

Estimation of the economic impact caused by flooding events in dwellings in Sinaloa, Mexico

Estimación de afectaciones económicas causadas por inundaciones a nivel hogar en Sinaloa, México

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Abstract

In Sinaloa, Mexico, rainfall is intense and can cause floodings in rural and urban areas. Although the risks cannot disappear entirely, deficient urban planning, poor drainage system, and accumulation of waste increase the vulnerability of the population, generating inequality derived from urban conditions. Through 160 surveys applied to dwellers in three of the most important cities of Sinaloa: Los Mochis, Mazatlán, and Culiacán, this work evaluates the losses suffered per household as a result of a flood incident. Losses of at least \$70 256 Mexican pesos (3800 USD considering 18.00MXN/USD currency exchange in 09/06/23) per home were estimated, in addition to a significant devaluation of the properties. The study concludes that a socio-environmental justice approach should be adopted to ensure equal vulnerability reduction for all families, instead of the current approach of compensation and transfers which solves nothing in the long-term.

Keywords: Planning; vulnerability; Mexico; floods; Sinaloa.

Resumen

El estado de Sinaloa, México, recibe precipitaciones intensas que causan inundaciones en zonas rurales y urbanas. Aunque los riesgos no pueden desaparecer en su totalidad, la deficiente planeación urbana, el mal funcionamiento de drenajes y la acumulación de residuos incrementan la vulnerabilidad de la población, generando desigualdad derivada de las condiciones urbanas. Mediante la aplicación de 160 encuestas a hogares en las tres ciudades más importantes de Sinaloa: Los Mochis, Mazatlán y Culiacán, este trabajo evalúa las pérdidas ocurridas por hogar a raíz de un incidente de inundación. Se estimaron pérdidas de al menos \$70 256 pesos mexicanos por hogar, además de una significativa devaluación de las viviendas. El estudio concluye que se debe adoptar un enfoque de justicia socioambiental para asegurar la reducción de vulnerabilidad de todas las familias por igual, en lugar del enfoque actual de compensaciones y transferencias que nada resuelve en el largo plazo.

Palabras clave: Planeación; vulnerabilidad; México; inundaciones; Sinaloa.

Recibido: 06 de septiembre de 2023

Aceptado: 12 de abril de 2024

Publicado: 19 de junio de 2024

Cómo citar: Ibarra Armenta, C. I., Salazar Yanes, J. C. (2024). Estimation of the economic impact caused by flooding events in dwellings in Sinaloa, Mexico. *Acta Universitaria* 34, e4005. doi: <http://doi.org/10.15174/au.2024.4005>

Introduction

Socio-environmental justice consists of recognizing that the relationship of people with the environment is determined by different types of inequalities (cultural, socioeconomic, political, gender, age, etc.), these inequalities affect the experience of individuals in the face of degradation and environmental challenges. In recent years, it has been recognized that the environmental degradation generated by human economic activities, such as food production, clothing manufacturing, transport, energy production, and recreation, lead to various types of natural disasters. In addition to this, due to historical conformations of the housing centres, on many occasions, we find entire cities exposed to high levels of social vulnerability, given that the environment in which they are settled is subject to catastrophes in which prevention and planning can reduce the risks of casualties, though they cannot be completely eliminated.

In the case of the state of Sinaloa, and in other parts of Mexico, year after year the rains wreak havoc in rural and urban areas, partly because of poor urban planning (Bonasia & Lucatello, 2019). There are families that lose all their household belongings and suffer deterioration in their home, generating patrimonial losses of thousands of Mexican pesos. Even worse, these families continue to be at risk since they stay living in the same home, either by their free will -because families find it impossible to sell their house- or because they might get a very low sale offer given the loss of market value. As a result, they prefer to stay where they are. Unfortunately, this problem persists in many urban and rural centres, and long-term solutions have not yet arrived.

This problem has been analysed in the literature from the urban and technical perspectives, but the quantification of losses is scarce, especially the losses by dwelling. In fact, to the best of our knowledge, there are no quantifications of the damage suffered by families when their house is flooded in Sinaloa, nor are there public records of households affected or government aid beneficiaries. The estimates on losses are made about public infrastructure -see for example the publication series of the National Centre of Natural Disaster Preventions (Cenapred, 2019). As regards with the budget exerted on aid, there are pecuniary resources destined to compensate the citizens affected every year, but although the government sometimes restores goods and gives cash to the affected people, that does not compensate the total losses, especially when it comes to patrimonial losses, that is, the losses suffered by families whose homes lose market value due to being in flood-prone areas, as well as the significant amount of repairs needed. This work fills this gap in the literature by estimating the private losses in order to make the real social costs visible, providing elements to justify infrastructure works that reduce the vulnerability of areas that are already detected. At the same time, we provide elements of analysis so that better planning can be carried out when the urban infrastructure that affects runoff is modified. Indeed, it was identified that in some neighbourhoods the panorama has worsened with the construction of new subdivisions or urban modifications, which generates a condition of inequality, derived from urbanization.

Socio-environmental justice

Although this analysis is descriptive and does not offer specific infrastructure solutions to the flooding problems, we use the concept of socio-environmental justice as a base, in that we depart from the fact that, regardless of the living condition or income, all people in a city, rural, or urban area deserves to have similar conditions in order to protect them from vulnerability as much as possible, understanding of course that this is not totally possible. Yet, in the cases analysed, the flooding areas are clearly identified; and even with that, the many families reported to have suffered floods more than once, which is not expected in planned neighbourhoods, and the current compensation system is insufficient.

