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# Evaluation of Physical Infrastructure and Seismic Vulnerability in the Community of Joa, Jipijapa Canton

*Evaluación de Infraestructura Física y Vulnerabilidad Sísmica en la Comunidad de Joa, Cantón Jipijapa*

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## ABSTRACT

This research focuses on the evaluation of physical infrastructure and seismic vulnerability in the Joa commune of Canton Jipijapa (Ecuador). The lack of investment in adequate infrastructure can limit the community's growth and increase its vulnerability to natural disasters. The main objective is to diagnose the infrastructure and evaluate the seismic vulnerability of homes, identifying areas for improvement. The methodology combines surveys of residents and rapid visual assessments of buildings, utilizing the FEMA 154 methodology. The surveys collected information on housing characteristics and residents' perceptions of structural safety, while the rapid visual assessment classified homes according to their seismic vulnerability. The results showed that most homes are built with reinforced concrete or a combination of concrete and wood. Although most residents perceive little need for rehabilitation, the seismic assessment revealed that a significant percentage of homes have high vulnerability. The zoning map identified the areas of greatest risk. The main conclusion is that there is a worrying number of homes with high vulnerability that require urgent attention. It is recommended to implement reinforcement and rehabilitation programs, as well as education and awareness campaigns about seismic risk. Vulnerability zoning provides essential information for risk management and urban planning, with the aim of reducing the community's vulnerability to future earthquakes

*Keywords:* seismic resilience, infrastructure assessment, community development, risk mitigation, disaster preparedness

**RESUMEN**

Esta investigación se centra en la evaluación de la infraestructura física y la vulnerabilidad sísmica en la comuna de Joa del Cantón Jipijapa (Ecuador). La falta de inversión en infraestructura adecuada puede limitar el crecimiento de la comunidad y aumentar su vulnerabilidad a los desastres naturales. El objetivo principal es diagnosticar la infraestructura y evaluar la vulnerabilidad sísmica de las viviendas, identificando áreas de mejora. La metodología combina encuestas de residentes y evaluaciones visuales rápidas de edificios, utilizando la metodología FEMA 154. Las encuestas recopilaron información sobre las características de las viviendas y las percepciones de los residentes sobre la seguridad estructural, mientras que la evaluación visual rápida clasificó las viviendas según su vulnerabilidad sísmica. Los resultados mostraron que la mayoría de las viviendas están construidas con hormigón armado o una combinación de hormigón y madera. Aunque la mayoría de los residentes perciben poca necesidad de rehabilitación, la evaluación sísmica reveló que un porcentaje importante de viviendas tienen una alta vulnerabilidad. El mapa de zonificación identificó las áreas de mayor riesgo. La principal conclusión es que existe un número preocupante de viviendas con alta vulnerabilidad que requieren atención urgente. Se recomienda implementar programas de refuerzo y rehabilitación, así como campañas de educación y concientización sobre el riesgo sísmico. La zonificación de vulnerabilidad proporciona información esencial para la gestión de riesgos y la planificación urbana, con el objetivo de reducir la vulnerabilidad de la comunidad ante futuros terremotos.

*Palabras clave:* resiliencia sísmica, evaluación de infraestructura, desarrollo comunitario, mitigación de riesgos, preparación para desastres

## INTRODUCTION

Adequate physical infrastructure is a fundamental pillar for the productive development and quality of life of communities, especially in vulnerable contexts such as Joa, Canton Jipijapa. Infrastructure not only refers to the construction of buildings and roads, but encompasses a set of elements that facilitate social interaction, access to basic services, and the promotion of economic activities.

The quality of infrastructure directly influences the health, education, and general well-being of the inhabitants, which in turn translates into a significant impact on their quality of life. First, adequate physical infrastructure allows access to essential services such as drinking water, electricity, and medical care. The lack of these services can lead to unhealthy living conditions, which affects the health of the population and increases vulnerability to natural disasters, such as earthquakes.

