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INDEX OF SOCIAL VULNERABILITY DUE TO FLOOD

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Abstract: Floods are a problem that is aggravated by the levels of existing social vulnerability, by creating an environment of risk when they affect the human being, by causing loss of life or damage to the built and natural environment to which man has access and from which he obtains some benefit. To determine social vulnerability, we start from the characteristics and living conditions of the people, estimated in the Marginalization Index by electoral section 2010, and their proximity to the development of the floods registered in the flooding polygons of the Water Commission of the State of Mexico from 2000-2010; by making use of statistical tools and geographic information systems, social vulnerability due to floods can be more accurately determined; For the development of this research, the State of Mexico is taken as a case study, in which the result shows that 42.96% of the electoral sections were affected by floods, and 47.36% of the population for the year 2010. The general conclusion of this work shows that, the simplification of the analysis of vulnerability by product of the overlap of flood zones and the degree of marginalization, allow to estimate accurately and with high reliability the most vulnerable areas, which would be given priority in the taking of actions dedicated to the reduction and prevention of the existing and future situation of vulnerability.
Keywords: Risk, vulnerability, floods, disasters, marginalization index.

INTRODUCTION

The environment generated from the appropriation of the territory and the creation and construction of means and forms of life by the establishment of human settlements on some region of the planet, is undoubtedly a scenario in which the human being adapts to the geographical conditions that it contains, and in addition, to achieve an imposing establishment, it transforms this territory with the outline of communication routes, the construction of housing, infrastructure, equipment, among others, which is summarized, in the transformation of the natural landscape, to that of the cities, either in a rural or urban environment.

This appropriation of the territory is carried out far from the analysis of the physical conditions presented by this environment, where the development of natural processes typical of the evolutionary dynamics of the planet takes place, which due to the intensity with which they happen, are difficult to control since, generally, they occur unexpectedly for the human being, generating an environment of risk, and in some cases, they can lead to disasters.

There are disasters that visibly affect the territory, as evidenced by the devastation produced by the development of meteorological events that produce consequences for creating direct and indirect damage and macroeconomic effects on GDP, public finances, prices, inflation, employment, among others ECLAC (2005:20).

At present, the need is present to be able to generate the perspectives of the problem of risks of each country, because the conditions of damage or potential losses are due to the probability of natural events of great magnitude and intensity that occur recurrently, and to the socio-environmental conditions that facilitate the development of the disasters, due to the deficient socioeconomic resilience and little or no risk management, all this must be managed from their identification, prevention and mitigation, which is the main objective of dealing with natural processes IDB (2010).

As a result, average annual losses from earthquakes, tsunamis, tropical cyclones and river floods, estimated at $314 million, have been recorded globally in the built environment alone, representing an average

annual loss in low-income countries equivalent to approximately 22 per cent of social spending, compared to 1.45% in high-income countries, this situation keeps the least developed countries UNISDR (2015) in conditions of backwardness and economic backwardness.

These risks are closely linked to causal factors, such as environmental degradation, poor urban development planning and management, and weak governance, which according to UNISDR (2015:4), are also a concern for the population of low-income households that depend on public infrastructure and for the local governments that provide it.

The study of the problems arising from the development of natural processes is a complex issue, since they increasingly affect a greater number of the population, with loss of life and its built environment (Gómez, 2007). Emphasizing the above, for example, because there is a risk to the threat of floods, so we try to define criteria for the analysis of these areas, for the reduction of the impacts it receives, to reduce the levels of social vulnerability of the population centers where Martínez (2013) occurs.

The situation of disasters can be conceptualized as an adverse event, representing alterations in people, economic and social structure and the environment, product of nature, which is generated by human activity or by the combination of both and that cause most of the time an emergency (García, 2010).

In this sense, it is relevant for Marchezini (2014) that the risks derived from the precipitation of rains, indicate, that this is not a danger factor for the return of a group or community of vulnerable people, but it is the interaction, and synergy, of the physical event with the social systems where this set of individuals is inserted. In addition to this, there is a complication of the problem of floods because it is related to social practices outside the normative and regulatory framework for the establishment of human settlements, which turns floods into an environmental degradation of the urban and rural environment, and which also increases the social vulnerability of the city where they occur (Bartolomé, 2006).

As a result of the occurrence of various disasters associated with floods, these have received greater attention in the world due to their impact on the population, due to the economic impact they cause, their study has received attention mainly from earth sciences, which through the implementation of different methodologies analyze river dynamics, establish return periods, and delimit the possible areas of impact, among other aspects. The establishment of areas susceptible to this type of process is often developed with the help of tools such as Geographic Information Systems and Remote Sensing techniques, also, through mathematical models applied in Hydrology; all of the above in order to express through maps (in graphic form) the potential areas to present floods of different magnitudes (Garnica and Alcántara, 2004).

OBJECTIVE

The objective of this research is to determine the degree of social vulnerability due to floods from an index elaborated based on the information of the 2010 marginalization index at the electoral section level, and the percentage of flooding of the same, to obtain ranges of vulnerability and, with the previous information, the database and maps that represent the spatial analysis of the Social Vulnerability Index will be elaborated. by Floods in the State of Mexico.