Most environmental justice research focuses on the disproportionate environmental impact that affects lower income groups or ethnic and social minorities. This concept arose in the seventies, in the United States, with a marked connotation of a social movement but which has currently led to a more scientific and institutional position (Laurian, 2007; Moreno, 2008), whose best example is the creation of the Office for Environmental Justice in 1992, as well as the National Environmental Justice Advisory Council in 1993, by the Environmental Protection Agency (EPA) in the United States. According to Wenz (1988), environmental justice is carried out when people get what they deserve or what is owed to them, then the key lies on estimating what every individual deserves or is owed to, establishing or valuing allocations impartially.

The environmental justice paradigm must pursue equitable distribution, considering the negative environmental effects as well as the positive implications and equitable distribution of impacts (Ramírez *et al.*, 2015). This allows to infer that environmental justice will also be influenced by cultural aspects, standard of living, empowerment, and some others (Ramírez *et al.*, 2015). Likewise, Ramírez *et al.* (2015) say that environmental justice is linked to the unequal distribution of environmental ills and access to resources, but, at the same time, the authors put on stage a new paradigm of environmental justice, speaking of the unequal distribution of social resilience, identifying environmental damage with socially constructed disasters.

In this sense, socio-environmental justice encompasses the components of non-discrimination of environmental benefits and damages, and the participatory decision-making mechanisms that can enable an equitable distribution of those among a justice community made up of localized, current, and future entities, which can have unequal rights and obligations (Moreno, 2008).

For this reason, according to Ramírez *et al.* (2015), environmental justice is important not only for human beings, but also for non-humans, since both people and the environment are affected, which is why leaving environmental justice aside can lead to the destruction of ecosystems and the loss of quality of life. Likewise, it demonstrates that it is imperative to study a particular area and to verify its compliance with regulatory provisions on environmental matters in order to ensure the equitable distribution of environmental impacts. Also, it is vital to know and resolve differences or conflicts arising from the implementation of measures that affect a specific social group in both environmental, health, economic, and social terms.

Participation is fundamental in the socio-environmental justice approach, since, according to Mora (2019), a participatory process would be forged in which the weight of values and uncertainties would be accepted and incorporated into the dialogue of knowledge among all interested citizens. Citizens contribute with their knowledge, their understanding of the case, and their resources, generating the idea that progress can only be made through a committed dialogue and the construction of reciprocal trust. It privileges and transmits ideas of dialogue, shared responsibility, effectiveness, and consistency within a system whose extreme complexity is recognized.

Social vulnerability

The concept of social vulnerability is another important concept to consider and analyse in perspective of the losses caused on the individuals affected. According to Pizarro (2001), there are two explanatory components: on the one hand, the insecurity and defencelessness experienced by communities, families, and individuals in their living conditions as a result of the impact caused by some type of economic-social event of a traumatic nature; and on the other hand, the management of resources and the strategies that communities, families, and individuals use to face the effects of that event.

In addition to this, social vulnerability is made up of sociodemographic and economic factors that influence the level of risk faced by women and men, as well as communities in the face of disasters. Social vulnerability is the product of inequalities, and its repercussions are distributed in accordance to how a community is socially divided by gender. Some people are more vulnerable than others due to their limited levels of resilience, and, consequently, the population ends up suffering the most from the effects of disasters, directly and indirectly. By linking the characteristics of the population (poverty, age groups, minorities, the disabled, and gender) with social vulnerability, risks for people are intertwined because of their disadvantaged conditions (Granados, 2017).

As Cutter & Finch (2008) argue, social vulnerability measures the level of sensitivity of the population to risks, such as their ability to respond and recover from the effects of hazards. They point out that the characteristics of the population and social groups determine their level of incidence in the face of natural hazards and influence their ability to respond and recover adequately. They recognize that ethnicity, socioeconomic status, and gender, as well as age, migration, and home ownership are substantive characteristics in determining vulnerable populations.

On the other hand, urban environmental vulnerability is growing with greater exposure in a context of increases in extreme hydrometeorological events. Most studies on climate change recognize that the effects of climate and climate change will affect the poorest and most vulnerable populations to a much greater degree, and they also identify the very fragile conditions of vulnerability of the poorest populations. From a sustainability perspective, risk levels are high for low-income urban residents who reside in hazardous locations and lack the resources and options to change their vulnerability (Jordan *et al.*, 2012; Margulis, 2016). In addition, according to Winchester (2006), these residents are also the most affected by disasters and suffer the loss of major assets, such as housing.

For this reason, the development of new infrastructure plays a prominent role in strategies to mitigate this environmental vulnerability and to facilitate the adaptation of people to its effects (Jordan *et al.*, 2012). Economic analyses show the potential magnitude of the impacts that climate change could have for the most vulnerable, widening inequalities (Margulis, 2016).

Similarly, vulnerability is a component in a geographical space to a threat, taking into account that a deterioration exists only where there is vulnerability and depends on its degree of exposure, protection, and the reaction in terms of recovery (Alberto, 2007). Vulnerability should be reviewed as a systemic, multiscale, multitemporal, and multifactorial condition, just like the danger given by the dynamism of conditions (Huape *et al.*, 2021; Magaña, 2004).

