

ASSESSING THE SOCIAL VULNERABILITY TO FLOODS IN PANDORA OESTE, LIMÓN, COSTA RICA, CENTRAL AMERICA

Jenny Villalobos-Sequeira, ^a Jacqueline Centeno-Morales, ^a Stephanie Cordero-Cordero, ^a Deivis Anchía-Leitón, ^a Marianela González-Varela ^a

^a *Institute of Social Studies in Population, Faculty of Social Sciences, National University, Costa Rica.*

ABSTRACT

The increase in floods as a consequence of climate change is causing considerable concern in vulnerable localities. The community of Pandora Oeste in Costa Rica has experienced increasingly frequent flooding, therefore, the aim of this study was to describe the social vulnerability to flood risk, associated with people and housing characteristics, as well as current conditions to generate information that contributes to integrated risk management. The action-research methodology utilized allowed the development of joint activities between local actors and the academia, in order to better understand several variables that influence social vulnerability. To achieve this, a survey was applied to the community residents, and a social mapping workshop was conducted with the participation of members of the Valle la Estrella Community Emergency Committee. This gathered information is an input for the community decision-making, to direct efforts in the implementation of flood risk mitigation actions. At the same time, the results have established an approach to the flood problem, providing the methodological scenarios implemented, which could potentially be replicated in other communities, including new perspectives from community management to the articulation of actors, strengthening shared responsibility for social resilience in the face of future extreme weather events.

Key words

Social perception; flood risk; Costa Rica; community participation; social resilience.

VALORACIÓN DE LA VULNERABILIDAD SOCIAL ANTE LAS INUNDACIONES EN PANDORA OESTE, LIMÓN, COSTA RICA, CENTROAMÉRICA

Resumen

El incremento de inundaciones a consecuencia del cambio climático genera creciente preocupación en localidades vulnerables. La comunidad de Pandora Oeste en Costa Rica ha experimentado afectaciones por inundaciones cada vez más frecuentes, por lo tanto, este estudio buscó describir la vulnerabilidad social ante el riesgo de inundaciones, asociada a características de personas y de viviendas, así como, condiciones actuales para generar información que contribuya en la gestión integrada del riesgo. La metodología utilizada de investigación-acción, permitió el desarrollo de actividades conjuntas entre actores locales y la academia, para comprender diversas variables que influyen en la vulnerabilidad. Para lograrlo, se aplicó una encuesta a habitantes de la comunidad, asimismo, se realizó un taller de cartografía social con la participación de miembros del Comité de Emergencias del Valle la Estrella. Esta información recopilada es un insumo en la toma de decisiones a nivel comunitario, para dirigir esfuerzos en la implementación de acciones en la mitigación del riesgo por inundaciones. Al mismo tiempo los resultados establecieron escenarios metodológicos que podrían ser replicados en otras comunidades, incluyendo nuevas perspectivas desde la gestión comunitaria hasta la articulación de actores, fortaleciendo la responsabilidad compartida para la resiliencia social ante futuros eventos climatológicos extremos.

Palabras claves

Percepción social; riesgo de inundación; Costa Rica; participación comunitaria; resiliencia social.

Introduction

Human processes associated with intensive land use change combined with the increase in extreme climatological phenomena, are nowadays considered key factors influencing the intensification of flood disasters (Rogger et al., 2017). Despite the knowledge of these factors, as well as the efforts made in the implementation of various measures to mitigate their impacts in recent decades, floods remain to be the most devastating natural hazard worldwide at present (Rufat et al., 2015; Ridha et al., 2022; Pinos and Quesada-Román, 2021; Ulibarri et al., 2023).

Furthermore, studies related to hydrometeorological phenomena in the Central American region (Durán-Quesada et al. 2020; Quesada-Román and Villalobos-Chacón, 2020; Quesada-Román et al., 2021), pointed out the influence of meteorological movements such as El Niño-Southern Oscillation (ENSO), Inter-Tropical Convergence Zone (ITCZ), tropical cyclones, and cold fronts; in relation to the frequency and intensity of storms as a consequence of climate change. Consequently, the increase of adverse natural events reduces overall growth potential, increases poverty, and lowers human development indicators (Ishizawa and Miranda, 2018).

Specifically, the case of Costa Rica is not far from this context, because floods are the natural events reported as having the most impact on the national territory during the period from 1970 to 2019, where 63% of the registries correspond to damage to homes caused by the effects of high rainfall events (DesInventar Sendai, 2023). Moreover, Quesada-Román and Campos-Durán (2022) pointed out that the largest number of reported incidents (11,746) during the period from 1990 to 2015, are related to extensive risks that include floods, landslides, and storms.

This situation is predominant in the Huetar Caribe region of Costa Rica, which according to indexes estimated by Quesada-Román (2022), was classified as a region of high vulnerability to flooding. In addition to the estimation of these indexes, the Rural Development Institute [INDER] (2022) pointed out that the Estrella Valley, which is located in this region, presents physical factors specific to the territory, such as deforestation, the expansion of productive activities of the large transnational banana companies, and the location of human settlements on the banks of La Estrella River; factors that contribute to increased social vulnerability in this area, as in the case of the community of Pandora Oeste, where flooding is becoming more frequent.