FLOODS

According to Vergara et al. (2011) worldwide the problem of flooding lies mainly in inadequate planning and socio-economic circumstances involving human settlements in areas susceptible to flooding. That is why, disasters are built from social processes, which modify or alter the environment; understand that natural events themselves do not involve disasters, but that societies turn events of natural origin into dangers and these result in a risk and subsequently translate into disasters when combined with the vulnerability of the population.

The international environment addresses the concept of flooding, as does the World Meteorological Organization (WMO, 2012) when describing it as the overflow of water outside the normal confines of a river or any body of water, in addition, it considers that it is an accumulation of water from drains in areas that are not normally flooded; from which the term flooded zone follows, defining it as an area covered with water when the flow exceeds the capacity of the channel.

Floods are also considered as times when part of the earth's surface is covered by water and these occur from severe storms or heavy rains that cause flooding in low-lying or poorly drained areas, because natural runoff and riverbeds have been altered mainly by human activities Baró (2012).

The National Center for Disaster Prevention (CENAPRED) in Mexico defines them as an event caused by the precipitation of rain, waves, storm surge, or failure of some hydraulic structure that causes an increase in the level of the free surface of the water of the rivers or the sea itself, generating invasion or penetration of water in places where there usually is none and, generally, damage to the population, agriculture, livestock and infrastructure of the place (CENAPRED, 2014:5).

In streams and rivers the natural process by which the flow overflows the channel is called flooding; and most floods in a river are related to the amount and distribution of rainfall in the basin to which it belongs, and are the product of different factors such as drainage, the rate of filtration of precipitation into the soil and the speed with which surface runoff from such precipitation reaches rivers; thus, the amount of moisture in the soil at the time of precipitation saturates it with water preventing it from absorbing more water, and that is when a Keller and Blodgett (2007) flood will take place.

There are different positions regarding the explanation of the cause of the floods, among the most outstanding, is that referring to global warming, however, it is important to clarify and it should be borne in mind that the climate factor is a natural process, derived from evolutionary phases of planet Earth, and the terrestrial dynamics itself; where the effects of that change or climatic process are natural, and although there is greater frequency and intensity of changes to the climate and its hydrometeorological processes, as well as geophysical processes, seem stronger, extensive and recurrent, both continue to have a natural origin.

What happens when considering them a problem product of global warming, is because of the way in which they happen and their consequences, and that they are harmful to the human being, for example, when a locality is found with human settlements established in lands with little slope or close to bodies of water, and intense rains occur, which when combined with deficient drainage systems and surface covered with asphalt or concrete of the communication routes, the natural channel of rainwater tends to stagnate as it does not have a flow of runoff and filtration, generating floods; in the case of settlements next to the bed of

rivers, lakes or lagoons, the intensity of rains can cause their growth, reaching levels or areas that were used for the construction of housing, roads, schools, among other goods, that's when floods occur.

The above is evidence that a flood is produced by different factors caused, mainly by man, caused in the natural part, because the capacity has been exceeded by containing the amount of rainwater, which occurs with an intense precipitation of rain or hail in a certain period.

Some of the characteristics that cause flooding are also those that define the type of housing, the degree of marginalization existing in areas susceptible to flooding, the socioeconomic status of the people who inhabit these areas, the deficient systems of public services and infrastructure, government weakness and regulations in terms of territorial planning and urban planning, among others, which have allowed the establishment of human settlements in areas of risk.

VULNERABILITY

In the global environment, the Intergovernmental Panel on Climate Change (IPCC, 2007) conceptualizes vulnerability, as the degree to which a system is susceptible and unable to cope with the adverse effects of climate change, including climate variability and extreme events; in addition, it depends on the character and magnitude in which a system is exposed, sensitivity and its adaptive capacity. Where exposure refers to the events and frequency of the same that can occur in a certain place whose characteristics predispose it to receive damage, sensitivity is determined as the degree of susceptibility, that is, it measures how much a system can be affected by the effect of some extraordinary natural process, and adaptive capacity is the way in which it can cope with the changes that are experienced, and, to its responsiveness while maintaining its current structure and functionality.

On the other hand, the term risk is associated with the concept of vulnerability, which for González (2009) is an attribute of individuals, households, or communities, which are linked to structural processes that configure situations of fragility, precariousness, helplessness, or uncertainty, in the case of dynamic conditions that affect the possibilities of integration, upward social mobility or development and are correlated with processes of social exclusion. González (2009:2) says that an individual, household, or community is vulnerable because of the joint effect of multiple risk factors, which configure a situation or syndrome of social vulnerability.

A vulnerability approach proposes the determination of the causes or factors that counteract well-being and block the opportunities for its development that manifest situations of precariousness and job instability, creating processes of exclusion and marginalization, and the origin of these forces that affect their condition and quality of life can be exogenous or endogenous to vulnerable households Kaztman (2000).

The notion of vulnerability is a central aspect in the conceptualization of disasters, since it refers to a socially defined condition and therefore subject to change (Bartolomé, 2006). Based on the social problem, generated by the inequalities that are a consequence of market forces, vulnerability for Kaztman (2000:281) is understood as the inability of a person or a household to take advantage of the opportunities available in different socioeconomic areas, and improve their welfare situation or prevent their deterioration.