Therefore, this association of factors or processes that determine the condition of vulnerability are addressed and divided into five dimensions:

- Natural vulnerability. This dimension considers the need of living beings for good environmental and social conditions to achieve development, given that if optimal conditions do not exist, they become vulnerable to them.
- Physical vulnerability. This is the location of urban areas in vulnerable areas with physical risks, environmental conditions, and ecosystems in reference to the location, resulting in, most of the time, human settlements in risk areas.
- Economic vulnerability. It is related to income at different levels of government and the impact of extreme physical phenomena; that is, poverty increases the risk of disaster.

- Social vulnerability. This dimension is an essential component of risk and is approached segmentally by types or groups, always starting from the need for a comprehensive risk analysis, and with the idea that the vulnerabilities of each subject are different and depend on their ability to act against any threat (Foschiatti, 2004; Huape et al., 2021).
- Environmental vulnerability. It is one of the most important risks, which is related to the high or low exposure that a territory has to being impacted by an event, as well as the magnitude of possible impacts generated by an environmental problem with only the occurrence of a natural event (Huape et al., 2021; Pérez et al., 2017).

In this way, socio-environmental vulnerability occurs in the intersection of social and environmental vulnerability, closely linked to the coexistence of humans with the environment. This causes vulnerability of ecosystems with anthropogenic activities added to the urban areas, thus exposing society to unfavourable environmental conditions (Alberto, 2007; Huape *et al.*, 2021).

Taking into account the importance of assessing the vulnerability and the magnitude of inequalities generated by the urban planning, this research estimated the economic losses that a family suffers when their home is flooded, aiming to show that the individual costs are very high and that the authorities must seek long-term solutions to the constant flooding and waterlogging occurred to a considerable number of residents in Sinaloa.

This work used a qualitative approach where interviews were conducted with Civil Protection personnel to find out the most important risk areas, as well as the preventive actions taken by those in charge, according to the identification they had already made. In addition, 160 questionnaires were applied to estimate losses of goods (furniture, clothing, etc.) as well as to obtain a record of the repair expenses made by those affected. In a complementary way, an engineering technical evaluation of the minimum costs faced by a house that is flooded from 50 cm is presented, which puts into perspective the real costs of the deficient infrastructure and planning, since the expenses are not a complete indicator of the repair costs and losses, namely: (1) most families only fix the most essential damages and (2) most of them do not have an estimated value of the total losses. Likewise, some families defer the expenses through several years, given the lack of financial resources and the inexistent insurance in most cases. It is important to note that in the case of families which suffered frequent floods, the humidity is never completely eradicated, thus time to time there are new walls to repair, mentioned the dwellers. Finally, it is of vital importance to incorporate the patrimonial loss into the analysis when living in a high-risk flooding area, since this fact reduces the market value of their homes and perpetuates their situation of inequality and social vulnerability.

Due to limited financial resources, it was not possible to cover all neighbourhoods (or communities) which have experienced floods in the cities analysed. The areas chosen are those which have had high levels of damage and where flooding have occurred more than once. The survey included two neighbourhoods in Los Mochis, two in Mazatlán, and four in Culiacán. It is difficult to determine the size of the sample with respect to the total population of those dwellers affected yearly, since there are no official data on it. The surveys were carried out during March, April, and May 2022 and included only houses that had been flooded at least one time and could provide information on the damage occurred. The confidentiality of the information was guaranteed to the participants, so the results are disclosed, avoiding any data that identifies the people who participated in the surveys.

As a summary, the rest of this work is organized as follows: after this introduction, in the second section the materials and methods are presented, including the description of the sample and the applied instrument; the third section shows the analysis of the survey results, as well as the estimates of losses; in the fourth section a brief discussion is presented; and the last section offers the conclusions.

Materials and methods

This research is descriptive, since it seeks to analyse the problem and show the economic losses of the families affected, while we argue that the causes are related to poor urban planning, not by presenting technical studies but by showing that the families have been affected for a long time proving that the actions in terms of infrastructure have not been good enough to address the problem. For this, questionnaires were applied to dwellers that have suffered floods to find out the types of damage suffered, their knowledge of repair costs and estimates of total losses. They were also asked about the types of aid received by the authorities and their current perception of the vulnerability.

Sample

As stated in the introduction, this project covers the urban areas of Mazatlán, Los Mochis, and Culiacán. For all the cities, the respective heads of the Civil Protection system provided lists of the neighbourhoods that are at risk of flooding. There are at least 25 in Los Mochis, 30 in Mazatlán, and 80 in Culiacán, only in the urban area; this is, rural communities are excluded. Some of the neighbourhoods at risk are old settlements carrying the problem through many years, such as the Magisterial in Los Mochis, Jacarandas in Mazatlán, 6 de Enero and Infonavit Humaya in Culiacán.

Note that given the high number of vulnerable areas and that the level of affectations varies a lot, it was discretionally decided to take neighbourhoods that have suffered from significant flooding or whose problem has persisted in the long term. Table 1 shows the neighbourhoods by city and the reasons to include them in the sample. It is important to note that some of the study areas correspond to old neighbourhoods that began with irregular settlements, as mentioned by the director of Civil Protection in Culiacán, so the same settlers could be considered part of the initial problem. However, there are also neighbourhoods that are part of real estate projects, which have had serious flooding problems anyway.

Table 1. Neighbourhood in the sample and reasons.