When referring to the concept of social vulnerability, the Economic Commission for Latin America, and the Caribbean (ECLAC) relates two explanatory components. On the one hand, the insecurity and defenselessness experienced by communities, families, and individuals in their living conditions because of the impact caused by some type of traumatic economic, social, and environmental event. On the other hand, the management of resources and strategies used by communities, families, and individuals to cope with the effects of that event (Pizarro, 2001).

Therefore, to assess social vulnerability Roder et al. (2017), highlights the broad spectrum of variables to consider such as the human environment in relation to individual characteristics, complex community dynamics, and support systems that may influence the ability to respond to a specific event.

In addition to the consideration of different variables, it is essential to conduct research that incorporates local actor's perceptions as part of the risk management process (Bodoque et al., 2019). Likewise, Rufat and co-participants (2015) emphasize the importance of incorporating into these studies, factors that contribute to the

characterization of human beings, environmental precursors, and interactions within a given context in order to strengthen social resilience and facilitate the adoption of appropriate measures to mitigate the negative consequences of floods.

The pursuit of results entails multiple benefits in terms of reducing social vulnerability, especially for decision-making from a shared responsibility perspective, in which the community should have the same commitment as the State and achieving adequate attention in risk management both in the assignment of resources and in the prioritization of projects (Raška et al., 2020).

Considering the above aspects, the project "Contributions for citizen management of flood risk in the community of Pandora Oeste in the Valle la Estrella, Limón" was proposed for a period of three years (2020 to 2022). The main objective was to "Strengthen citizen competencies for community management of flood risk in the community of Pandora Oeste in the Valle la Estrella, Limón".

This initiative was developed within the framework of two instances of the National University of Costa Rica, the School of History, and the Institute of Social Studies in Population (IDESPO), in collaboration with the Valle la Estrella Community Emergency Committee (CCEVE), which has been responsible for risk management in Valle la Estrella since 2018, when it was formed in response to the problem of recurrent flooding.

Furthermore, the actions implemented within the context of this initiative were based on a methodological approach of action research, which is oriented towards social change; hence, it must incorporate democratic participation in the decision-making process of those involved (Bacayán and Vega, 2020). In this regard, the aim of this article is to describe the social vulnerability of the Pandora Oeste community, associated with several variables such as community characteristics and flood experiences, as well as current infrastructure conditions; for the generation of base information that will contribute to community flood risk management.

Materials and Methods

Study area

This study focused on the Pandora Oeste community, which is located on Costa Rica's Caribbean slope. It has a territorial extension of approximately 200 m² and is inhabited by 304 people, according to data from the survey conducted by this study in 2021. In addition, according to Costa Rica's political and administrative divisions, this community is in the Valle de la Estrella district of Limón's central county, in the province of Limón (Figure. 1).

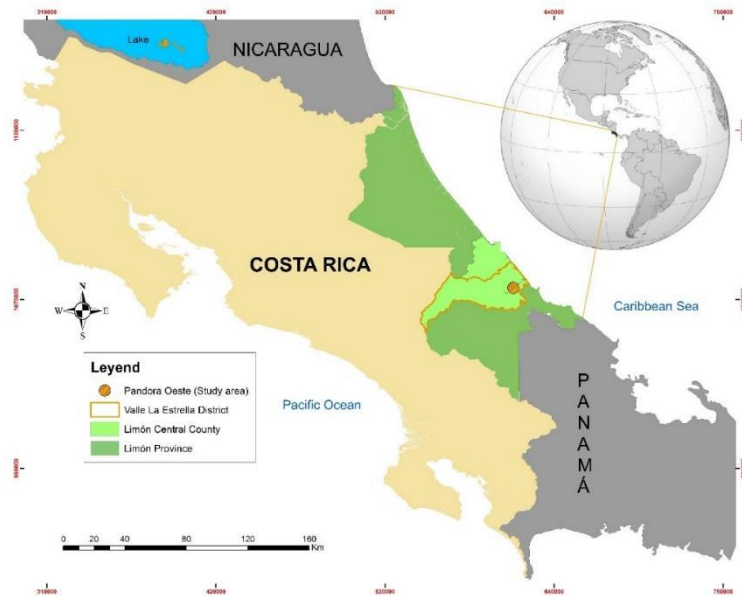


Figure. 1. Location of the study area: Pandora Oeste, Costa Rica.
Source: Authors, 2023.

Pandora Oeste is in the lower part of La Estrella River basin, which is located in the tropical humid life zone, with an average annual temperature of 16 to 28 °C, an altitude of 10 to 50 m above sea level, an average annual rainfall of 2,000 to 4,000 mm, and average of 204 rainy days with the rainiest months being July and December (Costa Rican Ministry of Environment, Energy and Telecommunications [MINAET] and National Meteorological Institute [IMN] 2011). Furthermore, in terms of soil classification, the ultisol order is predominant in this basin, which is typically found in very humid areas with a lot of precipitation and is one of Costa Rica's oldest and most weathered soils (Mata, 1991).