Filgueira (2001:10) explains that vulnerability is conceived as a particular, negative configuration, resulting from the

intersection of two sets, one defined at the macro level relative to the structure of opportunities and the other at the micro level, referring to assets (financial capital, human capital, work experience, educational level, composition and attributes of the family, among others), of the actors. Where the structure of opportunities refers to resources that the individual does not control and on which it does not affect or does so marginally and indirectly, and for its part the assets are direct consequences of their action that affect their individual attributes or resources.

On the other hand, the concept of vulnerability also responds to two components, one related to the insecurity and helplessness experienced by communities, families and individuals in their living conditions as a result of the impact caused by some type of social, environmental or economic event, and the other, by the management of resources and strategies used by these groups and people to face the effects of that event Pizarro (2001: 11); in addition to starting from studies on disasters, where the risks of communities and families in the face of catastrophic events are assessed and strategies are designed to face them and the reaction to the change in living conditions experienced by poor rural communities or more susceptible to damage.

Consequently, the pattern of development implemented in Latin America and its impacts on individuals and families in urban areas caused the resources available to them to a lesser or greater extent to be affected, manifesting vulnerability in the dimensions of social and environmental life Pizarro (2001:14).

Faced with the fragility and helplessness caused by changes originated in the environment, and the helplessness of the State, the internal weakness to face them and the need to take advantage of the opportunities that arise, such as the insecurity that slows down the possibility of acting in the future to achieve better levels of well-being; in Latin America for example, since the beginning of the XXI century the perception of uncertainty, Defenselessness and insecurity in the population is very noticeable and according to Busso (2001) is related to the living conditions that have been affected in the type of employment, income, housing, among others, within the framework of a new mode of development that has been implemented in the region.

With the above, the situation before environmental problems or events is understood as the vulnerability or the degree by which a system or a part of it, can react unfavorably during an event or event of a dangerous event Proag (2014). Therefore, the population becomes vulnerable due to its socioeconomic characteristics before the development of a natural event.

CASE STUDY: STATE OF MEXICO

To exemplify the method of calculating social vulnerability due to floods, the State of Mexico was taken, which has the largest number of population affected by floods, the State of Mexico (Figura 1), is a portion of the country that is characterized by being the federative entity that concentrates most of the population of Mexico, and is located in the south center of the Mexican Republic, located between the extreme geographical coordinates to the north 20°17'09", to the south 18°22'01"; to the east 98°35'49", to the west 100°36'47" west longitude; the State is framed to the north with Michoacán, Querétaro and Hidalgo, to the east with Hidalgo, Tlaxcala, Puebla, Morelos and Mexico City (formerly the Federal District), in the southern part, is Morelos and Guerrero and, to the west a part borders Guerrero and Michoacán. The State of Mexico is an entity