City		Neighbourhood	Reasons
Los Mochis	1.	Subdivisión Las Mañanitas	This settlement suffered a severe flood in 2018 but has had recurring problems. It is important to note that it is a settlement developed by a real estate company; therefore, it is not an irregular housing area, thus, it should have had all the conditions to avoid flooding, given its closeness to a stream of water, which shows that the problem comes from poor project planning.
	2.	Colonia Magisterial	This settlement is an old neighbourhood which presented minor floods in the past, but the problem has been aggravated by the construction of new settlements. The residents said that they always had a problem of water accumulation, but after the construction of an exclusive neighbourhood and new boulevards, water gets locked-up and the level rises a lot in this area, especially at the end of the street, next to the boulevard.
Mazatlán	1.	Colonia Estero	This area is a very old neighbourhood located in a marsh area, so water tends to pool, thus, it has suffered floods on several occasions.
	2.	Colonia Las Jacarandas	This is an area where quite intense floods have occurred on more than one occasion. The main reason is the rising water level carried by an adjacent big cater-channel. Modifications have been made to the adjoining creek, but the problem remains.
Culiacán	1.	Fraccionamiento Villas del Río/Valle Alto	This area, adjacent to the Bacurimi drain, transcended due to the severe flooding suffered in 2018. It is particularly notorious that the homes lost a lot of market value since this area is well known as a flood zone.
	2.	Infonavit Humaya	This area has had several floods, the families reported to have lost their furniture, clothes, appliances, and/or vehicles more than once, and they cannot sell their houses due to this locally well-known fact.
	3.	6 de Enero	This area is close to "El Piojo" stream, whose level can rise causing flooding during rainfall season, even in more than one occasion within a year. This particular settlement is born as an irregular settlement, without planning, which is a constant justification for its poor infrastructure and planning. It is also notorious the death of several people in this area.
	4.	Fraccionamiento Acueducto	This subdivision is close to the Bacurimi channel, and although it only suffered serious flooding once, waterlogging also persists in some areas.

Source: Author's own elaboration.

From the neighbourhoods studied, those affected on more than one occasion can be easily identified because the houses show watermarks. In addition, on visual exploration there are noticeable modifications to the entrances that people make to protect themselves from the water, for example, erecting fences at the entrance, with steps on both sides to enter and exit. In the Jacarandas neighbourhood in Mazatlán, a house has a wall around the house almost the same height as the house to protect it from the water. Also, modifications can be observed in the Magisterial neighbourhood in Los Mochis, the Estero in Mazatlán, and in the 6 de Enero in Culiacán (see annexes for pictures).

It is also important to remark that not all the houses in the same neighbourhood are affected, which also makes it difficult to quantify the number of dwellings damaged. In addition, since there are no official quantifications per flood event, it is difficult to determine the population from which the sample was taken. Certainly, there are records of aid beneficiaries from the federal government, but not all affected people receive aid, and it is usually aimed at those areas of low income, or those with worse damages or depending on the process to declare a disaster zone, as it used to happen with the Fonden (a special spending section to attend disasters in Mexico). Hence, when carrying out the study, it is recognized that the sample taken is important, but not statistically significant. It is also recognized that not all homes suffer the same level of flooding; therefore, in the technical analysis of repair costs, scenarios with different levels of affectation are also presented.

The instrument is included as an annex at the end of this document. The general items included in the questions are listed below:

- General characteristics of the respondents such as their occupation, household integration, and years of residence.
- Current condition of the house.
- Losses suffered in the last flood.
- Repair costs incurred as a result of that event.
- The causes that they think are generating the problem.
- The precautions they take.
- The aid received.
- The estimation of real losses and necessary compensations.
- The expectation about the occurrence of new floods.

The information collected in the questionnaires was complemented with the technical estimate of the repair costs of a flooded house, to later obtain an approximate total cost of property losses per neighbourhood in the most recent event.

Results

The general information of the sample is shown in Table 2. Most of the people who responded are workers (53.13%), and another important proportion reported that they are housewives/househusband (25.63%). The number of members per household is diverse, but most households had four (21.25%), two (20%), and five (19.38%) members. Also, most of the respondents have lived in their homes for five years (34.38%) or more (43.75%), many mentioned to be residents since the neighbourhood was established.

Table 2. General information of residents.

Occupation	Total	Percentage	Household members	Total	Percentage	Years in residence	Total	Percentage
Housewife/ househusband	41	25.63%	1	10	6.25%	1	2	1.25%
Student	4	2.50%	2	32	20.00%	2	7	4.38%
Retired	20	12.50%	3	23	14.38%	3	18	11.25%
Pensioner	9	5.63%	4	34	21.25%	4	3	1.88%
Worker	85	53.13%	5	31	19.38%	5	55	34.38%
Did not answer	1	0.63%	6 or more	11	6.88%	more than 5	70	43.75%
			NC	19	11.88%	NC	5	3.13%
Total	160	100.00%	Total	160	100.00%	Total	160	100%

Source: Author's own elaboration.

