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RISK ANALYSIS TO ASSESS SOCIAL VULNERABILITY IN THE COUNTRY CLUB LA VILLA, MOQUEGUA-2023

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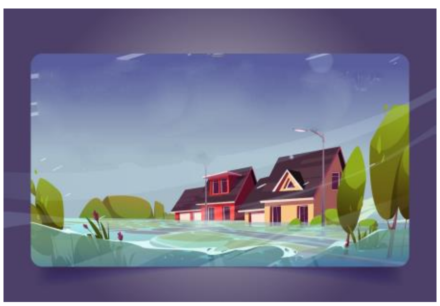
Graphical abstract



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Abstract

This article research aims to determine the social vulnerability as seismic prevention of the Country Club La Villa Urbanization through risk analysis and the level of the seismic vulnerability. Due to the events registered in the Moquegua region and the evaluation of the visible vulnerability of the inhabitants of the Country Club Urbanization, interest has been aroused in considering the said area and inquiring by the inhabitants about a place where they reside. From the event caused by the landslide registered in 2019 in the Moquegua River, the construction company Cuba Bulege, faced with the notorious risk of the river, built a construction wall that separates it from the mentioned Urbanization. Still, it does not fully cover the prevention of possible risks that may occur. The possible rock slide, the possibility of a landslide through the channel, and the level of prevention will be calculated in the following research article to prepare an analysis of the geological and structural conditions they present and contribute to the club residents. The study seeks to anticipate the possible risks identified in the IPERC and how to act against them according to the degree of risk that will be determined. It has been determined that 70% of the homes in Country Club La Villa have high seismic vulnerability, due to deficiencies in their construction.

Keywords: Social Vulnerability, Risk prevention, contingency plan, and risk level.

1.0 INTRODUCTION

This article details the level of social vulnerability found in the homes of the Country Club La Villa Urbanization. A great danger in the Peruvian territory is earthquakes; because we are facing the tectonic plates of Nazca and South America. The Country Club La Villa Urbanization is surrounded by natural slopes, with possible rockslides. The area may be affected by debris flows of moderate to large magnitude, coming from the activation of the ravine. It can compromise the physical safety of homes and residents of the Country Club settled at the mouth of the stream and the reservoir built within its channel Perspectives on climate risk attribute causality to threats and social variables such as poverty. Rarely are questions about lack of capacity, inadequate assets, or failures in social safeguards.

Vulnerability and security are framed as problems of access to goods and social protections[1].

According to INGEMMET (Geological, Mining and Metallurgical Institute): Seismic events were recorded in Moquegua with dates: a 6.9 magnitude earthquake (Richter scale) on June 23, 2001, and a 5.8 magnitude earthquake on August 26, 2003. Moquegua and Samegua were affected by the increase in the flow of the Moquegua River on February 8, 2019 [2][3][4], in self-constructed houses in the Samegua District, Moquegua Region determined that the Seismic Vulnerability found in the analysis of the houses was High at 56% and Medium at 44%; the main influencing factors being the density of walls and the quality of labor during the construction process, as shown in Figure 1.

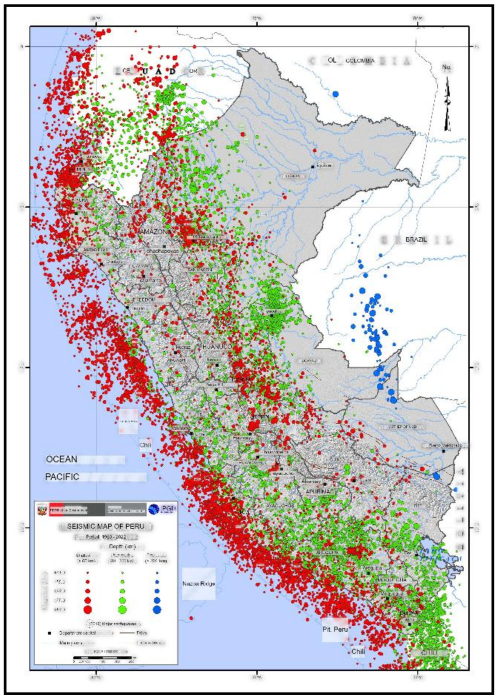

Figure 1 Seismic map of Peru for the period from 1960 to 2019[3]

As highlighted in [3], our research on the seismic threat and vulnerability of Moquegua City, a significant urban area with a population of eighteen thousand (18 000) homes, is a crucial step in understanding the city's seismic risk. We used the technique of microtremors to calculate the periods of vibration of the soil, categorize the dust, and determine the ground's flexibility and rigidity, with fifty-three (53) homes serving as a sample for our investigation.Landslides are frequent and hazardous, particularly in areas with noticeable morphological differences. They impact infrastructure and socioeconomic activities in river systems. Landslides and debris flows caused by volcanic activity and heavy rainfall on loose soils are also impacted[5].

The construction company Cuba Bulege, faced with the notorious risk of the river, built a construction wall that separates it from it but needs to cover the prevention of possible risks that may occur fully. The possible rock slide, the entrance of a landslide through the channel, and the level of prevention are the factors to be calculated in the following research article. The purpose is to prepare an analysis of the urbanization's geological and structural conditions, which can serve the inhabitants as a contribution Club. The plan seeks to anticipate the risks and determine how to act against them according to their degree of risk[3][5].

This study takes a comprehensive approach to understanding the level of vulnerability from a seismic framework, considering both social and physical dimensions. As [6] suggests, it is crucial to relate social and physical vulnerability, evaluating vulnerability from a multidimensional perspective. This underscores the importance of conducting an analysis of social vulnerability. This approach can be a powerful tool, enabling government agencies to allocate resources more efficiently and safeguard human life. The seismic evaluation is guided by the seismic-resistant philosophy, which aims to minimize damage and loss of human life[7].