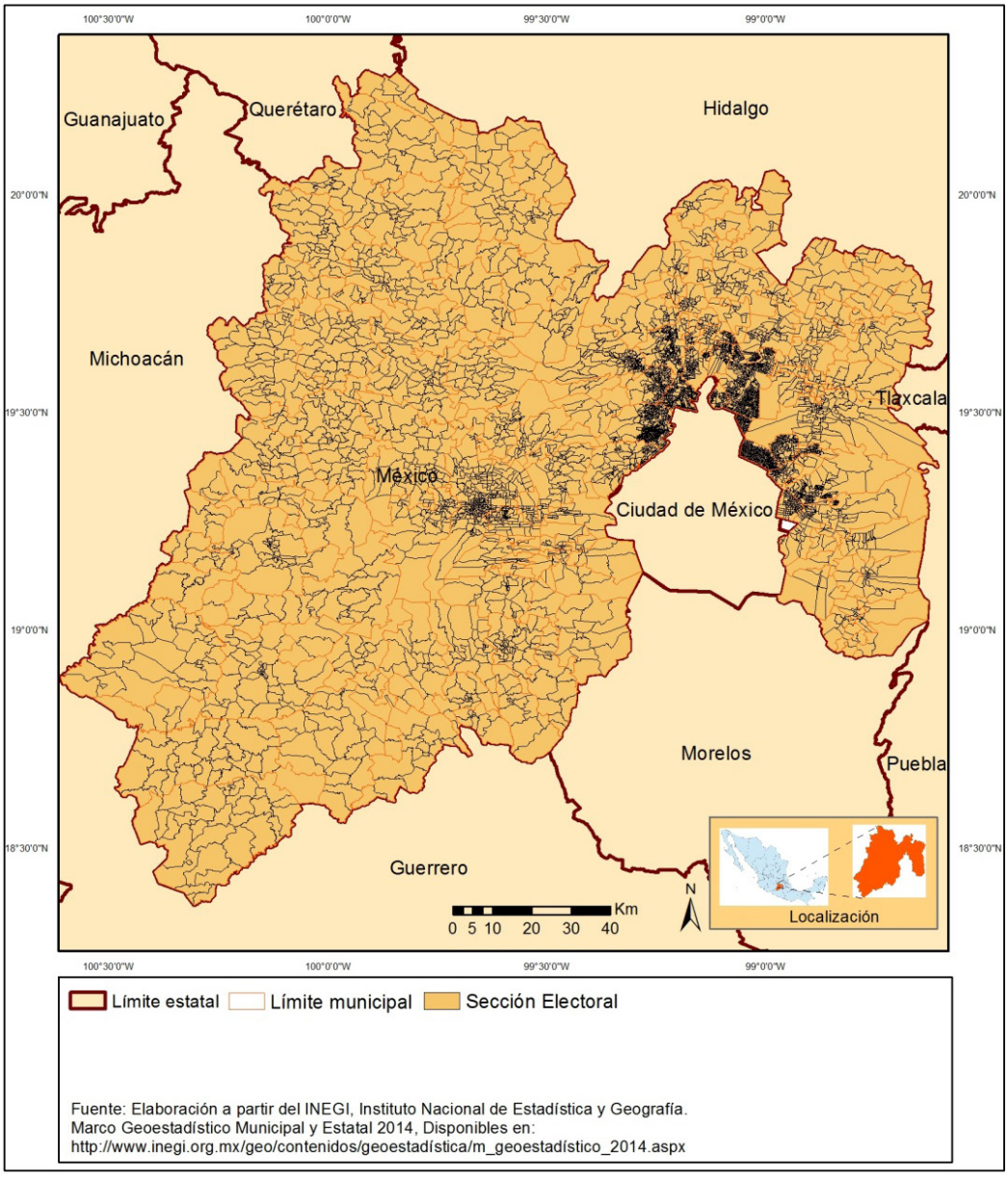

Figure 1. Map of the State of Mexico study center.

of medium extension, representing 1.1% of the surface of the country, with 22,337.59km^2 INEGI (2015).

METHODOLOGY

The methodology used for the development of this research, includes a first part of collection of documentary and bibliographic information on the topics related to concepts of vulnerability, risks, floods, and disasters, mainly, and derived from them, the detailed description of each of the topics has been compiled and thus, have greater understanding for the development of this research.

The second part of the information collection focuses on the statistical data of the electoral sections as a basic unit of information, combined in the Marginalization Index 2010, calculated by Mancino (2015), and which contemplates the socioeconomic

variables, with respect to the percentage of the population aged 6 to 14 years that does not attend school; percentage of the population of 5 years or more without complete basic education; percentage of the population without the right to services. basic health: percentage of private dwellings inhabited without piped water inside the dwelling; percentage of private dwellings inhabited without drainage connected to the public network or septic tank; percentage of private dwellings inhabited without toilet with water connection; percentage of private dwellings inhabited with a dirt floor; and, percentage of private dwellings inhabited without refrigerators, according to CONAPO and INEGI for the year 2010.

Using the information by electoral section of the year 2010, the necessary databases were generated, supporting the research in the statistical analysis program SPSS (for its acronym in English Statistical Package for the Social Sciences), and with this information the marginalization index will be represented, which will serve to measure and calculate the degree of social vulnerability of any place where there are human settlements and that is related to some natural event that reaches occur.

The next phase is to collect documentary information on the floods that have occurred in the State of Mexico, through the CAEM (Water Commission of the State of Mexico) to be able to locate them geographically and include them in the development of the research by linking them with the degree of marginalization.

This process of collection and management of information will be done from databases in database formats, xls, xlsx, sav, and vector data type shape mainly, to be able to use them in the GIS, all of them obtained from the National Institute of Statistics and Geography (INEGI), using the electoral section scale as a basis for the analysis and study of this research, and have the reliability of the content and handling of the information.

With the above, it is intended to correlate both the statistical information of the population and the geographical information related to environmental events, through the use of the geographic information system, ArcGIS 10.2, to be able to establish and identify that combination that will yield together, the social vulnerability index in a graphic way with maps, and this, will serve to accurately identify the highly potential areas of being affected by the presence or development of the natural events, which specifically cause flooding.

The mechanics of integrating statistical and geospatial information begins with vector data, in shape format, which represents the State of Mexico, adding them as new data to a work window, and includes state boundaries, municipalities and the State of Mexico to generate the location map. After this, the regions of the State of Mexico are added, to delimit by region the cartographic representation of the information of the degree of marginalization calculated by Mancino (2015), and after that, the polygonal floods are added, registered by the CAEM with what is seen the superposition of these on the degree of marginalization.

With this analysis, made from the set of data of the population by the rate of marginalization of the study area, and the polygonal floods, the index of social vulnerability due to floods in the State of Mexico will be formulated.

RESULTS

The delimitation of areas with vulnerability due to floods, was made using the regions by municipalities, which manages the CONAPO 2015, and thus facilitates the calculation of the vulnerability index by covering greater territorial extension, and indicate the areas

where flood events occur, in the map of the Figura 2 the regions of the State of Mexico and its flood polygons registered by the CAEM from 2000 to 2000 are shown. 2010.

The marginalization index of the State of Mexico 2010 represented in the map of the Figura 3, is taken as a determining factor for the increase in vulnerability, and during the development of the floods there are various affectations, which are intensified by the degree of marginalization of the communities where Mancino occurs (2015).

Vulnerability is directly associated with some weakness or lack of opportunity, that is, it is a considerable disadvantage to face the different dangers to which you are exposed, if there is no information, action plans, human and financial resources, in addition to the infrastructure and equipment necessary to address the negative effects or damages caused by the development of natural processes such as intense rains that cause floods resulting in disasters.

