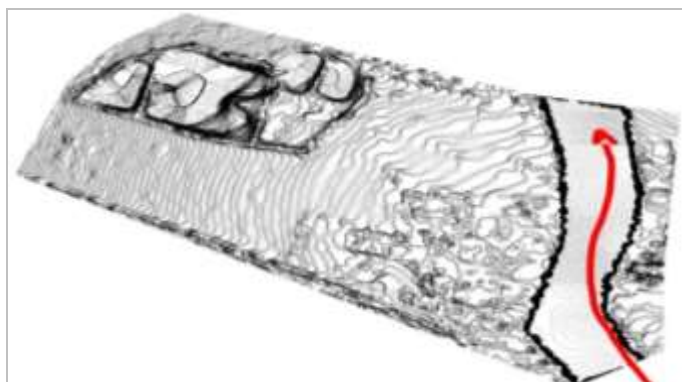


Fig. 1. Digital Elevation Model of the rural settlement of “El Playón” generated in Global Mapper

Satellite images allow to clearly observe the houses in the area and the vegetation. The results showed a higher pixel value for the blue stripe, in all cases. Which indicates that although the resolution did not allow to clearly show the water spots, they probably exist in the

vicinity of the river as the pixel value of the stripe that represents this attribute is higher in the combination 5-4-2 and/or 6-4-3.

Figure 2 shows the multi-temporal analysis with satellite images for the years 2021, 2017, 2011, the images were processed with the combination 5-4-2 or 6-4-3, which allows to evidence water spots for high-resolution images of the rapid eye satellite constellation, and the image of the year 2010, was made under the combination 5-4-2, appropriate to show water spots in LandSat 4-5 images, which were the only images available for the time. However, both combinations are used to highlight spots and/or bodies of water.