In terms of population dynamics, Pandora Oeste emerged decades ago along with other neighboring communities as a result of banana expansion, which settled on the margins of the highest parts of La Estrella River basin. Therefore, this community was born as a banana enclave, where workers of transnational banana companies lived, as in other locations in Limón province (Anchía-Leitón and Quirós-Vega, 2023). The banana farms continue to operate near the study area, as well as other activities such as cocoa farms, cattle ranching, and the informal economy.

Data collection

For the development of this study, the action research methodology was utilized, which according to Creswell (2012), addresses a specific problem and seeks solutions in a particular context. Additionally, using this methodology unlike traditional academic or scientific research, local people participate in the constructive process (Sandoval-Díaz and Martínez-Labrín, 2021), from problem definition to project evaluation, sharing knowledge, and interpreting the results (Zapata and Rondán, 2016).

Therefore, under this approach, it was proposed to address the social vulnerability of Pandora Oeste to floods. According to historical records and the knowledge from members of the Valle la Estrella Community Emergency Committee (CCEVE), this is the community that suffers the most damage when the Estrella Valley floods and the reason this location was prioritized in this study.

In this regard, a survey and a social mapping workshop were carried out to gather information through participatory spaces, in order to generate a better understanding of the local situation by the research team, both academic and local represented by the CCEVE.

The survey had a descriptive scope, as pointed out by Hernández and collaborators (2014), characterizing this technique by describing and detailing how phenomena exist and manifest situations, contexts, and events; with the aim of specifying properties, characteristics, and profiles of the units of study. In other words, its purpose is to determine relationships between the variables of interest.

For the application of this survey, it was necessary to divide the study area into three sectors: A, B, C. This was done to determine the characteristics and conditions of people and houses in relation to the level of impact caused by flood events in the community. Furthermore, to define these sectors, a field trip was conducted to Pandora Oeste to identify and record all existing structures, resulting in a total of 90 individual houses, of which 86 were occupied at the time of the study.

The fieldwork was carried out through the community from August 16 to 19, 2021, with one person interviewed at each occupied residence. A questionnaire was used to gather information from a resident of the household aged 18 or older. These two qualities were established to acquire reliable information from each household and the community.

This applied questionnaire was constructed collectively between the National University team and CCEVE, through online sessions due to the pandemic context generated by COVID-19 in 2020. In these joint work sessions, it was possible to identify community-relevant risk management topics, as well as formulate questions to gather information on household composition, people's characteristics, housing conditions, and some about flood knowledge and perception.

Finally, the survey's data were processed using IBM's SPSS (Statistical Program for the Social Sciences), version 28. According to Andraus (2010), this tool is widely utilized in many practical applications due to its facility of use and flexibility, which allows the development of statistical procedures and techniques as well as the presentation and visualization of results.

Regarding the second technique utilized, a workshop was developed for the elaboration of social mapping, as a participatory method of collective research, based on an integrative perspective, in which reality is culturally constructed by people, from cultural, interpersonal, and political experiences, that influence mental, graphic, subjective, and material representations of aspects within a socio-cultural context (Innovación Social Colectiva, 2021). This workshop was facilitated to CCEVE members, who had shown leadership and experience in flooding periods since its formation as a community organization. Therefore, the knowledge of concepts associated with flood risk management was strengthened in this activity.

Following this initial phase, each participant was given a map of the community with reference points, allowing them to use historical memory to identify the different scenarios experienced in Pandora Oeste as rainfall intensity increased. Subsequently, the group decided to select the map that was closest to the reality of the flooding scenarios, which was prepared by a person with extensive experience dealing with floods in Pandora Oeste, who also enriched this space for discussion and analysis of the activity's results by socializing situations and circumstances, and the other participants agreed to determine the sector that floods first.

Finally, the selected map was mapped using the Geographic Information System (GIS), specifically the ArcGIS software, an ESRI-produced technical platform. This tool makes it possible to illustrate the spatial vulnerability to flooding, since it has the advantage of monitoring the results over time and space (Roder et al., 2017).

Similarly, Leivas and collaborators (2017), mention that the purpose of these platforms is to facilitate the interpretation of information, noting that social mapping is a participatory planning process, used as a diagnostic tool in which actors recreate the

territory from a map, seeking collective solutions through citizen participation and dialogue. Furthermore, it can be viewed for communities to reflect, socialize knowledge and practices, and analyze their reality by understanding the aspects that define their daily lives (Betancourt et al., 2020).

On the other hand, it should be noted that the information obtained from both techniques responds only to the perception of the participants in this study, as it is based on each person's interpretation of reality, starting mainly with their experiences in Pandora Oeste; thus, generalizing the results to the entire locality is not possible.

Another important point to clarify in this section is that the information gathered in both techniques was worked on by the sectors described, facilitating community decision-making. Nevertheless, for the specific case of this study, the data was presented in a broad style for the Pandora Oeste community.

Results and discussion

Demographic characterization

As a result of the application of the survey, a total of 92 households were counted within the 86 residences visited. It should be noted that the difference between these values is attributable to the occasional presence of more than one household in the same structural unit. The total number of people registered was 304, with 157 women and 147 men; 96% were Costa Ricans and 4% were Nicaraguans. In terms of age category, 10% were under the age of five, 14% were between the ages of five and eleven, 69% were between the ages of 12 and 64, and 7% were 65 and beyond.