Regarding the condition of the houses, the information is presented by neighbourhood in Table 3 and 4. The majority responded that they considered their house is in fair condition (50%) in Culiacán, 70% in Mazatlán, and 45% in Los Mochis. On the other hand, in Culiacán and Los Mochis, similar percentages considered that their home is in good condition, with 45% and 40%, respectively. However, in Mazatlán, only 8% of those surveyed considered that their home is in good condition. It can be clearly seen that in Acueducto and Valle Alto/Villas del Río no one considered their home is in poor condition, which may be due to the fact that flooding events have been less frequent; furthermore, these settlements are newer, which may explain why no one yet considered that their home is in poor condition, coupled with the fact that thanks to the Infonavit insurance (Infonavit is the mortgage State-owned company) many were able to repair their homes. In neighborhoods such as 6 de Enero, Infonavit Humaya, Estero, Las Jacarandas, and La Magisterial, the interviewees commented that they have suffered frequent floods and that they barely manage to do the necessary repairs, or that every two or three years they have to re-flatten the walls due to the presence of humidity, which was observed in the houses. In the case of Fraccionamiento Las Mañanitas, there was a major flood in 2018, but those surveyed reported that the problem decreased; still not everyone has been able to fully repair their homes, even if they received the insurance from Infonavit.

It is important to mention that the damages were visible even after some years of the last flooding, yet the humidity and corrosion was evident. Also, people commented that they no longer invest much in repairs and keep the spaces austere for fear of future floods; thus, they make their kitchens out of concrete, and in some cases, they avoid buying fabric armchairs, sofas, or other furniture which could be costly and at risk.

Table 3. Status of homes by neighbourhood.

Physical status	6 de Enero	Acueducto	Infonavit Humaya	High Valley-Villas del Río	Total Culiacán	Percentage
Well	5	11	6	14	36	45%
Fair	1	0	2	0	3	4%
No answer	0	0	1	0	1	1%
Regular	14	9	11	6	40	50%
Total	20	20	20	20	80	100%

Source: Author's own elaboration.

Table 4. Status of homes by neighbourhood.

Physical status	Estero	Jacarandas	Total Mazatlán	Percentage	Las Mañanitas	Magisterial	Total Mochis	Percentage
Well	2	1	3	8%	8	8	16	40.00%
Fair	5	2	7	18%	3	2	5	12.50%
No answer	1	1	2	5%		1	1	2.50%
Regular	12	16	28	70%	9	9	18	45.00%
Total	20	20	40	100%	20	20	40	100.00%

Source: Author's own elaboration.

Table 5 shows the types of affectations in the dwellings. A dwelling can present more than one affectation, so the sum of the affectations is greater than 160; the percentage was obtained by type of affectation (row), with respect to the total number of surveys. The largest proportion, 86%, reported paint damage, 85% reported moisture problems, 78% identified damage in doors, and 74% revealed damage to floors and tiles. A smaller proportion had damage from electrical, hydro-sanitary installations, or landslides. However, in the case of plumbing installations, in many homes the drainage water came out through the bathroom due to collapsed drains, which caused a lot of dirt and loss of furniture and other belongings, although there was no subsequent damage to the installation.

Table 5. Affectations in the dwelling according to type and city.

Affectations	Mazatlán	Los Mochis	Culiacán	Total	Percentage of total respondents
Floors and tiles	24	31	64	119	74%
Paint	35	35	68	138	86%
Doors	30	29	66	125	78%
Humidity	35	35	66	136	85%
Wall cracks	23	17	52	92	58%
Coatings	16	16	27	59	37%
Electrical installations	7	10	24	41	26%
Hydro-sanitary	11	19	25	55	34%
Partial collapse	10	5	16	31	19%

Source: Author's own elaboration with survey data.

Table 6 shows the material losses reported by the respondents according to the type of belongings such as clothing, household items, furniture, and vehicles. Since the losses consider more than one answer, the percentage is presented by row. It is observed that a high proportion of those surveyed lost their washing machine, this being the highest incidence (65%), followed in importance by the loss of chairs (58%), refrigerator (57%), dining room (55%), stove (46%), sofas (45%), mattresses (44%), clothes, and shoes (38%). Losses of vehicles, televisions, blenders, microwaves, and other displayed items were reported with a lower incidence.

Table 6. Losses according to the type of good.

Good/furniture	Mazatlán	Los Mochis	Culiacán	Total	Percentage
Washing machine	20	29	55	104	65%
Chairs	20	26	46	92	58%
Fridge	26	25	40	91	57%
Dining room	20	23	45	88	55%
Stove	17	18	39	74	46%
Sofas	11	21	40	72	45%
Mattresses	18	17	36	71	44%
Clothes and shoes	16	9	35	60	38%
Total or partial loss of the vehicle	10	8	29	47	29%
TV	13	4	27	44	28%
Blender	6	9	24	39	24%
Microwave	5	8	20	33	21%
Telephone	0	4	16	20	13%
Carpets	3	5	9	17	11%
Computers	1	5	10	16	10%
Printer	3	4	8	15	9%
NC	2	0	0	2	1%

Source: Author's own elaboration with survey data.

The people surveyed reported that they understand that sometimes nature is important, and that accidents are inevitable; however, they were questioned about what they consider to be other causes of home flooding, and the results are reported in Table 7. 63% of the people considered that the cause is the lack of interest on behalf of the authorities, because as mentioned before, in some neighbourhoods the problem has persisted for many years. Another important proportion considered that the problem is the location of the house (59%) or the state of storm drainage (46%), since as soon as the heavy rains begin, the sewers clog and the drainage does not have enough capacity. Also, in several cases the houses are close to important water currents, which is why it is also a commonly reported cause, either to rivers (34%) or to drainage channels (24%). Many respondents considered the presence of garbage and debris in the waterways a problem (48%), while 28% considered that the problem stems from recent changes in the urban environment.

Table 7. Other causes of flooding.