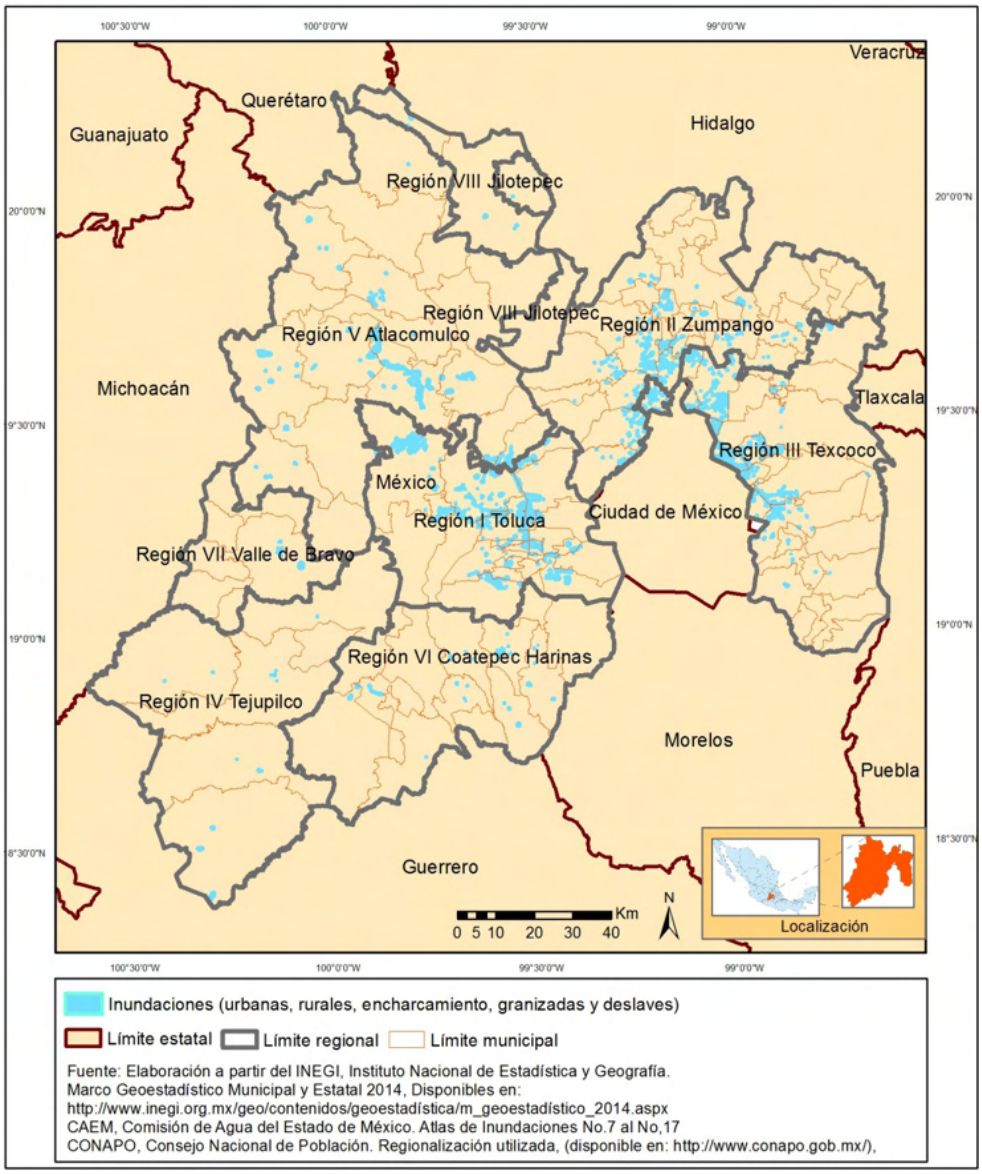

Figure 2. Map of the regionsof the State of Mexico and flooded areas 2000-2010.