Regarding the educational level of people aged five or above, it was found that the majority of them have completed primary school or less (63%), followed by 31% who have completed or are completing secondary school, and only 5% have university studies.

Associated with physical or intellectual disabilities, a total of 32 people were reported, with walk impediment being the most prevalent, followed by limb difficulties (Table 1). Regarding the location of this population, all three sectors have residents who suffer from some of the disabilities. Nevertheless, when comparing the three sectors, sector A has the most cases (13). It is worth noting that, according to the people interviewed, this sector is the second to be flooded, thus enabling the development of a framework for providing targeted attention to this population.

| Sociodemographic characteristics | Frequency |
|---|------------------|
| Sex | |
| Man | 147 |
| Woman | 157 |
| Instruction level | |
| Completed primary education or less | 200 |
| Secondary education | 85 |
| University education | 14 |
| Do not know / No response | 5 |
| Nationality | |
| Costa Rican | 292 |
| Nicaraguan | 12 |

| | |
|-----------------------------|-----|
| Hold social security | |
| Yes | 266 |
| No | 37 |
| Do not know / No response | 1 |
| Disability | |
| Walk impediment | 14 |
| Limb's difficulties | 7 |
| Vision impaired | 5 |
| Speech impediment | 2 |
| Intellectual | 2 |
| Mental | 2 |

Table 1. Number of people based on sociodemographic characteristics, Pandora Oeste census, August 2021.

Source: Authors, 2022.

It is possible to indicate that the sociodemographic characteristics mentioned above increase the effects not only economically but also in terms of health. This leads to the identification of Pandora Oeste as a susceptible community, as vulnerable groups are considered to be the elderly, children, adolescents, women, particularly pregnant women, chronically ill, and poor communities with little social support; where socioeconomic status, education level, and employment availability also modulate the impact on health due to flooding (Comité de Salud Medioambiental, Asociación Española de Pediatría, 2020, p.38).

In addition to the preceding, those people with limited mobility or who are dependent on others when responding to an eventual natural event, should be taken into consideration. In the case of Pandora Oeste, having this knowledge allows them to understand the individual features of the population and to develop strategies of attention before, during, and after a flood, thereby reducing the potential consequences.

Housing characteristics

Another element that may be used to characterize social vulnerability is the condition of infrastructure. According to Ulibarri and collaborators (2023), the predicted increase in heavy rainfall leads to an amplification of future flood risks, making coping capacity even more difficult.

In this regard, data relating to the type of structure and condition of housing in Pandora Oeste, revealed that 65 houses are one-story. Additionally, 43 people interviewed indicated having a defective roof or floor condition, while 31 alluded to a bad exterior wall condition. This community context aligns with the concept cited by Guevara Víquez (2017), where structural or bodily vulnerability refers to material damages to an infrastructure. Thus, the characteristics described reflect vulnerability to greater probabilities of material losses, given the frequency of floods and the resultant impacts.

Furthermore, access to utility services is an additional element contributing to the level of vulnerability. Regarding electricity, only three houses do not have this service. However, the critical situation lies in the supply of drinking water, with 78 houses lacking the service.

It should be noted that at the time the survey was conducted, 78 people interviewed from Pandora Oeste reported not having access to potable water, which contradicts or violates the reform No. 9849 of Article 50 of the Costa Rican Constitution, stating: "Every person has the basic and inalienable human right of access to potable water, as an essential good for life" (Sistema Costarricense de Información Jurídica, 2023).

In the same manner, the lack of drinking water remains an ongoing problem in this community, but is aggravated during flood periods, since the absence of potable water as a human right can lead to disease transmission, which is further reinforced by La Estrella River pollution.

Finally, in this characterization of utility services, internet access cannot be left out, because it is another of the locality's weaknesses. The results showed that 75 households do not have internet service, which increases the difficulty of responding to floods, as it does not inform the real condition of the people and their effects, especially when floods leave the community without overland access.

Flood affectations

The previous sections demonstrate how demographic and housing characteristics highlight Pandora Oeste's social vulnerability because of its geographical location in relation to La Estrella River. Moreover, the precipitation characteristic of the region in which the study area is located generates a significant rise in the flow of La Estrella River, which finds the ideal route to enter this community, along the streams of the several intermittent tributaries, as illustrated in Figure. 2.