The projection on the lower hemisphere of the focal sphere and the area of red color corresponds to that of comprehension. The circles and the area were restricted with a dotted line related to the aftershocks and rupture area of the earthquake on June 23, 2001. The red star indicates the location epicenter of the earthquake of August 26, 2003, and the star of yellow color to the aftershocks of greater magnitude [8][9], as shown in Figure 2.

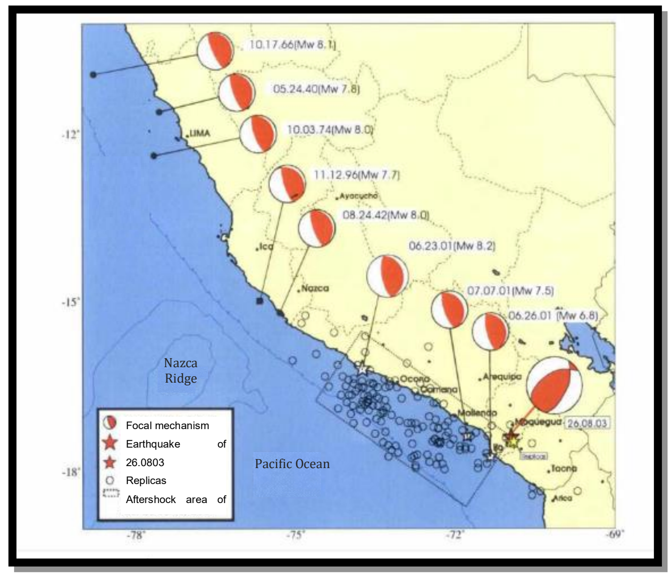

Figure 2 Focal mechanisms for huge edge earthquakes [3].

2.0 METHODOLOGY

The present investigation has a mixed approach. According to[8], two methods strengthen the research, which is why the first phase is qualitative: information is collected, and a survey is conducted. At the same time, a quantitative design will be carried out, determining the level of seismic vulnerability through hierarchical order matrices using numerical parameters and descriptors.

The research design, as per [9], is non-experimental, maintaining the natural variables and study situation. This design ensures that the information collected from the basic studies, such as the population of the Country Club La Villa Urbanization, is analyzed in its authentic context. The study is of a transversal type, determining the level of vulnerability at a specific moment and only once.

As per [9], the objects selected for study are residences with specific characteristics. This deliberate selection is intended to distribute the study variables, ensuring a focused and purposeful research. In total, 58 residences were included in the study[10].

Triggers like heavy rainfall and seismicity are added to the geological, slope, pedology, hydrography, and land use variables (conditioning factors)[11].

It is considered non-probabilistic because it is the same population, and there were no limitations. They were not selected by a probabilistic criterion[10][12]. To carry out the study, data observation sheets in the field and questionnaires were used:

Surveys ------------------------* Questionnaires

Direct Observation Sheets------------------* IPERC

2.1. Procedure

The process to reach the planned objectives was basically in 3 stages:

2.1.1 Pre-field stage:

• Collection of bibliographic information: Specialized reports on the subject, manuals and maps of government entities were collected; to obtain correct information related to the subject of study.

• Data collection: Information was collected from Miss Janet Buleje, who is president of the Owners Association of the Country Club La Villa Urbanization, maps, documentation that may be used, in addition to the authorizations for entering the authorization's Urbanization.

• Visit to the field: Priority was made to update the database obtained, such as the cadastral map of the Country Club La Villa Urbanization. In the same way, a direct observation was carried out to determine the typologies of the houses, and thus propose the appropriate questionnaire through an analysis process. To determine the total seismic vulnerability through physical and social dimensions. In addition, the visit to the board of directors was made for an adequate presentation and to communicate to the citizens of the present investigation.

• Information update: After obtaining the database, we proceeded to prepare the surveys and the observation sheet.

2.1.2 Field stage

• Data collection: Information was collected in the field, filling out the surveys and the observation form that were developed in 6 days, in turn we proceeded to fill out the information on the residential dwellings.

2.1.3 Post-field stage

• The vulnerability level of each survey carried out by the SPSS application is calculated.

• Application of the processing programs, the information from Excel is exported to ArcGIS.

• Preparation of plans, by evaluating the physical and social dimensions, as well as the level of seismic vulnerability.

Social vulnerability, which is influenced by various institutional, psychological, cultural, and economic elements, is defined as the particular degree of exposure and fragility experienced by human groups residing in a certain area in the face of specific dangerous events[13].

3.0 RESULTS AND DISCUSSION

The investigation revealed that the houses in the Country Club La Villa Urbanization have a considerable level of seismic vulnerability. The analysis of the physical vulnerability reveals several important aspects of the buildings in the Country Club La Villa Urbanization in Moquegua, Peru. First, the physical exposure was evaluated, considering the geographical location of the urbanization and the events registered in the area. They found that most houses are built with brick, cement, and reinforced concrete, which provide a solid and resistant structure.

However, it was discovered that the electrical, plumbing, and ventilation systems of the buildings require preventive maintenance to meet safety standards. It is crucial to implement maintenance measures to ensure the durability and safety of the buildings, particularly in conditions of humidity, deterioration, and the presence of nearby slopes.

Furthermore, it is imperative to establish a comprehensive building security and fire prevention system. This should include the installation of fire extinguishers, security lights, smoke detectors, alarms, and evacuation systems. Owners are also encouraged to consult a specialist in structural rehabilitation to propose changes that can enhance their building's structural system.

It is expected that during the disaster, confusion and chaos prevail to escape from buildings or closed places, and many times, more dangerous routes are taken, causing the death of many people. To avoid this type of accident, every building must have good anti-seismic signage [14].