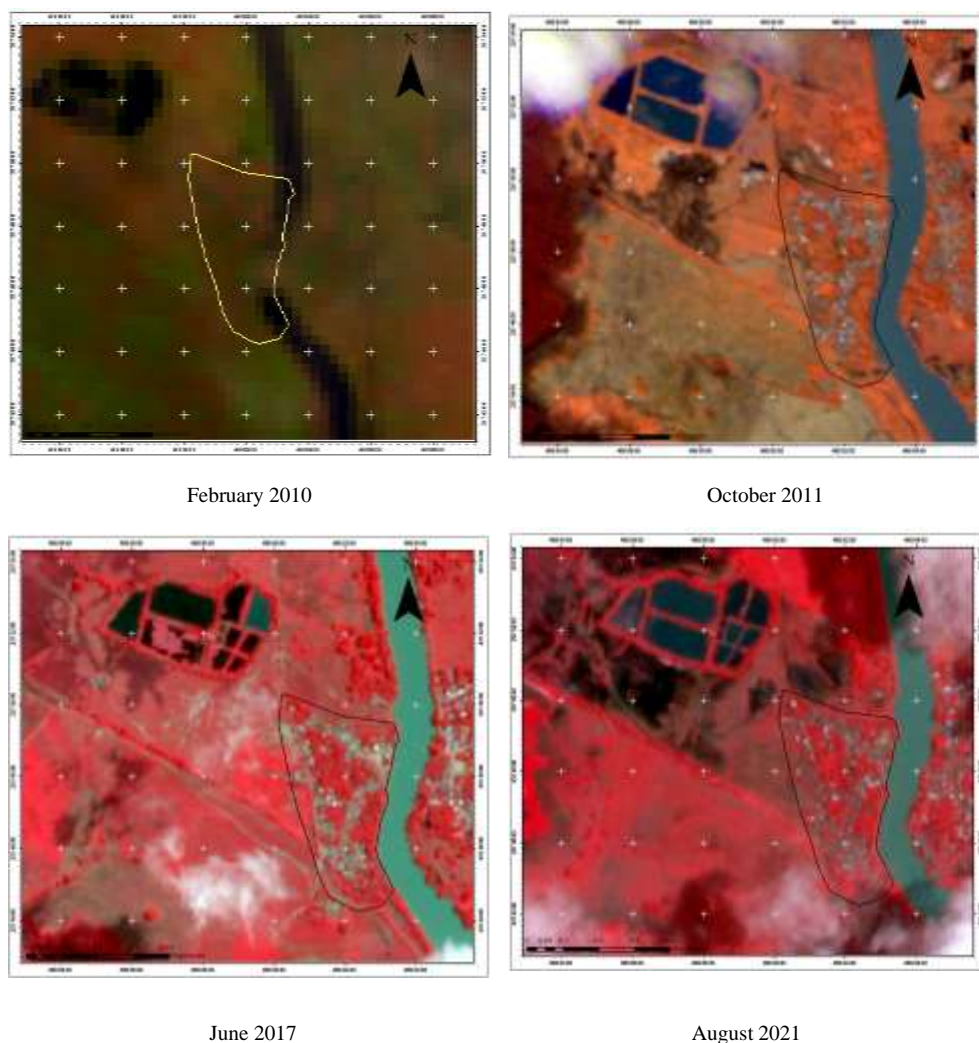


Fig. 2. Multi-temporal analysis with satellite images for different years in the study area

Figure 3 shows the results of the HEC RAS methodology model with the evolution of floods for different return periods in the center of the city "El Playón".

A record of flood events in the area is evident. Therefore, it aims to determine the vulnerability to this threat, generated by a set of social, geographical, climatic and hydrographical factors and that may be being aggravated in the face of the climate change

scenario that we are currently experiencing. The map below has a resolution of 2 meters developed under the processing of ortho-photos taken with drone, taking into account the precipitation data of the region and using the HEC-RAS software.

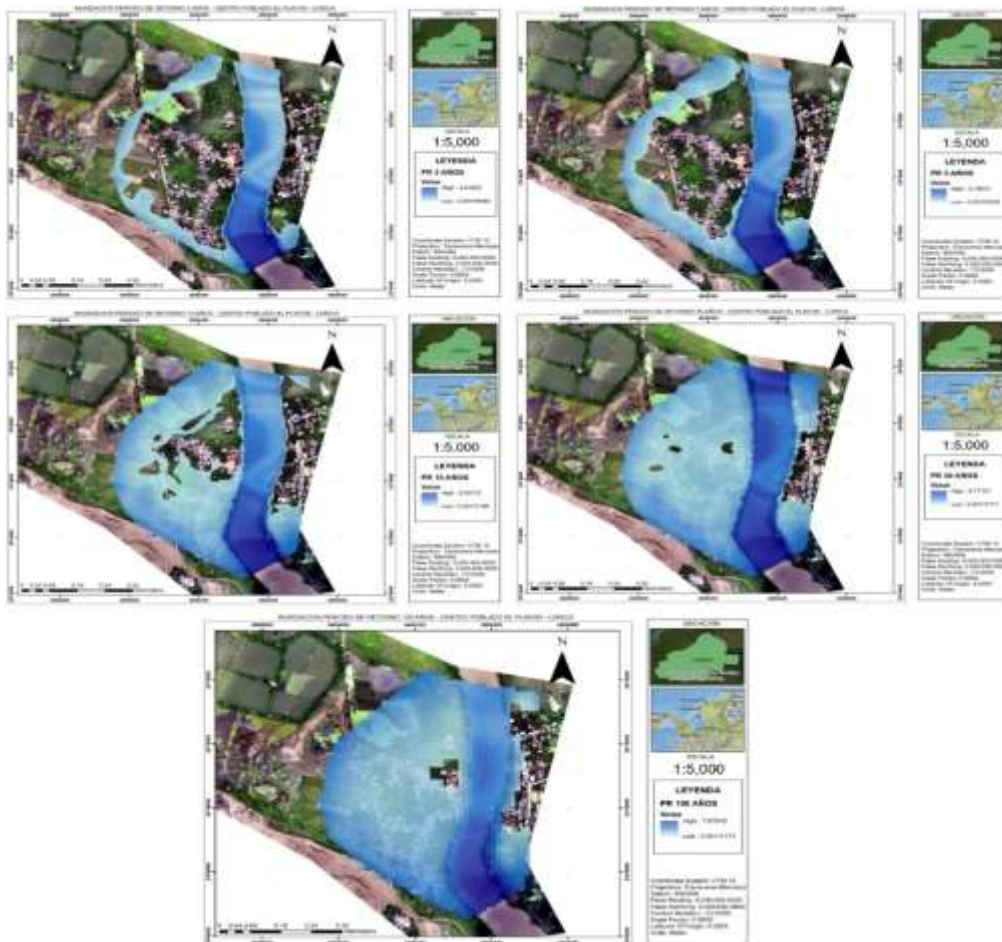


Fig. 3. Flood model for different return periods in the town center of “El Playón” – Lorica
Source: Own elaboration

It is evident that for a given period of return the flood spot goes from affecting a few properties to covering practically the entire area of the rural settlement, when projecting for critical events such as 50 and 100 years the growth of the spot and the increase in values is observed. Likewise, for extreme events of 50 and 100 years the water column reaches up to 6.77 and 7.67m.