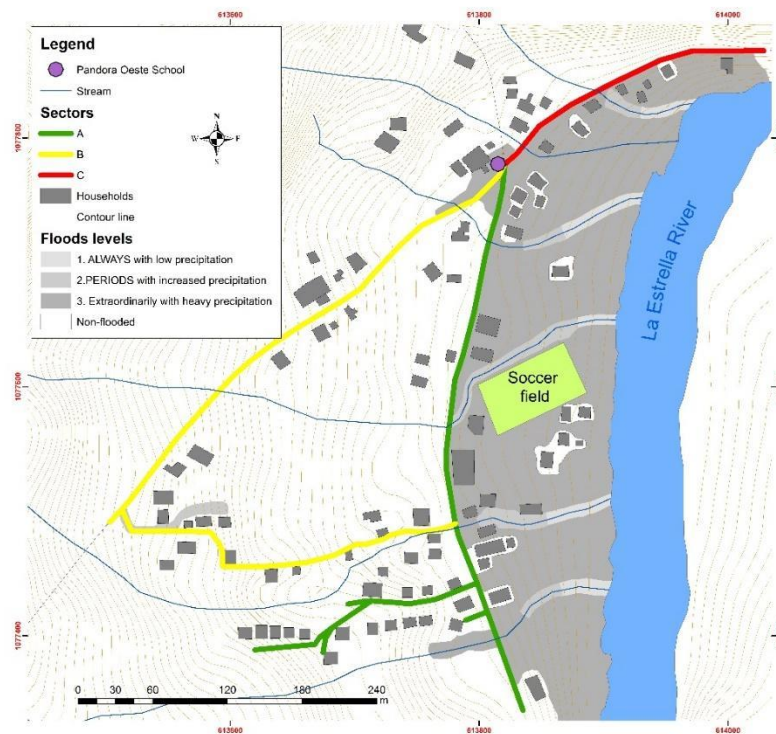


Figure. 2. Sectors and flooding levels corresponding to the study area.
Source: Authors, 2023.

Within this context, there are records of historical floods in the Valle de la Estrella district caused by the overflow of La Estrella River including 1970 with 12 homes destroyed, 1991 with 135 people affected, 1992 with 225 people affected, 2002 with 500 houses affected and 3,081 people affected, and 2021 with 17,908 people affected (DesInventar Sendai, 2023).

These historical records were linked to the results from the social mapping workshop, where participants, through experience and historical memory, zoned three different flood scenarios/levels experienced, concluding that sector C tends to be the first to be flooded, followed by sector A and finally sector B (Figure. 2).

Regarding the dynamics of these flooding scenarios, the first one emerges near La Estrella River, where it begins to flow toward the community's interior along the stream's mouths. This normally occurs with the first rain of the day, with no significance in terms of duration or intensity.

The second scenario occurs as the duration and intensity of rainfall rises, primarily affecting the community's stream beds, as well as reaching neighboring lands without causing damage to structures.

The third and last scenario occurs when La Estrella River's course changes abnormally as a result of rainfall in the middle and upper basin, causing the surface water bodies to progressively rise until they reach ideal places to overflow, affecting homes, businesses, churches, the educational center, and access to roads. This is the scenario that has the greatest impact on a large portion of the community.

In addition to the historical context and the flood scenarios described, the residents were consulted regarding their experiences with the effects of flooding, the greatest being food loss reported by 79 participants, followed by water supply and infrastructure damage, which were mentioned by 73 and 72 people, respectively. Regarding infrastructure damage, several houses have been damaged, including the one shown in Figure. 3, which was declared a total loss by the National Emergency Commission in 2021, and the property now has restrictive regulations on the construction of any type of infrastructure.



Figure. 3. Flood affectations in Pandora Oeste, July 2021.
Source: Author, 2021.

Added to the problem of housing conditions caused by flood events, data from the National Institute of Statistics and Census, in the National Household Survey (ENAH, 2022), indicate that the Huetar Caribe region has one of the highest incidences of poverty considering the multidimensional index (covering education, housing, internet use, health, labor, and social protection), with 23.9% of households in this situation. Moreover,

data from the Ministry of National Planning and Economic Policy [MIDEPLAN] (2023), indicate that the Valle de la Estrella is one of the ten districts with a low rating (26.28) in the social development index, according to the Territorial Administrative Division of Costa Rica.

Within the context of vulnerability, the United Nations Office for Disaster Risk Reduction (2021), recognizes that poverty and socioeconomic inequalities are factors that contribute to disaster risk, where people who are living in poverty, become trapped in a cycle of poverty. Therefore, poor housing conditions and limited access to basic services during an emergency negatively impact the ability to cope with basic needs before, during and after an event.

As a result of this, Pandora Oeste's social vulnerability has increased as floods have become more frequent, especially with the most recent flood considered historical by the level of impact occurring on July 24, 2021. Similarly, considering extreme natural events at the national level, Quesada-Román and Villalobos-Chacón (2020) relate the already existing vulnerability of the study (Upala), prior to the impact of Hurricane Otto in 2016, which resulted in a series of cascading disasters.

For this reason, given the circumstances outlined, community risk management strategies should be undertaken to improve community organization, as well as the development of emergency plans regarding the disaster prevention.

Community management

Because of the importance of community participation in mitigating the effects of hydrometeorological phenomena to increase community resilience, people interviewed in this study were asked about their knowledge of preventive measures to deal with potential flood emergencies. Among the results, 48 of the 86 interviewed stated that they lacked the essential knowledge.

This lack of knowledge demonstrates limitations at the community level taking into consideration the importance pointed out by the National Commission for Risk Prevention and Emergency Care of Costa Rica [CNE] (2019), of promoting the organization for risk management, by developing emergency plans that "manage to reduce and prevent risks at the family level, proactively influencing prevention, preparedness and family response in case of emergencies".