In communities where infrastructure is deficient, there has been an increase in diseases related to water and the lack of adequate medical care, which negatively impacts the quality of life of residents (Osorio Rodríguez, 2022). In addition, transportation infrastructure is essential to facilitate access to markets and job opportunities, which fosters local economic development (Sánchez De Madariaga, 2018).

Furthermore, physical infrastructure also plays a vital role in social cohesion and community interaction. Well-designed public spaces, such as parks and squares, promote physical activity and socialization, which contributes to better mental health and emotional well-being (Rojas et al., 2022; Sánchez De Madariaga, 2018). Physical activity, in turn, is related to a better quality of life, as it has been shown to reduce the risk of chronic diseases and improve mental health (Jiménez-Gómez et al., 2021). In this sense, adequate infrastructure not only supports physical health but also fosters a sense of community and belonging, which is essential for social well-being.

Additionally, educational infrastructure is a critical component for the development of communities. Well-equipped and accessible schools are essential to ensure that children and young people receive a quality education, which in turn influences their future opportunities and the economic development of the community (Osorio Rodríguez, 2022). Education is a determining factor in the quality of life, as it is closely related to people's ability to access well-paying jobs and improve their socioeconomic situation (Sánchez De Madariaga, 2018). Therefore, investing in educational infrastructure is a key strategy to break the cycle of poverty and promote sustainable development.

Seismic vulnerability is another aspect that highlights the importance of physical infrastructure (Utama et al., 2023). In earthquake-prone regions, such as Jipijapa, it is necessary to have buildings that meet safety standards to minimize the risk of collapses and loss of life. The lack of resilient infrastructure can lead to disasters that not only affect people's lives but also destroy the social and economic fabric of the community. Therefore, adequate infrastructure not only improves the quality of life but also acts as a resilience mechanism against natural disasters.

Finally, adequate physical infrastructure also impacts sustainable development and social equity. Communities with deficient infrastructure often face greater challenges in terms of access to services and opportunities, which perpetuates inequality. Investing in infrastructure not only improves the quality of life of residents but also promotes more equitable and sustainable development. This is especially relevant in the context of Joa, where improving infrastructure can be a catalyst for social and economic change (Pionce et al., 2024).

**Potential Challenges of Lack of Investment in Infrastructure**

The lack of investment in infrastructure in rural settlements like Joa, Canton Jipijapa, can significantly limit its growth potential and expose its inhabitants to risks, especially in seismic zones. Physical infrastructure, which includes roads, bridges, drinking water systems, and buildings, is essential for the economic and social development of any community.

In the case of Joa, the lack of these structures not only hinders access to basic services but also increases the population's vulnerability to natural disasters, such as earthquakes. First, deficient infrastructure affects connectivity and access to markets, which limits economic opportunities for residents. The lack of adequate roads can hinder the transportation of agricultural products and other goods, which in turn affects the income of local farmers and merchants (Du, 2023). This is particularly critical in rural areas where the economy depends heavily on agriculture and the sale of local products.

Without adequate infrastructure, transportation costs increase, which can make products less competitive in the market (Fitriani & Ajayi, 2023; Saheed & Obianuju, 2021). In addition, the lack of access to basic services such as electricity and drinking water can discourage investment in local businesses, perpetuating a cycle of poverty and limiting economic development. On the other hand, the seismic vulnerability of existing structures in Joa is a matter of great concern. Most buildings in rural settlements are not designed to withstand earthquakes, making them a significant risk to the safety of inhabitants (Agrawal & Jaiswal, 2022). The lack of investment in earthquake-resistant infrastructure can result in devastating losses during a seismic event, including the loss of life and the destruction of property. Studies (Deyuan et al., 2022) have shown that communities lacking adequate infrastructure are more likely to suffer severe damage during earthquakes, highlighting the need to implement mitigation measures and improve structural resilience.