Frequency of flooding events in the town center of “El Playón”

Floods - return period of 2 years: Frequency 3 (High)

Floods - 100-year return period: Frecuency 1 (Low)

According to the above, the most recurrent events are those ones associated with flooding of the Sinú River with return periods of 2 years, so they have a high rating as opposed to the events of those ones with return periods of 100 years.

Intensity of the flooding event in the town center of “El Playón”

Floods - 2-year return period: Intensity 1 (Low)

Floods - return period of 100 years: 3 (High)

For the most intense return periods presented in the floods that took place in 1997 and 2017 according to the study of the CVS affected crops and all houses, and it lasted approximately several months according to the inhabitants, there was no public lighting or aqueduct or sewer systems. The community received help from Diaconie, which is an NGO that helps in disaster issues, Unicef, Demposta, the Red Cross, Sidah architecture, Eco, Opsa Basic Sanitation "Methodological Guide for the elaboration of provincial plans for risk management" (2012). For this reason, a high value is attributed to floods with a return time of 50 years in the research region. On the other hand, for floods with a return time of 2 years, there are no fatalities, there is no significant and serious damage to the ground, there is no damage to the provincial infrastructure and there is partial destruction of homes, a low value is given.

Affected Territory by flooding events in the town center “El Playón”

Floods return period of 2 years: Affected territory 1 (Low)

Floods return period of 100 years: Affected territory 3 (High)

For flood events with a return period of two years, taking as input the results of flood modeling, it is clear that less than half of the households are affected by the water sheet, which is assigned a score of one; however, for flood events with a return period of one hundred years, it is clear that the water sheet covers all the properties of the area, having a territory with high affection.

According to Table above, flood events for return periods of 5 and 100 years have a Medium and High Threat respectively (Table 2 and Fig. 4).

Table 2. Threat rating

Threatening Events	Intensity	Affected Territory	Frequency	Total	Threat Rating
Floods return period of 2 years	1	1	3	5	Medium
Floods return period of 100 years	3	3	1	7	High



Fig. 4. Flood threat level return period 2 years – and 100 years. Town center “El Playón” – Lorica

Vulnerability assessment: The assessment of exposure or exposed components articulates people, subsistence resources, environmental services, economical and social resources, cultural property and infrastructure that may be affected by the manifestation of a hazard due to their location. In the context of the present research, the exposure to the real danger of flooding in the rural settlement “El Playón” was evaluated considering the historical

record of flood episodes provided by the environmental authorities of the region and the municipal entities of Santa Cruz de Lorica (Fig. 4).

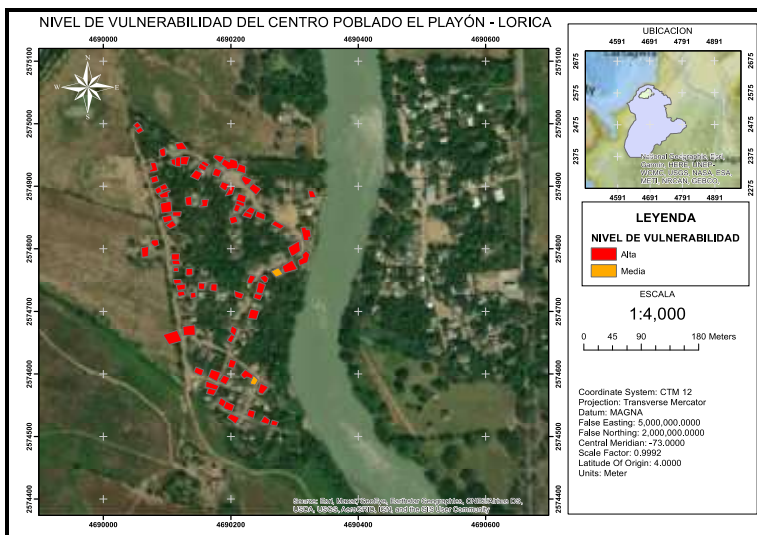


Fig. 5. Multidimensional vulnerability map of the rural settlement “El Playón”

The homes inspected were recognized during the survey of the primary information and the position of the properties was established using Google Earth Pro software, digitizing the polygons of the properties surveyed through ArcGIS and their editing capabilities.