In terms of community organization, only eight of the total number of the interviewed participants indicated that they belong to a group in their locality. However, there is interest in participating, since 44 people indicated that they are willing to get involved, but only six expressed their willingness to participate on a community organization's board of directors.

Associated with participation, an important element to rescue at the community level is the sense of belonging to a locality, since a relationship is established between length of time that the people interviewed have lived in Pandora Oeste, and their willingness to participate in a community group.

Therefore, for this locality it was found that those inhabitants with 10 or more years of living in Pandora Oeste, are more willing to participate in community groups, with 31 out of 50 people consulted indicating an interest in participation.

Regarding this participation, it is worth mentioning that community members acquire control over their environment, identify with their locality, and contribute to strengthening social cohesion through engaging in local groups. At the same time, according to Ramos-Vidal and Maya-Jariego (2014), citizen participation in communal groups helps to (re)construct collective identity by developing a system of norms and values aimed at satisfying the needs of community members.

In this sense, this willingness to participate specifically in Pandora Oeste would aid in the process of developing environmental responsibilities and rights, promoting the design and evaluation of public policies for disaster prevention, response, and mitigation (Coto-Cedeño et al., 2023). Furthermore, social cohesion and a sense of belonging can be used as indicators to improve the quality of life of residents, as well as focus attention on mitigating flood-related consequences.

Conclusions

Pandora Oeste exemplifies social vulnerability to floods by considering elements that explain the insecurity and helplessness experienced by its residents. The findings have provided a better understanding of this community's situation in terms of demographic characterization, current housing condition, and social perception. This information contributed to the generation of a baseline for local community management in the face of flood risk, as stated in the aim of this study.

The community scenario was created in a participatory manner with members of the Valle la Estrella Community Emergency Committee (CCVEE), which generated in this group responsibility and commitment as active protagonists in the research and extension process, being making this an outstanding element not only for the study, but also for the community, as it demonstrated the importance of self-management.

As a result, this study went beyond the impact of flooding by adding the generation of responsibility as relevant input for the academia in the approach to risk management from a social perspective, which encourages the participation of all stakeholders, with the aim of strengthening resilience to future extreme hydrometeorological events.

Similarly, this responsibility assumed in the search for solutions led the CCEVE to develop its first community emergency plan for the community of Pandora Oeste, which in turn integrates more residents of the area and involves other community organizations, resulting in new alliances that allow the flood response to be approached from a strategic perspective by considering both before and after the event.

This local experience becomes a replication opportunity for other communities in the Estrella Valley, since it has a group with organizational ability and knowledge of risk management. Furthermore, at a methodological level, the implemented techniques can be applied in other areas if there is a group of people engaged in constructive processes, and committed to cooperating in risk management actions, taking into consideration the characteristics of each community.

Methodologically, this study was successful in terms of the activities carried out. Nevertheless, some limitations were considered, such as a lack of spaces to carry out dialogues of knowledge, since research processes require more time and dedication because it is important to establish bonds of trust and cooperation. In addition, there is a lack of local studies, making it difficult to do a comparative analysis of the vulnerability of other communities located in the same river basin. Moreover, the method of working during the questionnaire's development had to be changed to online due to COVID-19, where some members of the CCEVE had limitations on connectivity.

Finally, it is concluded that the study conducted in the Pandora Oeste community can be viewed as an opportunity for improvement in risk management at both the community and academy levels, promoting the continuous construction of knowledge through the innovation of participatory methodologies that increasingly integrate the communities.

Acknowledgments

Special thanks to the Community Emergency Committee of Valle la Estrella for the cooperative construction of inputs, as well as the participants from Pandora Oeste's Community, for the information provided during the process of this study.

Data Availability

The data used and additional materials of this study is available at Universidad Nacional repository: <https://repositorio.una.ac.cr/handle/11056/27195>