Furthermore, the lack of proper planning and design in infrastructure can exacerbate the effects of natural disasters. For example, in areas where microzonation studies, which analyze the seismic vulnerability of different zones, have not been conducted, constructions may be located on unsuitable land that increases the risk of damage during an earthquake (Rahmania et al., 2023).

The implementation of a risk-based approach can help identify the most vulnerable areas and prioritize infrastructure investments (Edward Tuah et al., 2022). However, the absence of these studies in communities like Joa limits the ability of planners to make informed decisions about development and infrastructure investment.

With this background, the present study focuses on the diagnosis of physical infrastructure and the assessment of the seismic vulnerability of homes in Joa, with the aim of identifying areas for improvement and proposing solutions that promote the productive development and safety of the community.

## MATERIALS AND METHODS

To carry out the diagnosis of the physical infrastructure and the assessment of seismic vulnerability in the community of Joa, a combined methodology was implemented that included both the collection of primary data through direct surveys of residents and the application of rapid visual assessments according to the FEMA 154 methodology. This approach allowed for a detailed understanding of both the current conditions of the homes and their resistance to seismic events.

The first phase of the methodology consisted of collecting primary data through structured surveys, which were designed to capture relevant information about the characteristics of the homes, the living conditions of the residents, and their perception of the structural safety of their homes. The surveys were conducted directly, which facilitated interaction with the inhabitants and allowed for clarification of any doubts about the items raised. This method is widely recognized for its ability to provide quantitative data that reflect the reality of communities, which is essential for an accurate diagnosis (Carvajal Rivadeneira et al., 2023; Isla-Díaz et al., 2021). In addition, data collection through surveys allows for the identification of patterns and trends that can be useful for future planning and decision-making (Jaramillo Sanabria & Acevedo Osorio, 2019).

In parallel, a rapid visual assessment of the buildings was carried out using the FEMA 154 methodology, which is a standardized approach for assessing the seismic vulnerability of buildings. This methodology involves a visual inspection of the structures, where aspects such as the type of materials used, the quality of construction, and the presence of visible damage are evaluated (Calixto et al., 2023; Raoufy et al., 2023). The application of this methodology allows for the classification of buildings into different levels of vulnerability, which is key to prioritizing interventions and resources in areas that require urgent attention (Tampubolon, 2023).

The combination of data obtained through surveys and visual assessments provides a holistic view of the situation, allowing for the identification of not only the structural conditions but also the perceptions and concerns of residents about their safety.

The methodology also included training the team of surveyors and assessors in the use of the FEMA 154 tool, ensuring that the assessments were conducted consistently and accurately. Staff training is a critical aspect in the implementation of assessment methodologies, as it ensures that the collected data is reliable and representative (Ruiz Muñoz et al., 2024). In addition, protocols were established for data verification, which contributed to the validity of the results obtained.

The assessment with the FEMA 154 methodology considered aspects such as structural typology, height, construction irregularities, building code, and soil type, assigning a score to each parameter to determine the degree of vulnerability of each dwelling (Raoufy et al., 2023).

Data analysis was performed using descriptive statistical methods and spatial analysis techniques (Carvajal Rivadeneira et al., 2023). The survey results were tabulated, and percentages were calculated for each variable, while the seismic vulnerability assessment allowed for the classification of homes into three categories: high, medium, and low vulnerability. The combination of these results allowed for the identification of the main areas for improvement in the physical infrastructure and seismic vulnerability of the Joa community.

## RESULTS AND DISCUSSION

This section presents the findings on the physical infrastructure and seismic vulnerability of the Joa community. The data collected through surveys and visual assessments offer information on the characteristics of the homes, the perceptions of the residents, and the structural conditions of the buildings in the area. The analysis reveals that while most homes are built with reinforced concrete or a combination of concrete and wood, a significant percentage exhibits high seismic vulnerability. The discussion will delve into the implications of these findings, emphasizing the urgent need for interventions to improve the community's resilience to seismic events. In addition, the spatial distribution of vulnerability will be explored, highlighting the areas that require priority attention in terms of risk mitigation and disaster preparedness.