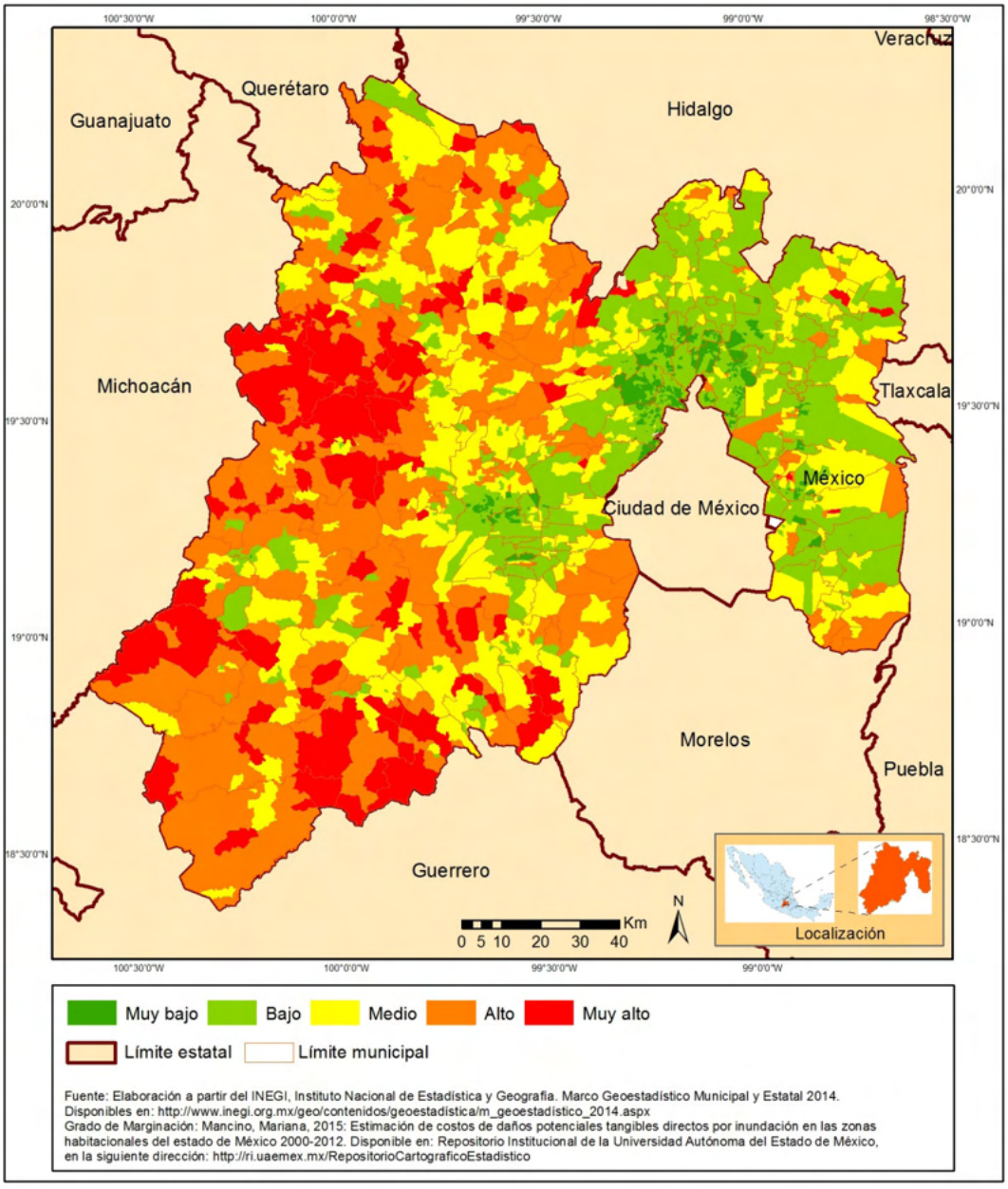

Figure 3. Map of the Degree of Marginalization in the State of Mexico, 2010.

This research uses a technique in the ArcGIS software, which superimposes the flood polygons on the 2010 marginalization index, and in this way the areas that, according to the very high or high estimate of the degree of marginalization, return to this area more vulnerable than others are identified.

The following figure illustrates the map of the correspondence between Very High, High and Medium degrees of marginalization, which, with the flood zones, help the accurate and punctual calculation of the social vulnerability due to floods, where there is a correlation between the areas by electoral section with the five levels of marginalization and the overlap of the floods registered in the period of 10 years, from 2000 to 2010 that CAEM has compiled .