The buildings are evaluated to guarantee safety for the lives inside or to satisfy an immediate occupancy level for the event produced. All aspects of the building's behavior are considered and assumed in terms of points on the structural, non-structural, geological hazard, and foundation[15].

3.1 Analysis of The Vulnerability of the Physical Dimension Location of Buildings

The study was conducted in the Moquegua region, Peru, in the Country Club La Villa Urbanization. This geographical location was selected to assess the level of seismic vulnerability of the houses in said urbanization.

Moquegua, located in the south of the country, provided an advantageous scenario due to the events registered in the area. The safety of the inhabitants of the Country Club la Villa Urbanization, as shown in Figure 3, was a primary concern that drove our research.

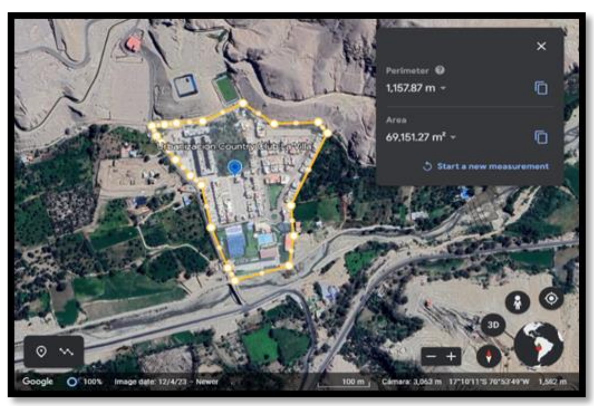

Figure 3 Area of influence Urbanization Country Club La Villa/ Country Club La Villa. Own Elaboration (2023)

The geotechnical investigation details the following processes:
a) Collection of preliminary information. A review of the site conditions, that is, remote sensing images in Google Earth Pro and zoning maps, was carried out.
b) Reconnaissance of the site: Here, a direct observation survey is carried out to recognize the land's surface, visiting the study area to identify if there are drainage problems, slopes, or others, as shown in Figure 4 and Figure 5.

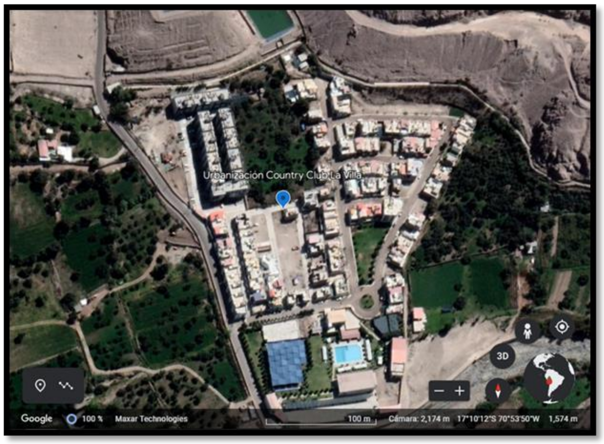

Figure 4 Urbanization Country Club La Villa

Figure 5 Panoramic view of the Country Club La Villa Urbanization

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INSTRUCTIONS
This observation guide is designed for the purpose of evaluating and measuring the process of seismic vulnerability in residential buildings in Country Club la Villa Moquegua –Peru. This instrument that will be used for this evaluation will allow us to determine the processes directly from the residents that will be observed from the

I. GENERAL DATA
Name and surname: ______
Sex: ______
Housing Block: ______
Housing Lot: ______
Address and reference: ______

II. Seismic vulnerability process in residential buildings

N°	ITEMS/DIMENSION
1.1	**¿Age of the people surveyed?** ☐ From 0 to 5 years and over ☐ From 6 to 12 years from 61 to 65 ☐ From 13 to 16 years old and from 51 to 60 ☐ From 17 to 30 years old ☐ From 31 to 50 years old
1.2	**¿Number of floors?** ☐ Five or more ☐ Four levels ☐ Three levels ☐ Two levels ☐ One level
1.3	**¿Has more floors been built than initially allowed?** ☐ Four more floors ☐ Three more floors ☐ Two more floors ☐ One more floor ☐ No
1.4	**¿Does it present inadequate flown staggering?** ☐ Staggered and Ruffled Ends ☐ Staggered and Ruffled Ends ☐ Ruffled Ends

	☐ Inadequate flown ☐ Does not present ☐ Does not know / Does not know
1.5	**¿Age of building?** ☐ 50 years and over ☐ 21 to 49 years old ☐ 11 to 20 years ☐ 3 to 10 years ☐ 0 to 2 years
1.6	**¿Types of beams?** ☐ Don't know / Don't know ☐ Does not exist ☐ Carob beam ☐ Wooden beam ☐ Concrete confined beam ☐ Concrete canted beam
1.7	**¿Types of columns?** ☐ Don't know / Don't know ☐ They do not exist ☐ Wood ☐ Concrete columns ☐ Reinforced concrete column ☐ Steel
	¿Types of roof slab? ☐ Don't know / Don't know

Figure 6 Sample of Survey designed for the purpose of evaluating and measuring the process of seismic vulnerability Adaptation of: [14]

3.2 Information Collection

For the collection of information, a hybrid survey was prepared, that is, face-to-face and virtual, in total it was possible to survey 58 owners of the Country Club La Villa Urbanization, allowing the necessary database for the investigation, as shown in Figure 6 and Figure 7.