References

- Anchía-Leitón, D., Quirós-Vega, J. (2023). Caracterización de las inundaciones en Pandora Oeste, Limón, Costa Rica. *Revista Environment & Technology*, 3(2), 74-91. <https://doi.org/10.56205/ret.3-2.4>
- Andraus Alfaro, E. (2010). *Estadística Descriptiva con SPSS*. Editorial Universidad de Costa Rica.
- Bacayán, C. and Vega, P. (2020). La investigación-acción en el contexto educativo. *Revista PAIDEIA* XXI. <https://revistas.urp.edu.pe/index.php/Paideia/article/view/2999/3165>
- Betancourt, D., Vélez, C. and Sánchez, N. (2020). Cartografía social: construyendo territorio a partir de los activos comunitarios en salud. *Entramado*. 16(1): 138-151. <https://dx.doi.org/10.18041/1900-3803/entramado.1.6081>
- Bodoque, J.M., Díez-Herrero, A., Amerigo, M., García, J.A. & Olcina, J. (2019). Enhancing flash flood risk perception and awareness of mitigation actions through risk communication: A pre-post survey design. *Journal of Hydrology* 568 (2019) 769–779. <https://doi.org/10.1016/j.jhydrol.2018.11.007>
- Comisión Nacional de Prevención del Riesgo y Atención de Emergencias [CNE]. (2019). Plan Familiar de Gestión de Riesgo. https://www.cne.go.cr/reduccion_riesgo/biblioteca/planes/documentos/Plan%20familiar%20de%20GR%202019.pdf
- Comité de Salud Medioambiental, Asociación Española de Pediatría. (2020). Inundaciones y grupos vulnerables: comprendiendo los impactos en la salud infanto-juvenil. En: Ortega-García JA (Ed), Impacto de las inundaciones en la salud de la infancia y adolescencia: un enfoque ambiental y comunitario (pp. 38-46). https://www.aeped.es/sites/default/files/documentos/esalud_inundaciones.pdf
- Coto-Cedeño, W., Centeno-Morales, J. & Zúñiga-Arias, Y. (2023). Participación Comunitaria y Estrategias Ciudadanas para la Gestión del Riesgo de Desastres. Experiencias locales para la sustentabilidad en Pandora Oeste de El Valle La Estrella, Limón, Costa Rica. *Revista de Estudios Latinoamericanos sobre Reducción del Riesgo de Desastres REDER*, 7(1), 174-185. <https://doi.org/10.55467/reder.v7i1.115>
- Creswell, J.W. (2012). *Educational research: planning, conducting, and evaluating quantitative and qualitative research*. — 4th ed. Chapter 17, (p. 577) <http://repository.unmas.ac.id/medias/journal/EBK-00121.pdf>
- DesInventar Sendai. (s/f). DesConsultar on-line—Flood Disaster - Costa Rica [Base de datos]. Sendai Framework for Disaster Risk Reduction. Recuperado el 09 de enero de 2023, de <https://www.desinventar.net/DesInventar/profiletab.jsp>

- DesInventar Sendai. (s/f). DesConsultar on-line—Flood Statistics – Flood Reports - Valle la Estrella, Costa Rica [Base de datos]. Sendai Framework for Disaster Risk Reduction. Recuperado el 12 de enero de 2023, de <https://www.desinventar.net/DesInventar/statistics.jsp>
- Durán-Quesada, A. M., Sorí, R. , Ordoñez, P., and Gimeno, L. (2020). Climate perspectives in the intra–Americas seas. *Atmosphere* 11 (9):959. doi: 10.3390/atmos11090959
- Guevara Víquez, S. (2017). Marginalidad y vulnerabilidad en Limón ante el riesgo de inundación. Un estudio del Proyecto de Limón Ciudad Puerto. *Cuadernos Inter.c.a.mbio sobre Centroamérica y el Caribe*. Vol. 14, No. 1 abril-setiembre, 2017, ISSN: 1659-4940
- Hernández Sampieri, R., Fernández Collado, C. y Baptista Lucio, M. (2014). *Metodología de la Investigación*. McGRAW-HILL.
- Instituto Nacional de Estadísticas y Censo [INEC]. (2022). Encuesta Nacional de Hogares [ENAHO] 2022. Resultados Generales. <https://admin.inec.cr/sites/default/files/2022-10/reenaho2022.pdf>
- Innovación Social Colectiva. (2021). *Innovación Social colectiva Conocimientos y aprendizajes para la transformación Social*. innovacion-soci.webs.upv.es/index.php/cartografia-social
- Instituto de Desarrollo Rural [INDER]. (2022). Plan de Desarrollo Rural Territorial Talamanca - Valle la Estrella 2015-2020. <https://www.inder.go.cr/talamancavallelaestrella/PDRT-Talamanca-Valle-de-Estrella.pdf>
- Ishizawa O. A. and Miranda J.J (2018). Weathering Storms: Understanding the Impact of Natural Disasters in Central America *Environ Resource Econ* (2019) 73:181–211 <https://doi.org/10.1007/s10640-018-0256-6>
- Leivas Vargas, M., Boni Aristizábal, A. and Mendoza Crespo, M. (2017). Del cuerpo a la ciudad: repensando nuestros territorios desde la investigación colectiva con cartografía social. *Agora*.
- Mata R. (1991). Los órdenes de suelos en Costa Rica, pp. 28-32. In: W.G. Vahrson, M. Alfaro y G. Palacios (eds.). *Taller de Erosión de Suelos*. Memoria. UNA. Heredia.
- Ministerio de Ambiente, Energía y Telecomunicaciones [MINAET] el Instituto Meteorológico Nacional [IMN]. (2011). Estudio de las Cuencas Hidrográficas de Costa Rica. Análisis biofísico, climatológico y socioeconómico. <http://cglobal.imn.ac.cr/documentos/publicaciones/EstudioCuencas/EstudioCuenca sHidrograficasCR.pdf>
- Ministerio de Planificación Nacional y Política Económica [MIDEPLAN], (2023). Índice de Desarrollo Social. <https://www.mideplan.go.cr/indice-desarrollo-social>
- Oficina de Naciones Unidas para la Reducción de Riesgo de Desastre. (2021). Vulnerabilidad y resiliencia. https://www.undrr.org/sites/default/files/inline-files/8-Vulnerabilidades%20y%20resiliencia_2.pdf
- Pinos, J.; Quesada-Román, A. (2021). Flood Risk-Related Research Trends in Latin America and the Caribbean. *Water* 2022, 14, 10. <https://doi.org/10.3390/w14010010>
- Pizarro, R. (2001). La vulnerabilidad social y sus desafíos: una mirada desde América Latina. División de Estadística y Proyecciones Económicas. Comisión Económica para América Latina y el Caribe. https://repositorio.cepal.org/bitstream/handle/11362/4762/S0102116_es.pdf