### Distribution of Homes by Area

Table 1 shows the frequency and percentage distribution of responses to the question "What is the area of your home?". Different area ranges (in square meters) and how many people selected each range are presented.

The most frequent category is "Up to 40 m²" with 27.71%, indicating that most of the surveyed homes have a relatively small area. This is followed in frequency by the categories "From 41 to 60 m²" (19.28%) and "From 61 to 75 m²" (24.10%), suggesting that a considerable proportion of homes have a medium area. The larger home categories ("From 76 to 90 m²" and "From 91 to 120 m²") have similar percentages (14.46% each), indicating that they are less common in this sample. It is noteworthy that no surveyed home exceeds 120 m².

The data allows us to conclude that most of the surveyed homes have a small or medium area, with large homes being relatively scarce and very large homes nonexistent in this sample.

**Table 1**

*Distribution of Homes by Area*

| VALUES | FRECUENCY | PERCENTAGE |
|---|---|---|
| Up to 40 m² | 23 | 27,71 % |
| From 41 to 60 m | 16 | 19,28 % |
| From 61 to 75 m² | 20 | 24,10 % |
| From 76 to 90 m² | 12 | 14,46 % |
| From 91 to 120 m² | 12 | 14,46 % |
| More than 120 m² | 0 | 0,00 % |
| **TOTAL** | 83 | 100% |

**Distribution of Homes by Year of Construction**

Table 2 presents the frequency and percentage distribution of responses to the question "What was the year of construction of your home?". Different ranges of home age and how many people selected each range are shown.

The range with the highest frequency is "From 1971 to 1990, between 49 and 30 years" with 36.14%, indicating that most of the surveyed homes are between 30 and 49 years old. This is followed in frequency by the range "From 1991 to 2010, between 29 and 10 years" with 27.71%, suggesting that a considerable proportion of homes are between 10 and 29 years old. Homes built "Up to 1970, more than 50 years" (16.87%) and "From 2011 to 2020, less than 9 years" (19.28%) are less common in this sample, although they still represent a significant portion.

The predominance of homes built between 1971 and 1990 could indicate a period of boom in home construction at that time, possibly driven by favorable economic or demographic factors. It may also reflect the durability of constructions from that period. The significant presence of homes built between 1991 and 2010 suggests continued activity in the construction sector, although perhaps at a slower pace than in the previous period. This could be related to changes in housing needs or economic conditions. Finally, the relative scarcity of very old homes could indicate a renewal of the housing stock, with demolitions or renovations of older homes. On the other hand, the lower proportion of very new homes could be related to factors such as land availability or the cost of construction.

**Table 2**

*Distribution of Homes by Year of Construction*

| VALUES | FRECUENCY | PERCENTAGE |
|---|---|---|
| Up to 1970, more than 50 years | 14 | 16,87 % |
| From 1971 to 1990, between 49 and 30 years | 30 | 36,14 % |
| From 1991 to 2010, between 29 and 10 years | 23 | 27,71 % |
| From 2011 to 2020, less than 9 years | 16 | 19,28 % |
| **TOTAL** | 83 | 100% |

**Distribution of Homes by Construction Material Type**

Table 3 shows the frequency and percentage distribution of the types of materials used in the construction of the surveyed homes. Different material categories and how many homes correspond to each are presented.

The most frequent categories are "Reinforced concrete" (48.19%) and "Mixed concrete/wood" (44.58%), indicating that the vast majority of the surveyed homes are built primarily with reinforced concrete, either alone or in combination with wood. The categories "Wood", "Cane", and "Mixed wood/cane" have very low percentages (2.41% each), suggesting that these materials are used in a very small proportion of the surveyed homes.