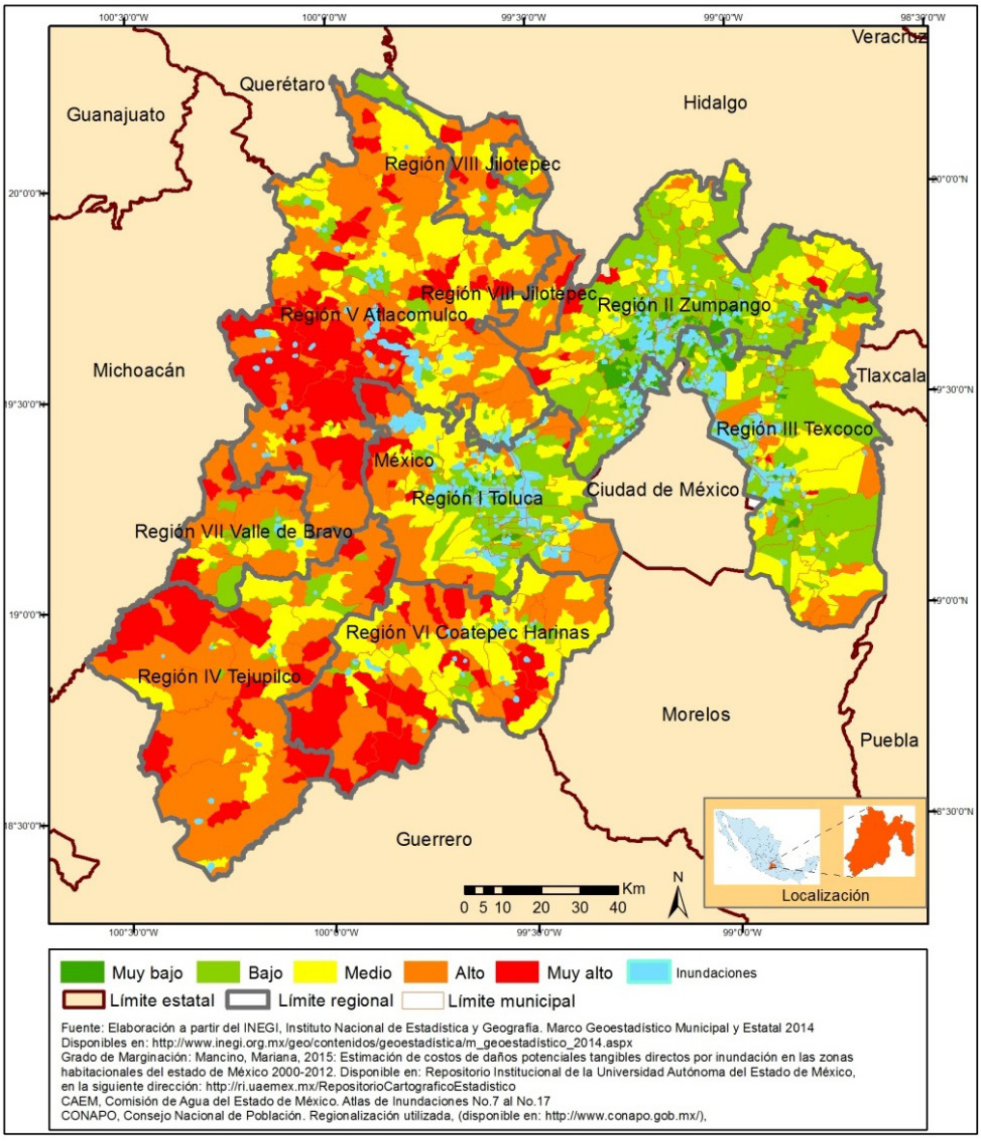

Figure 4. Map of the Degree of Marginalization and Floods in the State of Mexico.

The state of social vulnerability to events derived from rainfall such as floods, comes mainly from factors of a social nature, that is, from the capacity and efficiency of the components of a community, whether government, public and private organizations, infrastructure, economic actors, institutions, and the population itself, are elements that require having the adequate preparation to be able to react to the development of floods and minimize the damage and loss caused by them.

Of the parameters that show the level of progress in the growth and development of a community, are the living conditions, the educational level, and its economic capacity, which reflects the technological, scientific, and environmental care advance.

The above, if it is sufficient to cover and satisfy the demand of the population, then it is very likely that a community with these socioeconomic characteristics can face adverse situations resulting from natural processes that generate disaster risk situations.

The existence of a Marginalization Index is a benchmark of the joint capacity between government and population to solve problems or social situations such as housing, employment, health, among others. This indexshows which areas are most marginalized or limited to addressing these variables; thus: a Very High or High degree of marginalization reflects insufficient, deficient, or null conditions that are available to have an adequate quality of life and capable of attending to emergency situations.

In this research, the overlap of the degree of marginalization and the areas that are prone to be affected by floods is used to determine the electoral sections that are most likely to receive more damage and difficulty in acting in the face of the development of floods.

With the support of software specialized in statistical analysis, the information is worked with the SPSS to use the method of main components and generate an index from 9 indicators, eight of them represent the Marginalization Index and the ninth is a reference of the percentage of flooded area by electoral section, with this, the procedure that determines the numerical value of the index is carried out, and through the stratification of Dalenius and Hodges the ranges, Very low, Low, Medium High and Very high of the degree of social vulnerability due to floods are created, represented in the map of the Figura 5.

What this index represents in other words is that the information recorded by the CAEM in the period from 2000 to 2010 of the areas that suffered floods, serves to determine which places are highly likely to result in a new flood due to the antecedent of the occurrence of these events and, the degree of marginalization will also indicate those areas that have greater unfavorable living conditions than others and therefore, which are more vulnerable than others.

It is an overlap of information, first, the flood zones are identified and, the socioeconomic information of the Marginalization Index by electoral section, and then that analysis is carried out using the Main Components method and this process yields an index, which depending on the variables with which it was generated and that are referents of conditions that reflect levels of quality of life, the state of social vulnerability due to floods can be estimated with great probability.

The condition of social vulnerability due to floods reflects a weakness of the institutional system of the public administration and the population it represents, in the face of problems derived from situations of risk due to the development of floods; with the creation of the vulnerability index, the situation of disadvantage presented by the population due to their living conditions (Marginalization Index) and the proximity to the development of floods, reflect which are more vulnerable, and to which greater attention can be devoted to the minimization and reduction of the damage caused by them.

Floods occupy 1.73 percent of the state territory, which have been recorded in 2 thousand seven hundred and thirty-four electoral sections of the 6,364 counted for 2010, which translates into 42.96% of Sections directly affected by the floods and 47.36% of the population of the State of Mexico that occupies a home in them. Table 1.