According to the information collected in the 80 homes described, 97% of the properties have a high vulnerability and 3% a medium sensitivity, indicating that the entire population living in “El Playón” is subject to a flood threat.

Vulnerability thresholds: The result obtained based on the sum of the products made among the weighted scores of the descriptors, parameters, factors and dimensions by vulnerability, generates the values of significant vulnerability, of which the threshold is established to define the areas that present impacts with higher incidence.

Table 3. Vulnerability thresholds

Level	Ranks		
HIGH	0.397	≤ v ≤	0.576
MEDIUM	0.215	≤ v <	0.397
LOW	0.033	≤ v <	0.215

Values and levels of vulnerability: Considering the vulnerable and susceptible aspects (age group, exposed educational services, health services, etc.), an analysis of the scenarios exposed to the dangers of floods was carried out, assigning grades based on the descriptors present in their homes. The risk value is given to the descriptors of each of the characteristics found through the surveys based on the score assigned (1) for each of the components that make up the vulnerability (Dimension, factors, parameters and descriptors). Vulnerability threshold values are used to determine which properties are most susceptible to slow flooding.

Social vulnerability: In total 80% of the registered properties have a high level of vulnerability and the remaining 20% are classified with medium vulnerability, this is highly influenced by the number of people who inhabit the property, the quality of the public services

they have and the capacity of the population to be prepared for flood events thanks to prevention campaigns.

Economical Vulnerability: As a result of the dimensional analysis for the economical component, the results show that 20% of the properties show High vulnerability, 74% Very high and only 1% Medium, which is highly influenced by the materials of the house, the type of employment of the head of household and their salaries.

Environmental vulnerability: All properties are within a very high environmental vulnerability; this is due to poor practices regarding the management of household wastings, lack of environmental education and deficiencies in the municipal solid waste management system.

Institutional Vulnerability: All the properties of the rural settlement of “El Playón” present a very high vulnerability with respect to the institutional component, this is because the territorial management of the entities affects everyone equally, as the implementation of plans and management aimed at the knowledge of disaster risk is deficient, the population is politically unprotected within the jurisdiction of the mayors and governors, this added to the little interest of the population to appropriate and learn from the dynamics that occur in the territory.

Risk Analysis

Flood risk scenario (Table 4): According to the described methodology, the following matrix was designed for the flood event.

Table 4. Risk scenario of the flood event in the town center “El Playón” (Source: Own elaboration)

Flood		Risk Scenario	
High Threat	Medium Risk	High Risk	High Risk
Medium Threat	Low Risk	Medium Risk	High Risk
Low Threat	Low Risk	Low Risk	Medium Risk
	Low Vulnerability	Medium Vulnerability	High Vulnerability

The town center “El Playón” shows medium and high threat scenarios, and within the levels of vulnerability of the families and properties that make up its community, medium and high vulnerability values are shown, therefore at the time of a flood of medium threat in the territory (return period 2 years) those ones who have an average water vulnerability will present a medium risk taking into account the parameters used to measure the threat throughout the territory and those ones who have high vulnerability to these events will also present a high level of risk, at the time of a flood with critical return periods (50-100 years) of high threat, both properties and families that present a degree of medium and high vulnerability will have a degree of risk somewhat due to flooding.