1.8	☐ Calamine or others ☐ Clay with sugar cane ☐ Wood ☐ Lightened slab ☐ Solid slab
1.9	**¿Types of bricks in the walls?** ☐ Don't know / Don't know ☐ Adobe ☐ Birck tambourine ☐ Solid brick ☐ King Kong brick ☐ Concrete block
1.10	**¿Structural system?** ☐ Don't know / Don't know ☐ Adobe, masonry unconfined solid tambourine ☐ Reinforced adobe, confined tambourine masonry or solid hybrid system ☐ King's Unbounded Masonry Kong ☐ Masonry confined with brick King Kong or mixed system ☐ Reinforced concrete
1.11	**¿Is your house symmetrical?** ☐ No and ill-proportioned ☐ No and shapely ☐ If in X direction ☐ If in Y direction ☐ Yes in both X and Y directions
1.12	**¿Does your home show any deterioration (grey, corrosion, humidity, etc.)?** ☐ Yes, in four structural elements ☐ Yes, in three structural elements ☐ Yes, in two structural elements ☐ If in a structural element ☐ Does not present
1.13	**¿ What attitudes are there in the face of an earthquake?** ☐ Conformist attitude and without interest in preventing ☐ Incautious attitude ☐ Partially cautious attitude, assuming the risk, without implementing measures ☐ Partially cautious attitude, assuming the risk and implementing few measures to prevent the risk

	☐ Provident attitude of the entire population, implementing various measures to prevent risk
1.14	**¿Are the elements continuous?** ☐ Don't know / Don't know ☐ No and it has a soft floor ☐ No and it does not present a soft floor ☐ Yes in the X direction ☐ If in Y direction ☐ Yes in both X and Y directions
1.15	**¿Has more floors been built than initially allowed?** ☐ Four floors or more ☐ Three floors or more ☐ Two floors or more ☐ One more floor ☐ No
1.16	**¿ Have you received training on risk management in the event of an earthquake?** ☐ No ☐ Yes, 1 to 3 times per year ☐ Yes, 4 to 11 times per year ☐ Yes, 12 to 19 times per year ☐ Yes, 20 or more times per year
1.17	**¿ Do you have knowledge about the causes, occurrences or consequences of an earthquake in Country Club?** ☐ No ☐ I know how they originate ☐ I know how they originate and I know the movements of the plates ☐ I know how they originate and I know the movements of the plates and the importance of the magnitude, intensity depth ☐ Yes, totally and I know the risk in Moquegua
1.18	**¿Have you heard of any media outreach campaign about seismic disasters outside of Country Club?** ☐ There has been no dissemination in various media ☐ Scarce dissemination in various media ☐ Massive and infrequent dissemination in various media ☐ Massive and frequent dissemination in various media ☐ Massive and frequent dissemination in various media and they participate

Figure 7 Sample of Survey designed for the purpose of evaluating and measuring the process of seismic vulnerability Adaptation of:[16].

3.3 Physical Frailty

3.3.1 Building Construction Material

Many houses were built mainly with brick, cement, and reinforced concrete. These materials are common in buildings in urban areas. They recognized that using brick, cement, and reinforced concrete provides a solid and resistant structure, which contributes to the stability of the houses. However, it is essential to take into account that the State of conservation and proper maintenance of these materials are determining factors to ensure the long-term durability and safety of buildings, especially when there is presence of water in the subsoil and seasonal rain considerations torrential Regular inspections and maintenance measures recommended to ensure structural integrity and prevent potential hazards. Table 1 shows the State of conservation of the building according to the frequency and percentage.

Table 1 State of conservation of the building

VALID	Frecuency	Percentage (%)
Don't know	32.00	55.20 %
Concrete Confined beam	22.00	37.90%
Concrete Canted beam	4.00	6.90%
Total	58.00	100.0%

*(Own Elaboration)

3.3.2 State of Conservation of Buildings

The state of conservation of the houses in the Country Club La Villa Urbanization, located in Moquegua, Peru, was evaluated in the study. It was found that these houses, mostly built with brick, cement, and reinforced concrete materials, present different conservation conditions. Variations in structural resistance and deterioration of structural materials, as well as walls with humidity conditions affecting the general integrity of the buildings, were observed. These factors increase the seismic and geomechanical vulnerability of housing in urbanization. Therefore, it is recommended that inspections and periodic maintenance actions be carried out to guarantee the safety and proper conservation of the buildings.

3.3.3 Age of Buildings (Average)

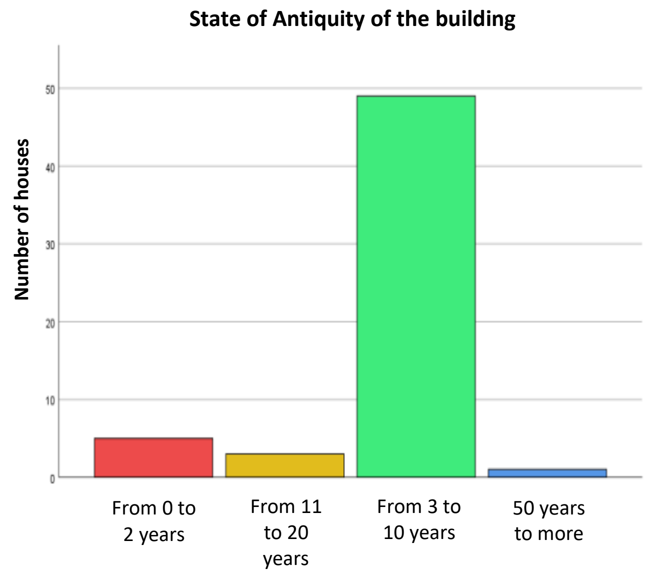
The age of the buildings in the Country Club La Villa Urbanization is a critical factor in assessing their seismic and geomechanical vulnerability. The age of the houses can significantly influence their ability to withstand seismic events and other geomechanical risks. In this case, most buildings are between 3 and 10 years old, highlighting the immediate need to consider age as a critical factor. This age data is instrumental in identifying potential areas for improvement and formulating risk mitigation strategies for housing in urbanization. Table 2 and Table 3 provide a detailed breakdown of the building age distribution, offering practical insights for future planning and development.