Causes of flood	Mazatlán	Los Monchis	Culiacán	Total	Percentage
Lack of interest on the part of public authorities	33	28	40	101	63%
Location of the house in a low area	23	22	49	94	59%
Storm drainage status	16	17	41	74	46%
Accumulation of household waste in the community	26	11	32	69	43%
Proximity of your home to the course of a river, flood plain, or river	18	20	17	55	34%
Construction or architectural modifications that maximize flood intensity	8	9	28	45	28%
Proximity to dams or storm drainage channels	15	3	23	41	26%
Proximity or difficulties with the supply of water for human consumption	13	7	1	21	13%
Lack of cleaning of the drain	2	1	1	4	3%
NC	1	0	1	2	1%
Other			2	2	1%

Source: Author's own elaboration.

The respondents reported that the authorities have made some modifications, trying to reduce the risks of future flooding; however, people do not feel sure that this would not happen again, so 92% said that they believe they will flood again, 6.2% said "no", and the rest does not know.

Regarding the preventive measures taken by the population, the results are shown in Table 8. In this question, people stated that they prefer to stay at home to move their things when possible, and that they also fear being robbed if they leave. Thus, the most frequent preventive measure is to place belongings in high parts (80%); or in two-floor houses, they move what they can to the second floor. People avoid leaving the house (50%) and buy enough water and food (38%). Some people mentioned other measures such as putting gates at the entrance, waterproofing or making small fences, while only 2% left their home. This is sometimes a problem, as people are in danger by staying in the zone but are reluctant to leave, which was also mentioned by the Civil Protection Chief in Mazatlán.

Table 8. Precautionary measures.

Precautionary measures	Mazatlán	Los Mochis	Culiacán	Total	Percentage
Place furniture and belongings in high parts	34	32	62	128	80%
Avoid leaving home	31	23	26	80	50%
Buy enough water and food	24	19	17	60	38%
NC	1	1	12	14	9%
Get out of the house		1	2	3	2%
Put a gate/Cover the entrance	1	1	0	2	1%

Source: Author's own elaboration.

Quantification of expenses and losses

Recognizing that it is difficult to quantify the economic loss, an estimate was made for the damaged furniture reported. The prices were checked at Coppel.com website, since this company is a common choice for people in Sinaloa, given that the store offers differed payments, and it is a very well-established local brand, with accessible prices. The prices of appliances for the lowest price and the highest price are presented in Table 9. According to this, a house that has lost all the furniture and belongings included here would have to spend at least \$40 747.00¹ to replace their furniture, without counting clothes, shoes, jewellery, carpets, and vehicles.

Considering the number of people who reported having lost some type of furniture from the frequencies in Table 6, in fourth and fifth column, the total spending is obtained. Once the total spending is obtained in Table 9, it is divided by the number of dwellings surveyed (180), thus an average of \$15 738 is obtained with low prices and \$170 659 taking the highest. This average is of course quite dispersed, since not all houses lost the same items, and the prices are also very different. There were even families that only reported the loss of a piece of furniture, or just clothes and shoes, while other households lost everything, including vehicles. On the other hand, the loss of clothing and shoes can be very large since, as can be observed in Table 2, most households have several members; and if we consider that only a complete outfit, such as shoes, shirt, pants, and underwear, can add up to more than \$1500, the loss of several clothing outfits for the whole family undoubtedly represents a large loss. Again, the difference in prices makes it very difficult to estimate; for example, there are pairs of shoes going from \$150 to thousands of Mexican pesos, and the same occurs with clothing.

Table 9. Average costs of new furniture and estimated losses for all households.

Furniture/Appliances	Low price (MXN)	High price (MXN)	Frequency	Low-cost spending per good*frequency (MXN)	Expense with high cost per good*frequency (MXN)
Electric washing machine	\$3,889.00	\$58 499.00	104	\$404 456.00	\$6 083 896.00
Stove	\$2,899.00	\$78 699.00	74	\$214 526.00	\$5 823 726.00
Fridge	\$6,999.00	\$77,499.00	91	\$636 909.00	\$7 052 409.00
Blender	\$429.00	\$8,799.00	39	\$16 731.00	\$343 161.00
Microwave	\$1,999.00	\$25 199.00	33	\$65 967.00	\$831 567.00
Chairs	\$209.00	\$3,799.00	92	\$19 228.00	\$349 508.00
Dining room	\$4,299.00	\$39,999.00	88	\$378 312.00	\$3 519 912.00
24" TV	\$3,999.00	\$4,799.00	44	\$175 956.00	\$211 156.00
Double Mattress	\$2,199.00	\$16 999.00	71	\$156 129.00	\$1 206 929.00
Computer desk	\$7,799.00	\$16 999.00	16	\$124 784.00	\$271 984.00
Printer	\$1,699.00	\$15 399.00	15	\$25 485.00	\$230 985.00
Landline	\$229.00	\$3,499.00	20	\$4,580.00	\$69 980.00
Sofas	\$4,099.00	\$18 199.00	72	\$295 128.00	\$1 310 328.00
Total	\$40 747.00	\$368 387.00		\$2 518 191.00	\$27 305 541.00

Source: Author's own elaboration.

¹ Prices are expressed in Mexican pesos (May 2022).