The data shows that reinforced concrete is the predominant material in home construction in the surveyed area, followed by the combination of concrete and wood. The use of wood or cane as the main material or even in combination is very infrequent. The predominance of reinforced concrete could be related to its greater availability, lower cost, or perception of greater durability compared to other materials.

Local building regulations could favor the use of reinforced concrete for safety or seismic resistance reasons. The use of certain materials could also be influenced by cultural or traditional factors. It is important to note that this distribution may not be representative of the entire population of homes in the area, as it is based on a sample. However, it provides valuable information about the most common construction practices in the surveyed area.

**Table 3.**

*Distribution of Homes by Construction Material Type*

| VALUES | FRECUENCY | PERCENTAGE |
|---|---|---|
| Reinforced concrete | 40 | 48,19 % |
| Wood | 2 | 2,41 % |
| Cane | 2 | 2,41 % |
| Mixed concrete/wood | 37 | 44,58 % |
| Mixed wood/ cane | 2 | 2,41 % |
| **TOTAL** | 83 | 100% |

**Perception of the Need for Housing Rehabilitation**

Table 4 shows the distribution of frequencies and percentages of the responses to the question "Rate your degree of need to rehabilitate the dwelling". Different levels of need for rehabilitation are presented and how many people selected each level.

The most frequent category is "Little need" with 46.99%, which indicates that almost half of the respondents consider that their home needs little or no rehabilitation. The category "Some need" follows in frequency with 25.30%, which suggests that a quarter of the homes have a moderate degree of need for rehabilitation. The options "Quite a lot of need" (16.87%) and "A lot of need" (10.84%) have lower percentages, indicating that, although there is a group that perceives a significant need for rehabilitation in their homes, this group is a minority compared to those who perceive little or some need.

Although the majority of residents perceive little need for rehabilitation, it is important to promote the importance of preventive maintenance to avoid future problems and ensure the safety and habitability of homes in the long term.

**Table 4**

*Perception of the Need for Housing Rehabilitation*

| VALUES | FRECUENCY | PERCENTAGE |
|---|---|---|
| A lot of need | 9 | 10,84 % |
| Quite a lot of need | 14 | 16,87 % |
| Some need | 21 | 25,30 % |
| Little need | 39 | 46,99 % |
| **TOTAL** | 83 | 100% |

**Rapid Visual Assessment of Buildings Seismic Vulnerability using FEMA-154**

**Typology of the Structural System**

Table 5 presents the distribution of frequencies and percentages of the different types of structural systems observed in buildings, in the context of a seismic vulnerability assessment using the FEMA-154 methodology. Several structural typologies are listed and it is indicated how many buildings correspond to each type.

The most frequent category is "Reinforced concrete frame (C1)" with 50.60%, which indicates that this is the most common structural system in the evaluated buildings. The category "Mixed steel-concrete or mixed concrete-wood (MX)" follows in frequency with 30.12%, which suggests that a considerable proportion of buildings combine different structural materials, mainly concrete and steel or concrete and wood. The other categories, including wood, masonry (with or without reinforcement), steel frames and prefabricated systems, have very low or zero percentages, which indicates that they are uncommon in the evaluated buildings.

Unreinforced masonry (URM) and wood structures, although present in a small percentage, are generally considered more vulnerable to earthquakes. Their presence, although a minority, could indicate a potential seismic risk for those specific buildings. The seismic behavior of reinforced concrete frames can vary significantly depending on their design and construction details. It is important to evaluate these aspects in detail to determine their actual seismic vulnerability. It is important to recognize that rapid visual assessment (FEMA 154) provides a first approximation of seismic vulnerability. However, to obtain a more accurate and reliable assessment, more detailed studies would be required that consider aspects such as the quality of the materials, the structural design, the age of the building and the soil conditions.