Table 2 Age of The Building

		Frecuency	Percentage
Valid	From 0 to 2 years	5.00	8.60 %
	From 11 to 20 years	3.00	5.20 %
	From 3 to 10 years	49.00	84.50 %
	From 50 years to more	1.00	1.70 %
	Total	58.00	100.0 %

*(Own Elaboration)

Table 3 Age of the house



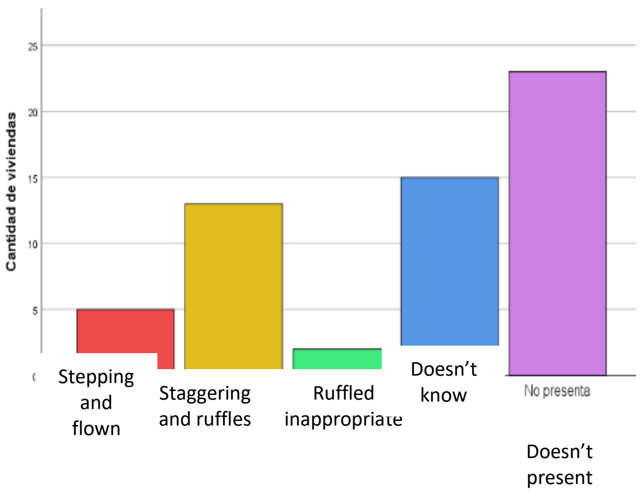
3.3.4 Building Elevation Configuration

Concerning the elevation configuration of the buildings, it is crucial to consider it as a relevant aspect of evaluating their seismic and geomechanical vulnerability level [17][24]. It found that a large part of the conformation of the houses of the Country Club Urbanization presents staggering and overhangs; the remaining dwellings do not present it because they are dwellings that make up buildings. Elevation configuration refers to the vertical arrangement of the buildings, such as the number of floors and the height of the buildings. This configuration can influence the resistance capacity against seismic events and other geomechanical risks. It is necessary to analyze how this configuration can affect buildings' stability and structural response in an adverse event. This analysis identifies possible mitigation and structural modification measures that contribute to reducing vulnerability and increasing the safety of buildings in urbanization. Table 4 shows the Parking and inadequate flying according to the frequency and percentage, as shown in Table 5 with Escalation and inadequate flying.

Table 4 Parking and inadequate flown

		Frecuency	Percentage
Valid	Stepping and flown ends	5.00	8.60 %
	Staggering and ruffles	13.00	22.40 %
	Ruffled inappropriate	2.00	3.40 %
	Don't know	15.00	25.90 %
	Does not present	23.00	39.70 %
	Total	58.00	100.0 %

Table 5 Escalation and inadequate flown



3.3.5 Foundation Or Base

Within the context of the study conducted in the Country Club La Villa Urbanization, the superficial foundations of the isolated footing of reinforced concrete. Considering the building's foundation or base is essential and critical in evaluating its seismic and geomechanical vulnerability. The foundation is the structure that transfers the construction loads to the ground, providing stability, resistance, and bearing capacity. In this sense, we demonstrated that it is necessary to analyze the quality and characteristics of the foundations of the buildings in urbanization, considering factors such as the type of soil, the depth, and the design of the foundation. It is mandatory to carry out detailed inspections and evaluate the foundation's integrity, implementing the necessary reinforcement or repair measures to mitigate the possible risks identified, as shown in the IPERC Baseline[18]

3.3.6 Base Terrain Of The Lot

Our in-situ analysis revealed a gravel soil base with a silty sandy matrix, indicating excellent soil-bearing capacity during an earthquake. However, this also makes it susceptible to other natural disaster factors. The base terrain of the lot is a key determinant in the seismic and geomechanical vulnerability assessment of the buildings. These aspects can significantly influence the structural stability and resistance of the buildings to adverse events [19] [20].

3.3.7.Type of cover

In the specific context of the study in the Country Club La Villa Urbanization, the type of roof of the buildings is a crucial factor in the evaluation of seismic and geomechanical vulnerability. The range of cover types, from tile roofs and metal sheets to reinforced concrete covers, poses a significant risk during an earthquake or natural disaster. These risks could lead to the crushing of vehicles, harm to people, and damage to the electrical infrastructure, underscoring the importance of this factor in the assessment.

The type of roof can influence the structural resistance of buildings against seismic events and other geomechanical risks, as well as protection against water seepage and other external elements, as shown in Figure 8 and Figure 9.

Figure 8 Type of cover

Figure 9 Non-structural elements

3.4 Non-Structural Elements

Within the context of the study carried out in the Country Club La Villa Urbanization, it is essential to consider the non-structural elements of the buildings as an integral part of evaluating seismic and geomechanical vulnerability and hazards and risks. Non-structural elements are those components of a construction that are not part of its resistant system but play an essential role in the functionality and safety of buildings.

It was found wall coverings, interior finishes, partitions, electrical and sanitary installations, furniture, and non-structural equipment and systems, to a certain extent, tend to deteriorate over time. Likewise, they can be damaged or detached, which represents a risk to the integrity of people and the general stability of the buildings, denoted explicitly to a large extent by the large windows in the buildings that represent a large part of them as a danger. Therefore, it is necessary to evaluate the quality, design, and installation of these elements, considering their ability to resist dynamic loads and seismic movements, as well as their adequate fixing and anchoring, as shown in Figure 10 and Figure 11.

Figure 10 Unstructured systems

Figure 11 Inadequate windows

3.5 Physical Resilience

Physical resilience refers to the ability of buildings to resist and recover from adverse events, such as earthquakes, landslides, or floods, minimizing damage and maintaining their functionality and structural safety.