Another type of affectation was the loss of food, thus 85% of those surveyed said that they lost their food due to lack of electricity in the days after the flood, because their refrigerator broke down or because the water reached a high level in their living place. Also, 85% of people had accumulation of garbage and mud in their home and 100% required cleaning. Regarding the water supply, in most cases the service was reestablished quickly, and only 30% said they had had subsequent problems.

To estimate the average losses in clothing, food, and cleaning supplies per household, data from the National Survey of Income Expenditure (ENIGH) carried out by INEGI in its 2020 version was used. This survey publishes estimated quarterly expenses per household in the aforementioned items, as shown in Table 10 below.

Table 10. Average expenditure per family in Sinaloa according to item.

Item	Quarterly expense (Constant 2023 prices)
Foods	\$13 610.13
Dress and footwear	\$1,361.72
Cleaning items glassware linens household utensils	\$2,671.30

Source: Author's own elaboration with data from ENIGH (INEGI, 2020).

Considering that food includes perishable and non-perishable items, a third of the quarterly value was taken to account for a loss of one month's food purchases, that is, \$4536. In the clothing item, one year's expense is considered, since clothing is a durable good, and families can lose clothes that they have bought for a long time; the corresponding expense for a year is \$5446. The cleaning items are included because 100% of the respondents reported to have cleaned their homes and had to replace household utensils. Once again, the spending of a whole year is added, taking into account that they lost their inventories accumulated. The total cost goes up to \$10 685. The sum of these four elements, namely, food, clothing, and cleaning items and home utensils, is \$20 668.

Adding all the reported losses, it is evident that the economic loss is quite large; for instance, a family losing all the average report of belongings, plus clothing, footwear, food, and cleaning and other utensils, shown in Table 9, lost at least \$36 406, which is the average sum provided above, considering a cheap price for the furniture (\$15 738 + \$20 668). The cost estimate of losing a vehicle is excluded, but it is understood that they represent considerable sums. Additionally, the existence of insurance does not exempt from additional costs, or the impossibility of recovering the full value of the car, and sometimes it can be difficult to get the insurance payment.

In addition, those affected were asked about the expenses incurred to repair the damage to their homes. In this case, the answers were very varied, which is why intervals of the amounts are presented in Table 11.

The most frequent spending averages are up to \$50 000, with 38% of those surveyed. Adding the amounts reported, an average expense per dwelling was obtained, which is shown at the last row of the table; thus, the highest average expense is for Los Mochis with \$40 850, and in Culiacán was similar with \$36 850. In Mazatlán the average was much lower (\$21 300). Also, people commented that this only counts the losses of one event, but there are families that have repurchased their furniture more than once, and that they must carry out continuous repairs, as mentioned above.

Table 11. Repair costs.

Spending range	Mazatlán	Los Mochis	Culiacán	Total	Percentage
Up to \$5000	6	3	6	15	9%
Up to \$10 000	6	2	12	20	13%
Up to \$20 000	16	3	15	34	21%
Up to \$50 000	8	20	33	61	38%
Higher	3	9	11	23	14%
Did not answer	1	1	2	4	3%
Does not know	0	2	1	3	2%
Total expenses	\$852 000.00	\$1 634 000.00	\$2 930 000.00	\$5 416 000.00	
Average expenses per home	\$21 300.00	\$40 850.00	\$36 625.00	\$33 850.00	

Source: Author's own elaboration with survey data.

It should be emphasized that this estimate considers only approximate expenses, since most of the families commented that they do not have records of expenses, and many times the cost is lower because they do the repair themselves. It was also observed that there is no proportion between the damage to the houses and the costs of repair, since many families do not repair their house given their income level. Thus, inequality is perpetuated in terms of well-being, not only due to the economic loss of families, but also due to the loss of well-being that they are unable to recover given their income situation. In this sense, it is important to highlight that many families experience constant nervousness with every rain, especially families that have had the problem for years, such as in the Magisterial neighbourhood of Los Mochis, La Estero y Jacarandas in Mazatlán, and Valle Alto/Villas del Río, 6 de Enero and Infonavit Humaya in Culiacán.

Given that the estimates based on repair costs per home are highly variable, a repair estimate for damage to a dwelling was requested to an architect office in three scenarios: with flooding of 50 cm, 1 m, and 1.5 m (The estimate is presented as an annex). The estimation is for a standard house with two bedrooms, living room, kitchen, bathroom, and front and rear patio on a 6.5 m X 16 m lot. Of course, many dwellings are bigger, but it is part of the difficulties faced for the estimation. The repair estimate includes items such as cleaning, demolition of flattening, curing, and new flattening, tiles, as well as the repair of electrical and sanitary installations. The estimation is shown in Table 12.

Table 12. Estimate of home repair costs made by an architect consultancy.

Height of the water level	Repair cost
up to 50 cm	\$73,904.65
up to 1 m	\$90,986.20
up to 1.5 m	\$104,536.20

Source: Estimate made by a consultant architect.

This estimate shows that market costs much higher than those reported by the participants. In the lower level considered (0.5 m), with an estimated repair cost of \$74 000, multiplied by 160 dwellings, the total is \$11 840 000, but many of the homes visited presented higher water levels, while others present lower water levels.

In another question, they were asked if there was any pending repair. In this regard, 54% said "yes" but reported that they do not have the resources, 40% said "no", and 6% did not answer. Likewise, they were asked if they have an estimate of the pending repairs, and the majority (65%) said they did not know. Of those who did respond, the average amount required to repair their home was more than \$20 000.