**Table 5**

*Typology of the Structural System*

| CATEGORIES | FRECUENCY | PERCENTAGE |
|---|---|---|
| Wood (W1) | 4 | 4,82 % |
| Unreinforced masonry (URM) | 4 | 4,82 % |
| Reinforced masonry (RM) | 0 | 0,00 % |
| Mixed steel-concrete or mixed concrete-wood (MX) | 25 | 30,12 % |
| Reinforced concrete frame (C1) | 42 | 50,60 % |
| Reinforced concrete H-shaped frame with unreinforced confined masonry (C3) | 8 | 9,64% |
| **TOTAL** | 800 | 100% |

**Building height**

Table 6 shows the distribution of frequencies and percentages of the heights of the observed buildings. They are classified into three categories: Low (less than 4 floors), Medium (4 to 7 floors) and Large (more than 7 floors). All the observed buildings (100%) are classified as low, that is, they have less than 4 floors. No medium-height (4 to 7 floors) or large (more than 7 floors) buildings were recorded in the sample.

The results suggest a predominantly horizontal construction pattern in the studied area, which may be related to factors such as population density, soil type, urban regulations or local construction traditions.

In general, low-rise buildings tend to be less vulnerable to earthquakes than high-rise buildings, due to their lower mass and height. However, this does not mean that they are completely safe, since their vulnerability also depends on other factors such as the type of structure, the construction materials and the quality of the construction.

This data may be relevant for urban planning and the future development of the area. For example, if an increase in population or greater urban density is expected, it may be necessary to consider the construction of taller buildings in the future, which would require proper planning and the implementation of earthquake-resistant construction regulations.

**Table 6**

*Building height distribution*

| VALUES | FRECUENCY | PERCENTAGE |
|---|---|---|
| Low (less than 4 floors) | 83 | 100% |
| Medium (4 to 7 floors) | 0 | 0,00 % |
| Large (more than 7 floors) | 0 | 0,00 % |
| **TOTAL** | 83 | 100% |

**Seismic Vulnerability Assesment**

Table 7 presents the results of the seismic vulnerability assessment of 83 homes, classifying them into three categories according to their degree of vulnerability: High: Requires special evaluation (Seismic vulnerability index "S" less than 2); Medium: ($2 \leq S < 2.5$); and Low: ($S \geq 2.5$). The frequency (number of dwellings) and the percentage corresponding to each category are provided.

Most of the houses evaluated (53.01%) have a low degree of seismic vulnerability, which indicates that they have a greater capacity to withstand earthquakes without suffering significant damage. A considerable percentage of homes (34.94%) are classified as highly vulnerable, suggesting that these buildings are at high risk of serious damage or collapse in the event of an earthquake. This represents a major concern in terms of safety and requires priority attention. A smaller percentage of homes (12.05%) have a medium degree of vulnerability, which indicates an intermediate risk of damage in the event of an earthquake.

The results highlight the need to prioritize reinforcement or rehabilitation interventions in homes with high vulnerability, with the aim of reducing the risk of damage and protecting the lives of their occupants. Information on the distribution of seismic vulnerability can be used for emergency planning and seismic risk management in the area, allowing the identification of the most vulnerable areas and the preparation of appropriate response plans.

**Table 7**

*Seismic Vulnerability Assesment*

| VULNERABILITY | FRECUENCY | PERCENTAGE |
|---|---|---|
| High: Requires special evaluation (S<2) | 29 | 34,94 % |
| Medium (2<S<2.5) | 10 | 12,05 % |
| Low (S>2.5) | 44 | 53,01 % |
| **TOTAL** | 83 | 100% |

**Seismic vulnerability zoning**

Figure 1 shows a map of the Joa community in Jipijapa, Manabí, Ecuador, where the homes have been zoned according to their seismic vulnerability. Homes are represented by colored dots: Red: Homes with high seismic vulnerability; Yellow: Homes with medium vulnerability; and Green: Homes with low seismic vulnerability.