CONCLUSIONS

In the sense of advancement and development of science to raise and improve the quality of life of developing countries, it should be borne in mind that indicators serve to order and systematize information for planning, evaluation and decision-making, and allow to constitute information systems that account for the quantitative characteristics

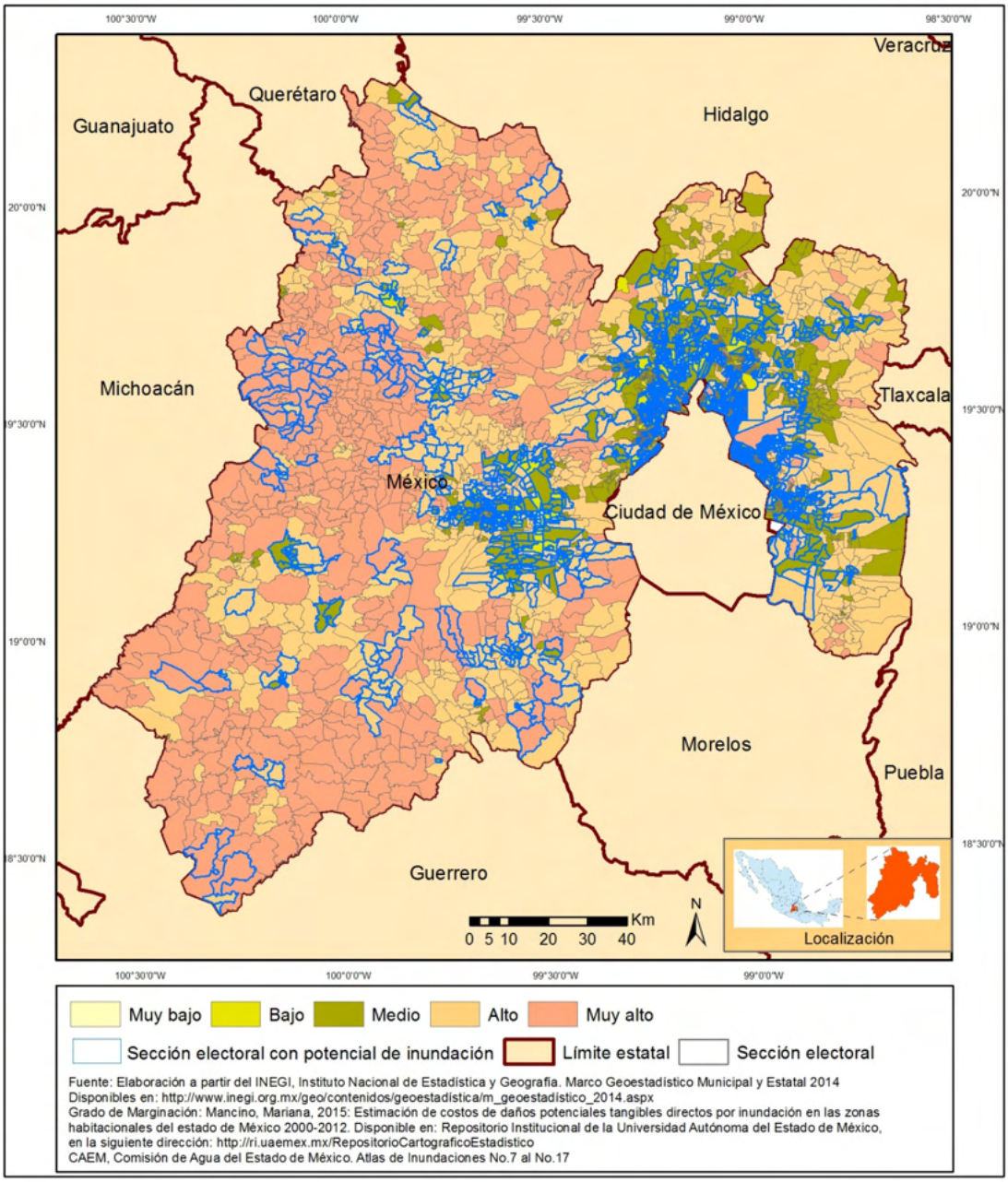

Figure 5. Map of the Degree of Social Vulnerability due to Floods.

Flooded electoral section	Flooded area (Km²)	Percentage of state population affected in 2010
2,734	383.16	47.36

Table 1. Flood damage in the State of Mexico in 2010.

Source: prepared from the Social Vulnerability Index by Floods 2010 and thePopulation and Housing Census 2010, available at: http://www.beta.inegi.org.mx/proyectos/ccpv/2010/

of an institutional environment, economic, geographical, cultural, educational, etc.; these are constructed from different types of information, most often coming from census data from regional, national or even international contexts.

These results of a simplification of the analysis of vulnerability, because of the overlap of flood zones and the degree of marginalization, allow to estimate accurately and with high reliability the most vulnerable areas, which would be given priority in taking actions dedicated to the reduction, and prevention of the situation of existing and future vulnerability.

From the information resulting from this research work, the following can be concluded and contributed:

- During the period of analysis, it was reported that more than 50% of the municipalities of the Mexican entity resulted in some flooding event;
- Particularly the municipalities most affected by the development of the floods were those with the largest population;
- The degree of marginalization is an effective parameter to consider the vulnerability of different areas affected by some type of natural event that leads to some type of disaster, in this case, floods;
- The support of Geographic Information Systems is important for the study and analysis of situations that have to do with large-scale geostatistical information;
- The application of simpler and more accurate methods on the quality of vulnerability of any community, system, process or individual, focuses on the prompt usefulness of the results it generates, and is proposed to measure social vulnerability due to floods, based on the proximity of the population to them and the degree of marginalization as a reference parameter, is undoubtedly a substantial contribution to the development of research on prevention, care and action in the development of natural events, which are dangerous for the human being, and,
- The estimation of social vulnerability due to floods, making use of the marginalization index, verifies that the electoral sections with Very High and High vulnerability, due to the proximity to the development of the floods cause greater vulnerability and vice versa.

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