Moreover, in the questionnaire people were asked the types of aid received by the government when they were flooded. In this matter, only 16% of the families received some type of government assistance. Regarding the types of government aid, some people reported having received financial aid of between \$1500 and \$5000, or furniture such as a refrigerator or mattresses, while others received only food. In the case of Valle Alto and Villas del Río in Culiacán and the Fraccionamiento Las Mañanitas in Los Mochis, no one received government support, but they did receive housing insurance compensation from Infonavit. Regarding the compensation that people consider fair, they responded that all their homes and belongings should be repaired or that they should be given an average of \$40 000. Some commented that they should also be exempted from paying property taxes.

Regarding property loss, they were also asked if they consider that their home has lost value due to the flood events. In this respect, 80% answered "yes", and the percentages of value-loss are highly variable. Many commented knowing neighbours who have sold their homes at a very low price, and others considered that they cannot even sell their homes.

Discussion

The individual costs incurred by families far exceed the compensation received, even for those who received cash and/or belongings. For example, during 2022, the state government delivered items such as stoves and refrigerators in areas affected by rains, and it also provided cash support of \$5000 and \$10 000, with a reported expense of over 6 million pesos only in that year, which could only support between 600 and 1200 beneficiaries, although this is an estimate because there was no access to the information from the beneficiaries records.

In summary, the estimated losses in the surveyed dwellings were as follows:

1. Recovery of belongings and furniture at low cost: \$15 738.
2. Loss of food, clothing, and other household utensils: \$20 668.
3. Average repair costs: \$33 850.
4. Devaluation of the price market for the house.

Adding up, the families surveyed presented losses of at least \$70 256. But if the total average repair costs for flooded houses from Table 11 are also assessed in the range from 50 cm to 1.5 m, the repair of the buildings requires an average of \$89 809; in fact, there were people who reported expenses that approximate this amount. Even if all of them had received economic support, it was shown to be totally insufficient, coupled with the fact that only 16% of those surveyed confirmed that they received government support in cash. Also, those surveyed reported that even when some social aid is distributed after floods, there is people who will ask for support even without having suffered damages. Hence, the compensatory aid approach is not effective even for the short term, neither for the long term.

In this way, it is demonstrated that compensation is a scheme that does not restore the well-being of families. The losses go beyond the economic, since the state of mental and physical health of those who have suffered these phenomena on several occasions is also affected, given the loss of emotional valuable assets that they cannot recover, leaving them vulnerable.

Seen from a socio-environmental justice perspective, it is imperative to avoid that families continue losing their belongings due to the frequent floods. Although they do not occur every year in all areas, the dwellers continue in a disadvantageous situation caused mainly by deficient urban planning. It should be highlighted that even if some settlements started as irregular, the floods have persisted for a long period. Therefore, the authorities must take more effective alternatives. On the other hand, not all the neighbourhoods surveyed are the product of irregular settlements, but they were real estate developments that showed deficient planning, or which with subsequent developments their situation of vulnerability worsened, as is the case of Valle Alto/Villas del Río, Acueducto, Infonavit Humaya, in Culiacán, and Las Mañanitas in Los Mochis, whose planning should have been done better, or else the subsequent modifications that have worsened their situation should have been foreseen. At the same time, the issue of garbage and silt from canals, rivers, and streams is added to the problem, worsening the situation, as expressed by some of the respondents. It is also important to add that such issue is not the sole obligation of the authority. It is a joint responsibility of society and government, calling for an active inclusion of the population, which is also within the socio-environmental justice approach.

Conclusions

This investigation showed that, although in the state there is a history of quite disordered urban settlements, not all risk areas have developed from it, but there are also subdivisions that, although they are supposed to have followed the established construction protocols, have presented flooding on more than one occasion.

It is shown that only the repair costs exerted per home in a flood amount to approximately \$33 850, but the actual costs of repairs are even higher, at least \$74 000 even for a 50 cm flood, but many families cannot face it. Also, the estimations provided a detailed view of the total losses by the families, which is a novel contribution of this paper, adding at least \$70 256, together with the cost of recovering belongings, plus the unaccounted-for patrimonial loss due to the reduction of the market value of the houses located in areas that have been flooded on one or more occasions. In addition, families not only lose household belongings and other material goods, such as vehicles, but also emotionally valuable items. The state of vulnerability leaves further affectations on their emotional state and satisfaction with life, feeling powerless in the face of an imminent loss of their property when it floods and, as already reported, more than 90% of those surveyed believe that they will flood again, indicating that the majority have a very high perception of vulnerability.

In sum, we conclude that the compensation approach is not even an effective palliative in the short term and, therefore, it is urgent that urban planning policies incorporate the concept of socio-environmental justice, that is, design solutions to floods and stagnation, not only in urban areas but also for all settlements that are already identified.

Finally, in recent years, when the rains cause various flooding, the authorities blame the density of rainfall; however, as shown in these eight neighbourhoods, the problems are persistent and even increasing due to lack of infrastructure improvement or poor planning, which could be the case in those areas already identified by the Civil Protection system mentioned before. This affects many people and causes accidents and human losses. Namely, some incidents occurred due to lack of drainage systems in underground urban roads, or a missing lid in a drain outlet.

Acknowledgments

The authors thank to Universidad Autónoma de Sinaloa for the grant received to do this research work, with PROFAPI resources, with grant number PRO_A6_041.

Conflict of interest

Los autores declaran que no existen conflictos de interés.

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