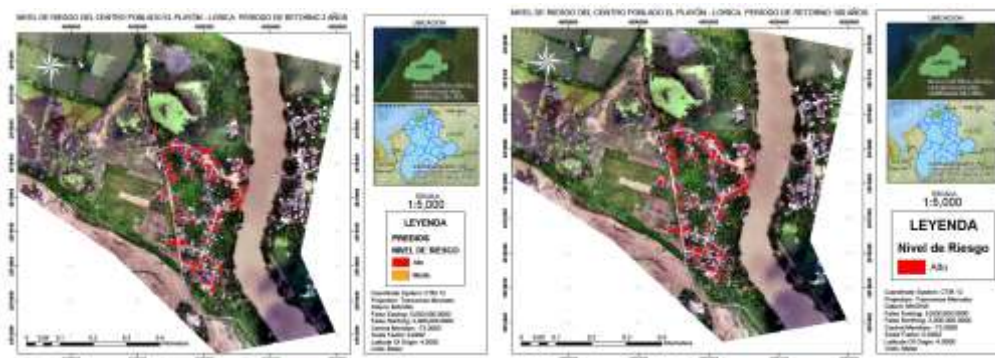


Fig. 6. Risk of flooding of the town center “El Playón” with a return period of 2 years and 100 years

Risk Drivers

In this part of the research, it was evaluated the component of Disaster Risk Management in “El Playón” community, under approaches of comprehensive risk analysis: Holistic and Systemic, generating a complex system from an overview of the interrelation of the parties and originating synergies that then triggers what complexity theory stipulates for the analysis of social characteristics, environmental, economical and political in a system; as well as, the articulation and association of the same to achieve an effect of higher power and in turn produce a higher impact on the population.

At the same time, it was evident that there are mechanisms that contribute to the risk condition: the underlying causes show us the development models, causing dynamic pressures that are the result of the development models that have been implemented in the territory, which originate unsafe conditions, there is evidence of the result of the dynamic pressures that in other words are the effect that these generate.

In brief, the unit of analysis is characterized by the elements of flood risk in the Lower Basin of the Sinú River, which are explained in two lines: first one, considering the climatic variations of the study area, and the other one, focusing on the causes associated with unsafe conditions and unsustainable development, a scenario caused mainly by deficiencies in planning, decrease in wetland areas, modification of land use, the construction of hydroelectric and environmental degradation, translated into the generation of a fragile physical and social environment.

When assessing the risk of a natural or man-made disaster, vulnerable social media should consider themselves to be of the same level of importance as they devote to understanding and responding to natural hazards. Expressed in a schematic way, a PAR model is presented through which the underlying cause and its relationship with the dynamic pressures of the environment and the unsafe conditions of the geography and socioeconomic characterization of the community are established. This model is a strategy for considering people as key factors in a complex combination of vulnerability and threat or danger [10] In any case, catastrophes are the result of the interaction of both variables; there is no risk if there is a threat but the vulnerability is zero, or, if there is a vulnerable population but there is no catastrophic event.

The PAR model, Pressure and Disaster Release that applies to the case study and supports the proposed measures for prevention, reduction, mitigation and control of the impacts caused by floods, is presented below.

In this way, the main problem that occurs in the rural settlement “El Playón”, is associated with a threatening phenomenon such as flooding, accompanied by severe cases of river erosion due to those same changes in the hydrological dynamics of the lower basin of the Sinú River, caused by the Urra I reservoir and the environmental dynamics of the territory. It can be said that the insufficiency in the control and attention by the state, the social and economical vulnerability, have marked a current and progressive historical trajectory on the processes of environmental degradation and increase of disasters such as those ones experienced by the inhabitants in the floodings that occurred in the years 1999, 2007 and 2010.

Conclusions

Taking into account the vulnerable elements, an analysis of the areas affected by the floods was carried out, identifying that, due to the lack of implementation of plans and procedures aimed at reducing the risk of disasters, the population is administratively unprotected within the jurisdiction of the province of Córdoba.

There is a strong link among climate, ecosystems and development. As well as among climate change, the ability of ecosystems to provide goods and services, and the transformation of these goods and services for human well-being and economical growth. According to the

conclusions of this study, among the six (6) risk factors (climate change, conflict, gender inequalities, food and water insecurity, urbanization and forced displacement), the acceleration of climate change has the highest impact on natural disasters resulting from anthropic interactions with ecosystems, and food and water insecurity caused by the economical deficit of the population. Therefore, it is essential in all communities such as “El Playón” to apply and adopt measures to combat climate change and its effects, such as, for example, having financial and physical resources for better education and response to possible emergency scenarios.

Therefore, it is essential to identify and update planning instruments that are not aligned with this regulation. In this way, it is applied higher relevance and control of strategic ecosystems, and their temporal and spatial behavior, which are found in the territory

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