Houses have found and have built many deficiencies in fire safety and prevention systems and evacuation measures in case of emergency and traffic signs. In turn, no documented contingency measures represent the magnitude of exposure to earthquakes or natural disasters.

In addition, some criteria, such as seismic resistance energy absorption, capacity, load redistribution capacity, the adoption of preventive measures, and the implementation of early warning systems, must be considered. By evaluating and improving the physical resilience of the buildings and the risk system in the Country Club La Villa Urbanization, the aim is to guarantee the protection of human lives, reduce economic impacts, and promote the long-term sustainability of the community.

3.5.1 State of Construction

In the first place, the quality of the construction materials used and the quality of the labor used in the Construction of the houses and buildings were evaluated, taking into account the importance of assessing the state of the building structure, including the walls, ceilings, floors, columns, and beams.

Significant damage was found, such as cracks, fissures in the sidewalks and walls, deformations at the foot of the slopes, small sewers and open drains, and walls in poor condition due to saltpeter. These indicators of imminent risks pose a threat to people and/or the infrastructure of the place. Additionally, the state of the building's electrical, plumbing, and ventilation systems was assessed, revealing the need for preventive maintenance to ensure compliance with safety standards.

As part of the improvement process, a comprehensive security and fire prevention system was implemented for the building. This included the installation of fire extinguishers, smoke detectors, alarms, and evacuation systems. The effectiveness of these measures is demonstrated in Table 6, which shows the Number of floors of the houses, Table 7, which displays the Construction of permitted bases, Table 8, which details the Construction of permitted floors, and Table 9, which indicates the Number of floors built than initially allowed.

Table 6 Number of floors of the house

Number of floors of the house			
		Frequency	**Percentage**
Valid	**A level**	12.00	20.70 %
	Three levels	17.00	29.30 %
	Two levels	22.00	37.90 %
	Four levels	4.00	6.90 %
	Five levels and more	3.00	5.20 %
	Total	58.00	100.0 %

Table 7 Number of floors of the house

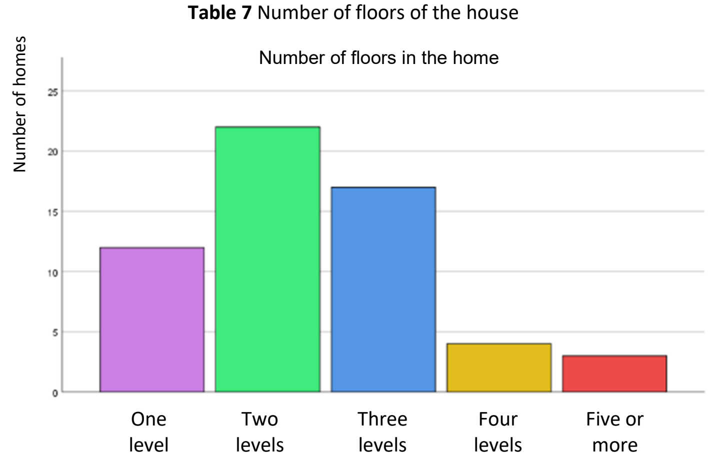
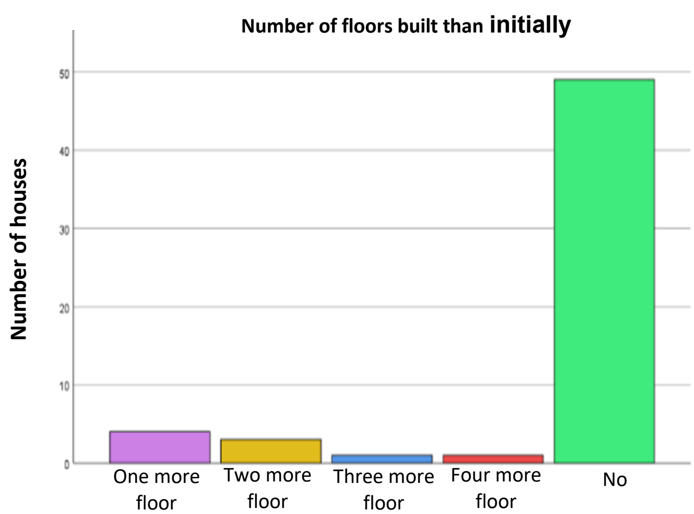


Table 8 Construction of permitted floors

		Frequency	Percentage
Valid	A floor more	1.00	1.70 %
	Two floors more	3.00	5.20 %
	Three floors more	49.00	84.50 %
	Four floors more	1.00	1.70 %
	No	4.00	6.90 %
	Total	58.00	100.0 %

Table 9 Number of floors built than initially allowed



The vulnerability map was prepared to visually represent the seismic and geomechanical risk level in the Country Club La Villa Urbanization. This map reflects the general hypothesis proposed, which establishes a high level of vulnerability in the homes in this area. The analysis of the geomechanical characteristics of the surrounding rock mass is considered to determine the vulnerability of the houses, as shown in Figure 12.