**Figure 1**.

*Seismic vulnerability zoning*


A concentration of homes with high vulnerability (red dots) is observed in the central and southern part of the community. Homes with low vulnerability (green dots) are found mainly on the periphery and scattered in other areas. Homes with medium vulnerability (yellow dots) appear to be more evenly distributed throughout the community, although in smaller numbers.

Considering the previous analyzes, it is likely that the concentration of homes with high vulnerability in the center and south of Joa is due to the presence of older buildings, built with techniques and materials that are less resistant to earthquakes. The houses on the periphery, possibly of more recent construction and with better construction practices, could explain the greater presence of green dots in that area. The dispersed distribution of homes with medium vulnerability could indicate a combination of factors, such as the age of the buildings, the quality of the materials and the type of structural system used.

The map allows clearly identifying the areas of Joa with the highest concentration of vulnerable homes, which facilitates the prioritization of reinforcement or rehabilitation interventions. Information on the distribution of seismic vulnerability is essential for urban planning and the future development of the community, promoting the construction of new homes in lower risk areas and establishing stricter construction regulations. The map is a key tool for emergency planning and seismic risk management, allowing the identification of the areas where the greatest impact is expected in the event of an earthquake and facilitating the organization of evacuations and the distribution of aid resources.

## CONCLUSIONS

The results of the evaluation reveal a worrying situation regarding the seismic vulnerability of homes in the study area. Although most of them present a low risk, a significant percentage of homes require urgent attention to improve their seismic resistance and guarantee the safety of their inhabitants. It is essential to take measures to address this problem and reduce the risk of disasters in the event of an earthquake.

It is essential to promote awareness of seismic risk and the importance of building and maintaining earthquake-resistant homes. This may include educational programs, dissemination of information and promotion of good construction practices.

The zoning of seismic vulnerability in Joa provides a clear vision of the distribution of seismic risk in the community. This information is essential for making informed decisions regarding risk management, urban planning and the development of mitigation strategies that allow reducing the vulnerability of the population and their homes to future earthquakes.

It is recommended to carry out more detailed seismic evaluations in the homes identified with high and medium vulnerability to determine the specific reinforcement measures required

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## REFERENCES


Agrawal, P., & Jaiswal, S. K. (2022). Seismic Vulnerability Assessment of Buildings: A Review and Comparative Study. YMER Digital, 21(07), 1158–1170. https://doi.org/10.37896/YMER21.07/96

Calixto, V., Cruz, C., & Huaco, G. (2023). Seismic vulnerability of state educational infrastructures in Cercado de Lima, using the FEMA 154 methodology. 1–7.

Carvajal Rivadeneira, D. D., Ponce Reyes, F. S., Sornoza Parrales, D., Pincay Pilay, M., Antonio, Q. S., & Miller Zavala, J. H. (2023). Elementos básicos de la investigación científica: ISBN: 978-9942-846-51-8. EDITORIAL INTERNACIONAL RUNAIKI, 1–75.

Deyuan, T., Rushan, L., Xuyi, X., & Zhenhui, W. (2022). Seismic Vulnerability Assessment of Thermal Power Plants Based on Beta Function. Mathematical Problems in Engineering, 2022, 1–10. https://doi.org/10.1155/2022/5799241

Edward Tuah, M. A., Tedong, P. A., & Md. Dali, M. (2022). THE CHALLENGES IN RURAL INFRASTRUCTURE PLANNING GOVERNANCE IN SARAWAK. PLANNING MALAYSIA, 20. https://doi.org/10.21837/pm.v20i24.1214

Fitriani, H., & Ajayi, S. (2023). Barriers to sustainable practices in the Indonesian construction industry. Journal of Environmental Planning and Management, 66(10), 2028–2050. https://doi.org/10.1080/09640568.2022.2057281