- Quesada-Román A. and Villalobos-Chacón A. (2020). Flash flood impacts of Hurricane Otto and hydrometeorological risk mapping in Costa Rica, *Geografisk Tidsskrift - Danish Journal of Geography*. <https://doi.org/10.1080/00167223.2020.1822195>
- Quesada-Román A., Ballesteros-Cánovas J.A., Granados-Bolaños S., Birkel C., and Stoffel M. (2021). Improving regional flood risk assessment using flood frequency and dendrogeomorphic analyses in mountain catchments impacted by tropical cyclones. *Geomorphology*, 396, 108000. <https://doi.org/10.1016/j.geomorph.2021.108000>
- Quesada-Román, A. (2022). Flood risk index development at the municipal level in Costa Rica: A methodological framework. *Environmental Science and Policy*. <https://doi.org/10.1016/j.envsci.2022.03.012>
- Quesada-Román A. and Campos-Durán D. (2022). Natural Disaster Risk Inequalities in Central America, *Papers in Applied Geography*, 9:1, 36-48. <https://doi.org/10.1080/23754931.2022.2081814>
- Ramos-Vidal, I. y Maya-Jariego, I. (2014). Sentido de comunidad, empoderamiento psicológico y participación ciudadana en trabajadores de organizaciones culturales. *Psychosocial Intervention* 23 (2014) 169-176. Doi: <http://dx.doi.org/10.1016/j.psi.2014.04.001>
- Raška, P., Warachowska, W., Slavíková, L. and Aubrechtová, T. (2020). Expectations, disappointments, and individual responses: Imbalances in multilevel flood risk governance revealed by public survey. *Journal of Flood Risk Management*. <https://doi.org/10.1111/jfr3.12615>
- Ridha, T., Ross, A.D. and Mostafavi, A. (2022). Climate change impacts on infrastructure: Flood risk perceptions and evaluations of water systems in coastal urban areas. *International Journal of Disaster Risk Reduction* 73 (2022) 102883. <https://doi.org/10.1016/j.ijdrr.2022.102883>
- Roder, G., Sofia, G., Wu, Z. and Tarolli, P. (2017). Assessment of Social Vulnerability to Floods in the Floodplain of Northern Italy. Vol 9, *Weather, Climate, and Society*. American Meteorological Society. DOI: 10.1175/WCAS-D-16-0090.1
- Rogger, M., Agnoletti, M., Alaoui, A., Bathurst, J. C., Bodner, G., Borga, M., Chaplot, V., Gallart, F., Glatzel, G., Hall, J., Holden, J., Holko, L., Horn, R., Kiss, A., Kohnová, S., Leitinger, G., Lennartz, B., Parajka, J., Perdigao, R.... Blöschl, G. (2017). Land use change impacts on floods at the catchment scale: Challenges and opportunities for future research. *Water resources research*, 53(7), 5209-5219, <https://doi.org/10.1002/2017WR020723>.
- Rufat, S., Tate, E., Burton, C. and Maroof, A.S. (2015). Social vulnerability to floods: Review of case studies and implications for measurement. *International Journal of Disaster Risk Reduction* 14 (2015) 470–486. <http://dx.doi.org/10.1016/j.ijdrr.2015.09.013>
- Sandoval-Díaz, J. and Martínez-Labrin, S. (2021). Gestión comunitaria del riesgo de desastre: Una propuesta metodológica-reflexiva desde las metodologías participativas. *Revista de Estudios Latinoamericanos sobre Reducción del Riesgo de Desastres REDER*, 5(2), 75-90. <http://revistareder.com/handle-0719-8477-2021-097>

Sistema Costarricense de información Jurídica. (s/f). Reforma Constitución Política N° 9849: Reconocer y garantizar el derecho humano de acceso al agua. Artículo 50 de la Constitución Política de Costa Rica. Recuperado el 17 de enero de 2023, de

http://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?param1=NRTC&nValor1=1&nValor2=91812&nValor3=121262&strTipM=TC

Ulibarri, N., Valencia-Uribe, C., Sanders, B., Schubert, J., Matthew, R., Forman, F., Allaire, M. and Brady, D. (2023). Framing the Problem of Flood Risk and Flood Management in Metropolitan Los Angeles. Vol 15, *Weather, Climate, and Society*. American Meteorological Society. DOI: 10.1175/WCAS-D-22-0013.1

Zapata F., and Rondán V. (2016). La Investigación - Acción Participativa: Guía conceptual y metodológica del Instituto de Montaña. p.11 <https://mountain.pe/recursos/attachments/article/168/Investigacion-Accion-Participativa-IAP-Zapata-y-Rondan.pdf>

PREPRINT