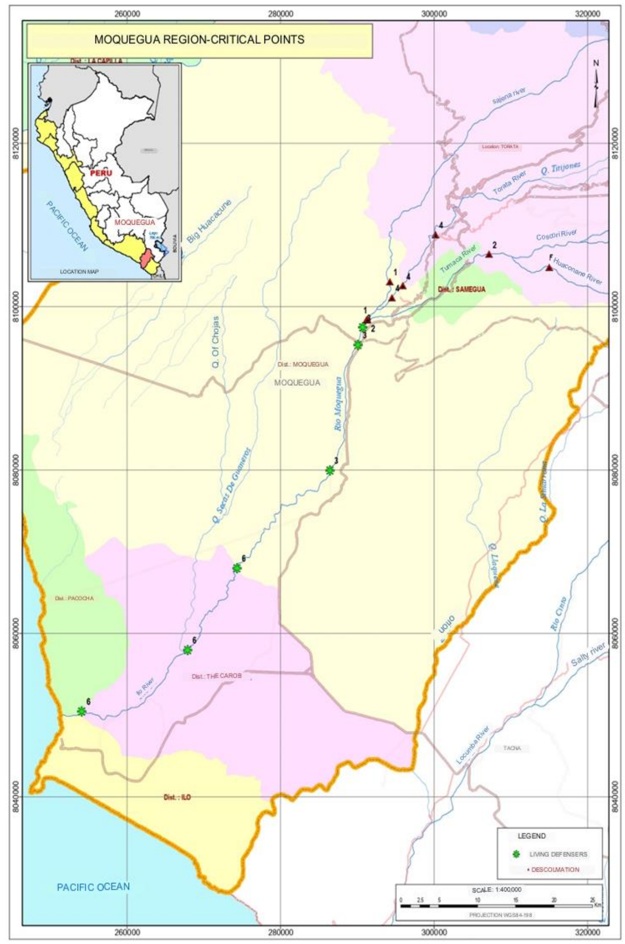


Figure 12 Moisture at the foot of the Slope [18]

3.6 Risk Level

The level of seismic and geomechanical risk in the Country Club La Villa Urbanization is estimated as high, following the general hypothesis proposed. Homes in this area are expected to be highly vulnerable to seismic events due to it.

Regarding the variables, the damage index is considered a measure to quantify damage caused by excessive deformations and seismic force. In addition, the concept of seismic vulnerability, defined by CISMID, is used to assess the degree of susceptibility to earthquake damage, classifying it into high, medium, and low levels.

3.7 Risk Map

The elaboration of the IPERC Baseline considered the tool of security management tools, was developed from the existence and detection of dangers and risks within the urbanization; for this reason, for the elaboration, the imminent dangers were considered for the generation of the map of risks, as shown in Figure 13.*Rain (statistics) and Table 9 with Summary matrix of IPERC Baseline considered the tool of security management tools.

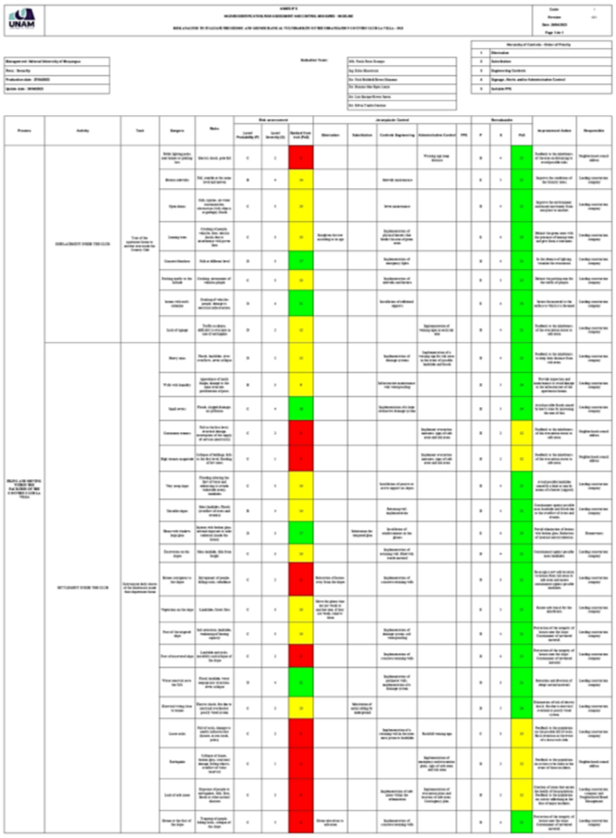


Figure 13 IPERC Baseline considered the tool of security management tools (own elaboration)

Table 9 Summary matrix of IPERC Baseline considered the tool of security management tools

Trigger	**Influence Level**	**Risk factors associated with an earthquake and/or landslide**	**Risk factors not associated with an earthquake and/or landslide**
Inadequate conditions in the infrastructures	**Low – Moderate**	The infrastructure of the Country Club presents concrete stands with a steep slope. The houses have been built with unstable materials such as sheet metal and glass in a large proportion that the presence of an earthquake for evacuation is a sign of high levels of risk.	The presence of slopes around the country club area in the event of heavy rains can cause slopes to slide presence of short sewers level of risk in evacuation increases
Wiring, vegetation in the wrong places, presence of steep slopes all around, lack of signage.	**Moderate**	The presence of green areas, carelessly and indiscriminately, creates infiltrations and can influence the most superficial water table. The evacuation will present difficulties in the event of an earthquake and/or landslide since there are no adequate signs to know the safe areas.	The presence of external factors in the infrastructure such as public lighting wiring, broken sidewalks, and open drains in the event of an earthquake can be an obstruction in the evacuation traffic in the event of an earthquake. The presence of humidity in the walls can influence the resistance of the walls.
Seismic activity according to its continuity or level. Presence of slopes around. loose rocks. Lack of safe areas.	**Moderate – High**	Peru is part of the Pacific ring of fire and is located almost on the edge of two tectonic plates (SIGRID, 2017) in the face of high levels of seismicity, the sliding of the slopes around the study area can mean a great risk factor for the population Likewise, heavy rains or precipitation can cause these landslides. In the event of an earthquake, the lack of signaling of safe areas can mean another determinant that puts the safety of the people who live in this area at risk.	The presence of houses at the foot of the slopes means that the inhabitants themselves putting their lives at stake in the event of possible landslides, the presence of loose rocks on the slopes can also be detached depending on the levels of seismicity.