Isla-Díaz, R., Hess-Medler, S., & Marrero-Hernández, H. (2021). El papel del alumnado en el Docentia tras diez años de evaluación: ¿evaluar al docente o la asignatura? Esa es la cuestión. Revista Española de Pedagogía, 79(280). https://doi.org/10.22550/REP79-3-2021-08

Jaramillo Sanabria, L. M., & Acevedo Osorio, G. O. (2019). Impacto de la estrategia de higienización de manos en comunidades escolares de Pereira, Risaralda. Documentos de trabajo Areandina, 2. https://doi.org/10.33132/26654644.1717

Jiménez-Gómez, S., Sánchez Rojas, I. A., Castro-Jiménez, L., Rubiano-Espinosa, O., Carrillo-Ramírez, C., Garavito-Peña, F., & Barrera-Cobos, N. (2021). Calidad de vida en asistentes a un programa de actividad física en Bogotá, Colombia. Revista Iberoamericana de Ciencias de la Actividad Física y el Deporte, 10(2), 95–111. https://doi.org/10.24310/riccafd.2021.v10i2.12210

Osorio Rodríguez, M. N. (2022). Brechas e Inequidad en infraestructura educativa en el Perú. UCV-Scientia, 14(2), 51–66. https://doi.org/10.18050/RevUcv-Scientia.v14n2a5

Pionce, J. A. M., Mendoza, I. C. O., Morales, J. M. E., & Sornoza-Parrales, D. (2024). El Enfoque Social de las Ciencias y la Tecnología: Implicaciones en la Educación Superior. Technology Rain Journal, 3(1).

Rahmania, Rasmid, Meidi Arisalwadi, & Febrian Dedi Sastrawan. (2023). Microzonation Mapping in Supporting Construction Plan, New Capital City of Indonesia (Case Study: Sepaku Sub-district, Panajam Paser Utara Regency). Proceedings of the 4th International Seminar on Science and Technology (ISST 2022), 82–91. https://doi.org/10.2991/978-94-6463-228-6_10

Raoufy, A. A., Kheyroddin, A., & Naderpour, H. (2023). Seismic Vulnerability Assessment of Reinforced Concrete Hospital Buildings Using Rapid Visual Screening Method According to FEMA P-154 criteria and Iranian Code# 364. Civil Infrastructure Researches, 9(2), 77–93.

Rojas, A., De León, E., & Juárez, A. (2022). Actividad Física y Calidad de Vida en el Adulto Mayor. European Scientific Journal ESJ, 11. https://doi.org/10.19044/esipreprint.11.2022.p365

Ruiz Muñoz, G. F., Paz Zamora, Y. E., & Grijalva Endara, A. D. L. M. (2024). Análisis de la producción científica de docentes en la educación superior. Revista Social Fronteriza, 4(3), e43268. https://doi.org/10.59814/resofro.2024.4(3)268

Saheed, Z. S., & Obianuju, C. K. (2021). Assessment Of The Effect Of Socio-Economic Infrasturcture On Rural Economy In Kaduna State, Nigeria. European Scientific Journal ESJ, 17(15). https://doi.org/10.19044/esj.2021.v17n15p157

Sánchez De Madariaga, I. (2018). Infraestructuras para la vida cotidiana y la calidad de vida. Ciudades, 08, 101–133. https://doi.org/10.24197/ciudades.08.2004.101-133

Tampubolon, S. P. (2023). Comparison of High-Rise Building Structural Performance Using Response Spectrum Method SNI 03-1726-2019 and FEMA-154 Rapid Visual Screening (RVS). MIJR: Multidisciplinary International Journal of Research, 1(3), 89–100.

Utama, W., Indriani, R. F., & Garini, S. A. (2023). Analysis of the Effect of Local Magnitude on Peak Ground Acceleration and Seismic Vulnerability Index for Geothermal Field Monitoring Using Microearthquake. Jurnal Penelitian Pendidikan IPA, 9(10), 7855–7864. https://doi.org/10.29303/jppipa.v9i10.3743