3.8 Risk Matrix

A risk matrix is a tool to evaluate and visualize the risk levels associated with different variables or factors in a given context or situation. It is a graphic or tabular representation that allows risks to be identified and classified according to their probability of occurrence and their potential impact[21], as shown in Figure 14 with Basic Risk Assessment Matrix.

SEVERITY							
	Catastrophic	1	1	2	4	7	11
	Mortality	2	3	5	8	12	16
	Permanent	3	6	9	13	17	20
	Temporary	4	10	14	18	21	23
	Minor	5	15	19	22	24	25
			A	B	C	D	E
			Common	Has happened	Could happpened	Weird that happened	Practically impossible that happened
			FREQUENCY				

RISK LEVEL	DESCRIPTION	MEASUREMENT PERIOD CORRECTIVE
HIGH	Intolerable risk, requires immediate controls. If the DANGER cannot be controlled, the operational work in the work is paralyzed.	0-24 HOURS
HALF	Initiate measures to eliminate/reduce risk. Evaluate if the action can be executed immediately	0-72 HOURS
LOW	This risk may be tolerable.	1 MONTH

	CRITERIOS		
SEVERITY	Injury personal	Damage to the property	Damage to process
Catastrophic	Various fatalities. Several people with permanent injuries.	Losses for an amount greater than US$ 100,000	Stoppage of the process of more than 1 month or permanent stoppage.
Mortality (Loss major)	A mortality. Vegetative state.	Losses for an amount greater than US$ 100,000	Stoppage of the process of more than 1 month or permanent stoppage.
Loss permanent	Injuries that disable the person for their normal activity for life. Advanced occupational diseases.	Loss in an amount between US$5,001 and US$10,000	Paralysis of the process from more than 1 day to 1 week.
Loss temporary	Injuries that temporarily disable the person. Ergonomic position injuries.	Loss in an amount between US$5,001 and US$10,000	Stoppage of 1 day.
Minor Loss	Injury that does not disable the person. Minor injuries.	Loss in an amount between US$5,001 and US$10,000	Stoppage of less than 1 day.

	CRITERIA	
PROBABILITY	Frequency probability	Exposure frequency
Common (very likely)	It happens too often.	Many (6 or more) people exposed. Several times a day .
It has happened (probably)	It happens frequently.	Moderate (3 to 5) people exposed several times a day.
Could happen (possible)	It happens occasionally.	Few (1 to 2) people exposed several times a day. Many people occasionally exposed.
Rare to happen (unlikely)	It rarely happens. It's not very likely to happen.	Moderate (3 to 5) people occasionally exposed.
Virtually impossible to happen.	It rarely happens. It's not very likely to happen.	Moderate (3 to 5) people occasionally exposed

Figure 14 Basic Risk Assessment Matrix
(Regulation of Occupational Safety and Health in Mining. Edition 2020)

Several cities in South America, such as the City of Bucaramanga in Colombia, have various problems. A study calculated the vulnerability index and the damage index of Colombian buildings after an earthquake using a demand-capacity relationship. These defined functions made it possible to calculate the index above [19]. To ensure the construction of safe buildings for the population, it is essential to implement control and supervision that proposes good practices.

3.9 Discussion

In the case of the city of Cuenca, Ecuador, a significant step was taken in evaluating the seismic vulnerability of the buildings. An integrated map was used, which played a pivotal role in mitigating the danger. It identified safe areas accessible to the population and conditions that protect their inhabitants [20].

The earthquake that struck the south-central zone of Mexico on September 19, 2017, was a stark reminder of the importance of adhering to building regulations. The aftermath revealed 3,400 damaged structures, including 44 buildings that collapsed due to non-compliance with current regulations. The study further highlighted that the conditions that led to the disaster in Mexico City can be partially extrapolated to the northwestern area of Santiago [22][23]. This underscores the need to learn from such disasters and take appropriate actions in the face of earthquakes and river overflows near the Country Club Urbanization, Moquegua.

Following the Sustainable Development Goal (SDG) 13.1, it is essential to promote the search to strengthen resilience and adaptive capacity in the face of natural disasters[23]. All inhabitants must be familiar with preventive measures and know how to act in case of natural disasters.

The explosive Cerro Machín volcano in Colombia can do great harm. A 2009 study used geographic information systems to assess its risk using threat and vulnerability indices. Tolima was the primary location where risk maps, escape routes, and shelter places were created for the impacted area[24] The effects of natural and technological disasters on society during the past few decades have outweighed government institutions' efforts to lessen the vulnerability of specific social groups unintentionally exposed to potentially catastrophic dangers[21].

4.0 CONCLUSION

According to the vulnerability index, 70% of the houses are in a state of HIGH VULNERABILITY built under construction technical support. This methodology is more rigorous because it has more qualitative evaluation components. Various parameters were taken into account, such as the irregularities of the buildings present, the house's geometry, the position of the foundations, and the maximum distance between slopes.

• It has been determined that the structures of the Country Club La Villa urbanization have vulnerability indices that increase according to the irregularity in plan and irregularity in the buildings due to the internal infrastructure of the houses. The frequency table reveals the direct and proportional relationship between these factors and the Vulnerability percentage.

• According to the vulnerability index evaluated with the methodology, 75% of the houses are of Medium To High Vulnerability because they do not have construction criteria, and at the time of a seismic movement, a large number of them would collapse because they did not have a system of proper construction.

• When evaluating the seismic risk map of the Country Club la Villa Urbanization, we conclude that it is in high-level seismic danger due to the geological aspects in the area as accredited by IPERC.

• The survey provided information on the construction of the houses located in the vulnerable zone, which was used to carry out the infrastructure studies, which allowed obtaining information in situ and in real time.

• The presence of non-structural elements that are part of the development, such as moisture on the slope, contributes to the weakening of slopes and structures.

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Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper

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